School of Physiotherapy

Playing-related musculoskeletal problems in children learning instrumental music: prevalence and associated potential risk factors

Sonia Ranelli

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DECLARATION

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgment has been made.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

Sonia Ranelli

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ABSTRACT

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Introduction

Musculoskeletal playing–related problems (PRMP) are common amongst professional musicians, music teachers and tertiary music students. The problems are not new, are similar to those seen amongst workers and include pathologies such as tendinopathies, neuropathies and focal dystonia. Adult music studies have investigated the association of intrinsic and extrinsic music and non-music related risk factors with PRMP. Musicians commence playing at very early ages and the literature suggests that PRMP are experienced in young musicians. However, precise rates of problems in children are unclear and there is limited evidence regarding the relevance of known risk factors (in adults) with PRMP in children.

Aims

The aims of this thesis were: 1) to establish the prevalence and location of playing-related musculoskeletal problems (PRMP), both symptoms (PRMS) and disorders (PRMD) in school aged children, and 2) establish the independent association of potential risk factors with PRMP accounting for gender and age.

Methods

A cross-sectional questionnaire and anthropometric measure survey gathered data from 731 children enrolled in the instrumental music programs in six primary and five secondary government schools in Perth, Western Australia. The sample was representative of a range of socioeconomic areas, a range of ages and a range of instruments. The cross-sectional study involved completion of a questionnaire (YAQ-m) containing items related to the participant's music playing and participation in other non-music related activities. Physical measures of height and weight were collected at the time of questionnaire completion.

Descriptive statistics were performed for life and month prevalence of Playing-Related Musculoskeletal Symptoms (PRMS) and month prevalence of Playing-Related Musculoskeletal Disorders (PRMD) with prevalence rates calculated as a percentage of the whole sample. Descriptive analyses were also performed to characterise the intrinsic and extrinsic risk factors of the sample. Chi square analysis was used to examine differences between males and females for categorical variables and ANOVA was used to examine gender differences for continuous variables. Bivariate Pearson correlation analysis examined the relationship between age and continuous variables.

A series of univariable logistic regression analyses were performed to estimate the unadjusted effect of each independent variable on the PRMP outcomes (i.e. PRMS and PRMD). Multivariable logistic regression analyses (for each PRMP outcome) were performed to estimate the independent association of each variable after accounting for gender and age and covariance between other variables. Analyses were performed using SPSS software (versions 10-17).

Results

67% of children reported the experience of PRMS at some point and 56% reported the experience of PRMS within the past month. 30% of children reported being unable to play the instrument as usual, that is, the experience of a PRMD, and of these students, 4.6% reported taking medication and 4.2% reported health professional visits.

Female gender was significantly associated with PRMP (OR 1.38-1.56, $p=0.004 – 0.046$), as was age (OR 1.19-1.23, $p<0.001$). The most commonly reported location of problems were the distal upper extremities, followed by the neck and shoulders (right > left). After adjustment for gender and age, the following intrinsic risk factors were related to PRMP; a) the number of non–music activity related soreness experiences were significantly associated with increased risk of all PRMP (OR 2.2 – 9.1, $p <0.001$) and b) the experience of butterflies in the stomach before a concert/exam sometimes, most times and always was significantly positively associated with PRMP risk compared to almost never (OR 1.7-2.5, $p<0.001$). After adjustment for gender and age, the following extrinsic music-related risk factors were related to PRMP; a) type of instrument, specifically upper and lower strings, woodwind and brass were significantly associated with all PRMP (p<0.001) compared to piano, b) playing three instruments was protective against monthly symptoms (OR 0.43, p=0.05), c) the number of years spent playing the main instrument was protective against a PRMD (OR 0.88, p=0.003), d) the time spent practicing was positively associated with increased risk for monthly symptoms (OR 1.06, p =0.025), and e) the pattern of playing, specifically, playing less than usual (OR 2.1, p=0.002), and playing more than usual, more often and for longer (OR2.7, p<0.001) was positively associated with all PRMP.

Conclusions

PRMP are common across childhood with prevalence and location of PRMP in children disconcertingly similar to that in adults. Examination of the potential multifactorial risk factors associated with PRMP in children found intrinsic factors (gender, age, the experience of non–music activity related soreness and the experience of music performance anxiety), and extrinsic music-related factors (instrument type and number, years of playing main instrument, practice time and pattern of practice when practicing more than usual), were significantly associated with PRMP in young instrumentalists.

These findings will help the young instrumentalist and their family, music educators and health professionals, understand the potential risk factors associated with PRMP. The findings will help direct intervention initiatives for young instrumentalists, maximizing the benefits of and minimising the potential risks associated with learning instrumental music, and help prevent the development of disorders in adulthood. Collaboration between music educators and health professionals should aim to ensure the longevity and enjoyment of music for all.

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LIST OF PUBLICATIONS

The following publications and submissions have also been made on the research described in this thesis:

1. Ranelli S, Straker L, Smith A. Prevalence of playing-related musculoskeletal problems in children learning instrumental music. The Proceedings of the 43rd Annual Conference Human Factors and Ergonomics Society of Australia, 26-28 November 2007; Perth, Western Australia pg. 143-150.
2. Ranelli, S., Straker, L. and Smith, A. Prevalence of playing-related musculoskeletal symptoms and disorders in children learning instrumental music. *Medical Problems of Performing Artists. 2008; 23*(4):178–185.
3. Ranelli, S., Smith, A. and Straker, L. Playing-related musculoskeletal problems in child instrumentalists: the influence of gender, age and instrument exposure. *International Journal of Music Education. 2011; 29*(1):28-44.
4. Ranelli S., Straker, L. and Smith, A. Playing-related musculoskeletal problems in children learning instrumental music: the association of problem location, and gender, age and music exposure factors. *Medical Problems of Performing Artists.* 2011; 26(3):123-139.
5. Ranelli, S., Straker, L. and Smith, A. The influence of music practice on playing-related musculoskeletal problems (PRMP) in children learning instrumental music. *International Journal of Music Education-in review*
6. Ranelli S., Straker, L. and Smith, A. The experience of non-music activity related soreness influences Playing-Related Musculoskeletal Problems in child and adolescent instrumentalists – proposed submission *Journal of Physiotherapy* April 2012.

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CONTRIBUTION OF OTHERS STATEMENT

I, Sonia Ranelli, contributed to the research questions, contributed to the research design, performed the literature search, performed the data analyses and interpretation and contributed to the manuscript writing of the papers/publications during the course of my studies.

Sonia Ranelli
PhD Candidate

I, Leon Straker, the supervisor of the Doctoral Thesis of Sonia Ranelli, contributed to the research questions, the research design, study supervision and revision of drafts of the papers/publications during the course of her studies.

Professor Leon Straker
Supervisor

I, Anne Smith, co-supervisor of the Doctoral Thesis of Sonia Ranelli, contributed to the research questions, the data analysis and interpretation and revision of drafts of the papers/publications during the course of her studies.

Dr Anne Smith
Co-Supervisor

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2. Ranelli S, Straker L, and Smith A. Prevalence of playing-related musculoskeletal problems in children learning instrumental music. The Australian Society for Medical Research, Western Australian Scientific Symposium, 4 June 2008; Perth, Western Australia.

3. Ranelli S, Smith A, and Straker L. Playing-related musculoskeletal problems in the child instrumentalist - the influence of gender, age and music exposure. Australian Hand Therapist Association Biannual Conference, 24-26 October 2008, Melbourne, Victoria.

4. Ranelli S, Straker L, and Smith A. Hand and upper limb problems in children learning instrumental music. International Federation Society Hand Therapy Conference, June 24-26, 2010, Orlando, Florida, USA.

5. Ranelli S, Straker L, and Smith A. Playing-related musculoskeletal problems in children learning instrumental music – the association between problem location and gender, age and music exposure factors. The Alice G Brandfonbrener Young Investigator Award Presentation. The Performing Arts Medicine Association, 29-31 July, 2010, Snowmass, Colorado USA.

6. Ranelli S, Straker L, and Smith A. Playing-related musculoskeletal problems in children learning instrumental music. The State Paediatric and Adolescent Health Child Symposium. 27-29 October, 2010, Princess Margaret Hospital, Perth, Western Australia.

7. Ranelli S, Straker L, and Smith A. The association of music practice with playing-related musculoskeletal problems in children learning instrumental music. Performing Arts Medicine Association, 21-24 July, 2011, Snowmass, Colorado USA.

LIST OF ABBREVIATIONS

AUS	Australian
CI	Confidence Interval
EMG	Electromyography
HS	High School
ICSOM	International Conference of Symphony and Opera Musicians
JHS	Junior High School
LBP	Low Back Pain
MPA	Music Performance Anxiety
MSK	Musculoskeletal
NHMRC	National Health and Medical Research Council
OR	Odds Ratio
PE	Physical Examination
PRP	Playing-Related Problems
PRMP	Playing-Related Musculoskeletal Problems
PRMS	Playing-Related Musculoskeletal Symptoms
PRMD	Playing-Related Musculoskeletal Disorders
QA	Questionnaire
RSI	Repetitive Strain Injury
SR	Sonia Ranelli
VAS	Visual Analogue Scale
VPA	Vigorous Physical Activity
WRMD	Work Related Musculoskeletal Disorders

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CHAPTER 1 INTRODUCTION

1.1 BACKGROUND AND OVERVIEW

Twenty per cent (535,400) of Australian children aged 5 to 14 played a musical instrument outside of school hours in 2007 and 72% (384,000) of these children had formal music tuition (Australian Bureau of Statistics 2009). Forty nine per cent of children in the United Kingdom reported participating in music lessons (National Music Council 2002) and 36% of children in Canada reported participating in activities which included learning music (Guèvremont et al. 2008). Learning to play music is associated with positive cognitive, social, emotional and physical development in children (Hallam 2001) with governments in some countries committed to ensure all children have access to, and opportunities for, music education (Pascoe et al. 2005; Henley 2010).

Playing-related problems (PRP) are prevalent amongst adult musicians (Fry 1986a; 1987; Fishbein et al. 1988; Zaza 1995; Zaza and Farewell 1997; Zetterberg et al. 1998) and in primary and secondary school music students (Dawson 1988; Fry et al. 1988; Lockwood 1988; Birkedahl 1989; Fry and Rowley 1989; Grieco et al. 1989; Shoup 1995; Brown 1997; Betuel and Clairet 1999; Roset-Llobet et al. 2000; Burkholder and Brandfonbrener 2004; Britsch 2005; Bruno et al. 2008). Playing-related problems include: health problems such as hearing loss (Chesky et al. 2002), skin problems (Herman 1974; Gualitieri 1979), dental problems (Herman 1974; Gualitieri 1979); and playing-related musculoskeletal problems (PRMP) that include tendinopathies (e.g. tendonitis, tenosynovitis), peripheral neuropathies and focal dystonias (Newmark and Hochberg 1987).

For some musicians, these problems may end careers or force career changes (Lockwood 1989; Rozmaryn 1993). Musicians commence their careers at an early age and it is therefore important to understand the prevalence and development of these problems in children. Relatively few studies have investigated the presence and location of playing-related musculoskeletal problems in school aged children or adequately evaluated risk factors associated with these problems. Playing-related musculoskeletal problems (PRMP) in children are the focus of this thesis.

This introductory chapter summarises the background research on playing-related musculoskeletal problems briefly, with detailed literature reviews covered in relevant chapters to follow.

1.2 BRIEF LITERATURE REVIEW: PRMP PREVALENCE AND RISK FACTORS

PRMP were recognised in the early 1800s where they were seen to be similar to the problems seen in workers of the time, for example pianist's cramp exhibited clinical features common to writer's cramp and milker's cramp (Solly 1867; Poore 1887; Albert 1895). Epidemiological research in occupational medicine has established that multifactorial risk factors (intrinsic, extrinsic and interaction factors) contribute to the development of work-related musculoskeletal disorders (WRMD) (Armstrong et al. 1993; Kumar 2001). Analogous to WRMD, the risk factors associated with PRMP in musicians are therefore likely to be multifactorial. Intrinsic factors may include gender, age and psychosocial factors; extrinsic factors may include those related to music such as type and number of instruments played, years of playing and music practice and those related to non-music factors such as participation in physical activity and computer use; interaction factors may include the postures adopted to play the instrument.

The performing arts medicine field is a relatively new specialty with its inception only 30 years ago (Chong et al. 1989; Bragge et al. 2006b; Manchester 2007) and consequently the evidence base is still developing. Outside of this field a number of methods have been developed to evaluate the quality of research evidence. Using the scale developed by the Oxford Centre for Evidence Based Medicine, the majority of epidemiological research in musicians to date may be described as low level evidence (Oxford Centre for Evidence-Based Medicine 2009). The National Health and Medical Research Council of Australia (NHMRC) reviewed levels of evidence and grades for recommendations for guideline developers, and recognised the importance of varied research designs (that is, other than the gold standard randomised controlled trials for interventions) to address specific study aims or questions (i.e. aetiology, screening, diagnosis, prognosis or intervention). A new evidence hierarchy was subsequently developed with criteria varying according to the type of research question (National Health and Medical Research Council 2008).

The hierarchy of levels of evidence for aetiology questions identifies and grades study designs from: prospective cohort, Level II (where risk factors for outcomes may be evaluated), down to cross sectional studies, Level IV (where factors associated with outcomes may be established) (Table 1.1).

Table 1.1 NHMRC Evidence Hierarchy: designations for levels of evidence according to Aetiology research questions

Level	**Descriptor**
I	A systematic review of level II studies
II	A prospective cohort study
III-1	All or none*
III-2	A retrospective cohort study
III-3	A case-control study
IV	A cross-sectional study or case series

* all or none of the people with the risk factor(s) experience the outcome; the data arises from an unselected or representative case-series which provides an unbiased representation of the prognostic effect

The majority of studies that have investigated PRMP prevalence and risk factors associated with PRMP in adult and child musicians are cross sectional (level IV evidence) with fewer higher ranked prospective (level II) (Manchester and Lustik 1989; Dawson 1990; Fjellman-Wiklund and Sundelin 1998; Pfalzer and Walker 2001), retrospective (level III-2) (Hochberg et al. 1983; Knishkowy and Lederman 1986; Newmark and Lederman 1987; Dawson 1988; Manchester 1988; Dawson 1995; 1999; Brandfonbrener 2002; Dawson 2002; Warrington et al. 2002; Heming 2004; Dawson 2005) and case control (level III-3) (Pratt et al. 1992; Roach et al. 1994; Manchester and Park 1996; Zaza and Farewell 1997; De Smet et al. 1998; Miller et al. 2002) studies (see Tables 1.2, 1.3 for child and adult PRMP prevalence rates and 1.4 for risk factors associated with PRMP in children and adults).

The following review of the performing arts literature relevant to the prevalence of PRMP in children (Table 1.2, page 34) and adult (Table 1.3, page 36) musicians and risk factors (Table 1.4, page 45) associated with PRMP in adults and children has used this NHMRC level of evidence hierarchy for aetiology questions.

No further formal assessment of the quality of studies was made beyond the level of evidence, rather, studies are critiqued within this literature review as to potentials for bias within their level of evidence.

1.2.1 PRMP Prevalence and Location

PRMP are prevalent in children with reported lifetime rates of 9 to 90% in primary and secondary school music students (see Table 1.2) (Fry et al. 1988; Lockwood 1988; Birkedahl 1989; Fry and Rowley 1989; Grieco et al. 1989; Shoup 1995; Brown 1997; Betuel and Clairet 1999; Roset-Llobet et al. 2000), comparable to lifetime rates reported amongst adult musicians (see Table 1.3) (Fry 1986a; Zaza 1995). The varied prevalence rates across both groups of musicians may be explained by methodological issues such as: different case definitions used in studies (for example, discomfort or pain with no impact on music playing versus the presence of symptoms that interfere with music playing); various methods of data collection (for example questionnaire versus physical examination); and poor response rates which may introduce bias (as musicians with pain may be more likely to participate than musicians with no pain) (see Tables 1.2 and 1.3).

Commonly reported PRMP locations include the upper extremities, spine and embouchure (the mouth, lip, chin and cheek muscles involved in playing a wind or brass instrument (Lederman 2001)) and professional opinion suggests these areas reflect instrument specific biomechanics and ergonomics (Chong et al. 1989; Brandfonbrener 2000a; Dawson 2002). Detailed anatomical sites of PRMP unique to instrument type have been described in many adult studies (Fishbein et al. 1988; Larsson et al. 1993b; Roach et al. 1994; Zaza 1995; Fjellman-Wiklund and Sundelin 1998; Semmler 1998; Yeung et al. 1999; Chesky et al. 2002; Kaneko et al. 2005; Fjellman-Wiklund and Chesky 2006; Abreu-Ramos and Micheo 2007). The upper extremities are the most commonly reported PRMP location in child instrumentalists followed by the spine (Fry 1986c; Dawson 1988; Fry et al. 1988; Lockwood 1988; Fry and Rowley 1989; Grieco et al. 1989; Shoup 1995; Brown 1997; Betuel and Clairet 1999; Roset-Llobet et al. 2000; Dawson 2002; Burkholder and Brandfonbrener 2004; Britsch 2005; Bruno et al. 2008). The limited statistical analysis in these studies has at best described PRMP location prevalences according to type of instrument and there is limited comparison of PRMP prevalences between instrument groups.

1.2.2 Case Definition

Existing PRMP prevalence studies in adult and child musicians are difficult to synthesise due to differing case definitions. Research on adult musicians has defined mild aches and pains experienced during and following playing that may or may not affect performance as playing-related musculoskeletal symptoms (PRMS), and pain, weakness, lack of control, numbness, tingling, or other symptoms that interfered with the ability to play the instrument as usual as playing-related musculoskeletal disorders (PRMD) (Zaza 1995). More recent studies in adult musicians have used these operational definitions to report consistently defined prevalence of playing-related musculoskeletal problems (Zaza and Farewell 1997; Yeung et al. 1999; Ackermann 2003; Bragge 2006) (see Tables 1.2 and 1.3). No recent child studies have used PRMS or PRMD as operational definitions to investigate prevalence of problems in children.

Physiologically, the body's capacity to perceive mild aches and pains serves as a protective function in response to the threat of injury to tissues, so necessary adjustments can be made to avoid continued injury (Wall 1996). Continued exposure to risk factors may result in more severe pain and associated tissue dysfunction (Armstrong et al. 1993; Kumar 2001). Therefore investigation of milder symptoms may serve to provide an early warning of the development of more disabling disorders (Amadio and Russotti 1990; Armstrong et al. 1993; Brandfonbrener 2000a) and may thus be especially important for investigations of problems in children.

The use of established PRMS and PRMD definitions in child studies will allow for consistent prevalence rates and also comparison to adult studies. In this thesis, the term playing-related musculoskeletal problems (PRMP) is used to encompass both symptoms and disorders.

1.2.3 Impact of PRMP

The impact of musculoskeletal soreness or pain on children and adolescents includes activity limitations, such as school absenteeism, the inability to participate in social activities, the utilisation of health services, such as visits to doctors or health practitioners, and the use of medication (Burton et al. 1996; Mikkelsson et al. 1997; El-Metwally A 2004).

The impact of PRMP in musicians has focussed on health service utilisation and medication use in adults. Low rates for seeking medical attention, visits to health practitioners and use of medication have been reported in adult music studies across a range of NHMRC levels of evidence (Manchester 1988; Manchester and Lustik 1989; Middlestadt and Fishbein 1989; Guptill et al. 2000). Study design and poor response rates may explain the reported low rates. Also potential response bias, that is, musicians who have actually sought medical attention but failed to faithfully report so due to personal or professional reasons, may underestimate the true impact of PRMP.

15% (18/120) of students with PRMP sought medical treatment in a study comparing upper limb pain in 169 music students and 348 non-music students (Fry and Rowley 1989). However limited statistical analysis did not identify a difference in the number of music students with PRMP seeking medical treatment. The majority of child music studies have not investigated the impact of PRMP. However some indication of PRMP impact in children may come from studies of visits at medical clinics. For example, 314 music students (18 years and younger) with PRMP attended a specialised performing arts clinic and 84.4% (265) of these children complained of musculoskeletal pain (Burkholder and Brandfonbrener 2004). Children with PRMP have sought medical attention, however the use of other health services and the use of medication remains unclear in young instrumentalists.

1.2.4 PRMP and Risk Factors

As mentioned previously, PRMP are similar to WRMD and therefore risk factors contributing to the development of PRMP are likely to be similarly multifactorial. Figure 1.1 presents a multifactorial model that illustrates multiple intrinsic, extrinsic and interaction factors which may be associated with PRMP in musicians. (Occupational epidemiological literature traditionally uses ‘risk factor’ even when studies are cross-sectional and not prospective. This thesis will follow this tradition whilst recognising the causal evidence limitations of cross sectional research (see section 8.8)).

A review of the literature for reported risk factors associated with PRMP amongst adults and children was performed and studies reviewed are listed in Table 1.4 including the an assessment of the level of evidence according to the NHMRC evidence hierarchy.

Evidence of the association of potential risk factors with outcomes, such as PRMP, is dependent on the study's research design, measures and statistical analyses. As mentioned in the preceding section (1.2), the majority of music studies investigating risk factors associated with PRMP are cross sectional (level IV evidence), and due to methodological limitations (see section 1.2.1) (Fry 1986a; 1987; Revak 1989; Hartsell and Tata 1990) and limited statistical analysis, evidence of association of risk factors with PRMP was found in only some adult studies (Fishbein et al. 1988; Zaza 1992; Roach et al. 1994; Zaza 1995; Manchester and Park 1996; Zaza and Farewell 1997; Fjellman-Wiklund and Sundelin 1998; Yeung et al. 1999; Roset-Llobet et al. 2000; Fjellman-Wiklund et al. 2003; Kaneko et al. 2005; Bragge et al. 2006c; Furuya et al. 2006) and in only seven child studies (Lockwood 1988; Fry and Rowley 1989; Shoup 1995; Roset-Llobet et al. 2000; Dawson 2002; Burkholder and Brandfonbrener 2004; Bruno et al. 2008), even though the level of evidence of some of these studies was ranked higher than IV (see Table 1.4).

In other occupations, conceptual models of risk factors associated with musculoskeletal disorders (MSD) have been developed to facilitate an understanding and better management of the potential risks. Therefore to assist in the prevention and management of PRMS and PRMD in children, it is important to develop a multifactorial model of potential risk factors associated with PRMP in children and adolescents learning instrumental music (see Figure 1.1). The following section will summarise the available evidence for intrinsic factors, extrinsic music-related and extrinsic non-music related factors and interaction factors associated with PRMP, and identify potential risk factors for which the evidence remains unclear amongst children.

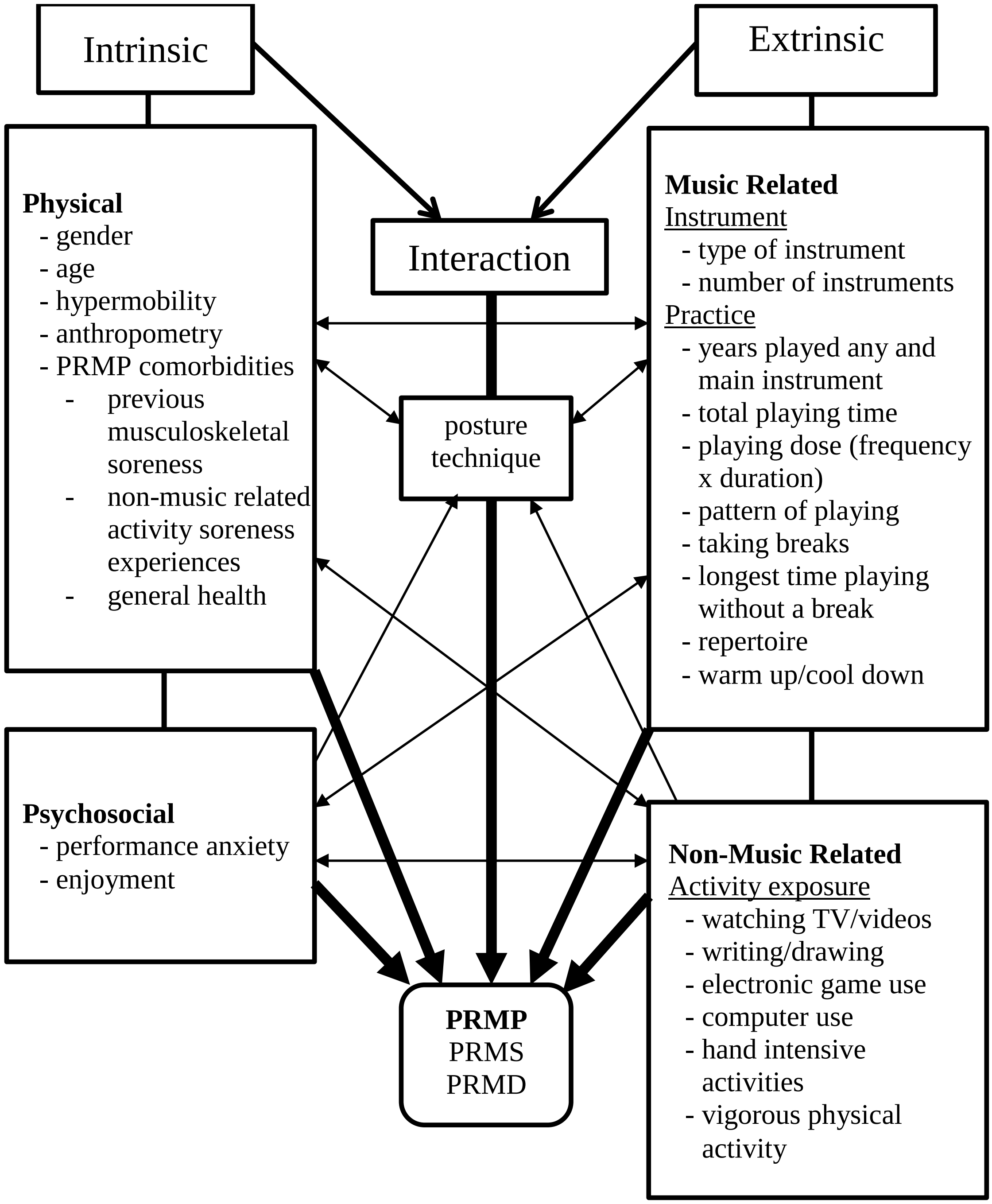

Figure 1.1 Risk factor model for Playing-Related Musculoskeletal Problems (PRMP) in musicians

1.2.4.1 Intrinsic Factors

The performing arts medicine literature has considered intrinsic risk factors such as gender, age, hypermobility, anthropometry, other soreness experience (such as previous injury or musculoskeletal complaint) and psychological factors such as performance anxiety, and several studies have investigated their association with PRMP (Caldron et al. 1986; Fry 1987; Dawson 1988; Hartsell and Tata 1990; Pratt et al. 1992; Tubiana and Chamagne 1993; Shoup 1995; Tubiana 1995; Zaza 1995; Ryan 1998; Betuel and Clairet 1999; Tubiana 1999; Brandfonbrener 2000a; Tubiana 2001; Davies and Mangion 2002).

1.2.4.1.1 Physical Factors

1.2.4.1.1.1 Gender

Gender was the most consistently investigated risk factor amongst both child and adult musicians, and female gender was positively associated with PRMP in several adult studies (Fishbein et al. 1988; Manchester and Lustik 1989; Zaza 1992; Zaza and Farewell 1997; Pak and Chesky 2001; Kaneko et al. 2005) and one child study (Lockwood 1988). Lockwood (1988) reported a significantly higher point prevalence of problems for females than for males ($p<0.04$) in a cross sectional study of 113 secondary music students. However no further analysis quantified the association of gender with PRMP.

Conversely, one child study ranked as higher level evidence found no association between gender and PRMP. In a well conducted case control study of 169 music students and 348 non music control students, no association was found between gender and PRMP (Fry and Rowley 1989). In another retrospective review of music students, the association of gender with PRMP was not investigated (Dawson 1988).

Unlike in adults, the evidence supporting an association between gender and PRMP in children is weak. Given gender differences in PRMP may emerge over puberty, gender prevalence of PRMP over childhood and adolescence needs to be established, to better understand its association as a potential risk factor for PRMP.

1.2.4.1.1.2 Age

Although age was commonly reported in adult and child (Fry et al. 1988; Lockwood 1988; Birkedahl 1989; Fry and Rowley 1989; Grieco et al. 1989; Shoup 1995; Brown 1997; Betuel and Clairet 1999; Roset-Llobet et al. 2000) studies it was often not evaluated as a PRMP risk factor. In a well conducted case control study of adult musicians, Zaza (1995) reported that there was a decreased risk of PRMD as the musician aged, however the risk was no longer significant in a multivariate regression analysis. Pak (2001) in a web-based cross sectional survey, reported a significant inverse association between age and the experience of pain (p=0.003). The case definition used in this study was unclear and the measure of severity was not disclosed. Limited statistical analysis did not quantify the association of age with PRMP (Table 1.4).

There was no association investigated between age and playing-related injuries in the more highly ranked child studies. One retrospective review of 314 students aged 18 years and younger, could not investigate the association between age and playing-related injuries because all students were injured (Burkholder and Brandfonbrener 2004). In another retrospective study, higher PRMP prevalence rates were reported amongst older pianists than young pianists, however no inferential statistics were reported (Dawson 2002). However, age has been investigated as a risk factor in one cross-sectional study including children, which reported that older children were at 2.2 times the risk for PRMP than younger children (CI 1.02-5.69) p=0.04) (Bruno et al. 2008) (see Table 1.4). However older children in this study were categorised as greater than 18 years of age compared to younger children aged 10 to 18 years of age.

General musculoskeletal symptoms are known to increase with age (Fairbank et al. 1984; Salminen 1984; Balague et al. 1988; Turner et al. 1989; Salminen et al. 1992; Troussier et al. 1994; Balague et al. 1995; Burton et al. 1996; Taimela et al. 1997; Balague et al. 1999; Gunzburg et al. 1999; Viry et al. 1999; McMeeken et al. 2001), with very low rates found in early childhood and middle childhood (Balague et al. 1994; Taimela et al. 1997), and higher prevalence rates starting at ages 13 to 14 (Fairbank et al. 1984; Salminen 1984; Balague et al. 1988; Viry et al. 1999).

The relationship between age and PRMP across childhood is unclear. As a child progresses with their music tuition, the associated cumulative exposure to the demands of music playing may place them at risk for the experience of a PRMP, potentially increasing PRMP prevalence rates. The experience of PRMP early in a child’s career may influence the decision to stop learning music and may potentially lower PRMP prevalence rates in late childhood, with the more unaffected music students continuing to learn music. Given the age at which a musician embarks on his or her career path is as early as four or five years of age (Nagel 1998; Tubiana 2002), better evidence is needed to identify PRMP prevalence across childhood and the association between age and PRMP over childhood.

1.2.4.1.1.3 Joint Hypermobility

Hypermobility of a joint is the ability to move in excess of normal movement, considering age, gender and race (Biro et al. 1983; Gedalia et al. 1993; Grahame 2000). Children have a greater joint range of motion than adults, with prevalence of childhood hypermobility ranging from 5–30% (Murray and Woo 2001). Therefore children may be more susceptible to musculoskeletal problems and hypermobile children may be even more susceptible.

Studies have examined hypermobility and musculoskeletal pain in ballet dancers (Klemp et al. 1984), musicians (Larsson et al. 1993a) and industrial workers (Larsson et al. 1995). Dancers, musicians and industrial workers with hypermobility reported significantly more musculoskeletal problems than their counter parts without hypermobility. Task analysis in musicians found those with hypermobility of the fingers and wrist reported significantly less problems than those that were not hypermobile at those joints ($p=0.001$), although musicians with hypermobility of the spine reported significantly more back symptoms than those who were not hypermobile at spine ($p<0.001$) (Table 1.4). The authors postulated joint hypermobility may be useful to prevent problems for tasks requiring repetitive motion at joints, and joint hypermobility may predispose the individual to musculoskeletal problems for tasks requiring support and stability at joints (Larsson et al. 1993a; Larsson et al. 1993b). However, the effect of hypermobility on PRMP was not quantified.

In a retrospective study of adult musicians (Brandfonbrener 2000b; Brandfonbrener 2002), 50% of musicians with lower arm PRMP were assessed (by physical examination) as hypermobile, however the association of hypermobility with PRMP was not investigated.

The relationship between hypermobility and PRMP in children learning instrumental music has not been investigated.

1.2.4.1.1.4 Anthropometric Dimensions

Anecdotal evidence suggests a musician's anthropometric dimensions, such as hand span, become adapted to the repetitive demands of their instrument over years of practice (Ericsson et al. 1993). Expert opinion has suggested this adaptation may prevent the development of PRMP (Bejjani and Nilsson 1984). Some music pedagogues are mindful about the importance of matching instrument size to the instrumentalist's physical attributes to achieve optimum performance (de Sales Baillot 1991; Eales 1992).

Low ranked, methodologically sound studies have investigated the differences in anthropometric dimensions, such as hand span and arm length, between musicians and non-musicians (Wagner 1984; Kloeppel 2000). Hand spans in pianists were found to be significantly wider than hand span in non-musicians (Wagner 1984). The left hand span was found to be significantly greater than the right hand span in cellists and also when compared to in a group of non-musicians (Kloeppel 2000). The authors suggested the differences in hand spans between musicians and non-musicians were attributable due to the specific task demands of the instrument over many years of practice, however due to limited statistical analysis, the relationship was not quantified and these studies did not investigate the association of hand span with PRMP. In a study of professional violinists, hand span measurements between pain free musicians and musicians with PRMP did not predict PRMP at any location (Ackermann and Adams 2003).

In a cross sectional study of successful female violinists and female violinists with musculoskeletal problems, smaller hand anthropometrics correlated with greater range of passive and active upper limb range of motion in the problem group. The association of hand anthropometric measures with problems was not quantified in this study (Wagner 1984). In a cross sectional study of physical attributes of professional violinists, shorter right arm length significantly predicted right arm pain and thoracic pain (Ackermann and Adams 2003). The authors suggested the greater amount of shoulder range of motion required of the bowing arm due to shorter right arm span and the associated muscle activity may explain the study's findings (Ackermann and Adams 2003) (Table 1.4).

No investigation of the relationship between basic anthropometric dimensions and PRMP in children has been reported. Baseline anthropometric measures in children would be useful to establish any association with PRMP, particularly as these measures may change during periods of physical growth over childhood.

1.2.4.1.1.5 Adiposity

Unhealthy weight ranges are linked to musculoskeletal soreness (Webb et al. 2004; Adamson et al. 2006; Jinks et al. 2006). One adult music study found a significant positive association for BMI with PRMP (Zaza 1995). A systematic review (28 studies) investigated the association between adiposity and tendinopathy and reported elevated adiposity was associated with tendon injury. Mechanical and systemic mechanisms have been postulated to explain the association between adiposity or increased adiposity and musculoskeletal soreness. Mechanically, the potentially higher loads placed on weight bearing tendons can lead to tendinopathy (Pottie et al. 2006). Systemically, the chronic low-grade microvascular inflammation and increased cytokine levels associated with increased adiposity (and mechanisms associated with chronic vascular and kidney disease), are thought to influence tendon structure directly and indirectly (Gaida et al. 2009). Physically, adipose tissue may interfere with the musician and instrument interface, potentially necessitating postural or technique adjustments changing the stress or load on musculoskeletal structures and potentially triggering a new soreness experience. Given 25% of Australian children are overweight or obese (Magarey et al. 2001), it may be appropriate that this factor be considered in future research and any association with PRMP established.

1.2.4.1.1.6 PRMP Comorbidities - Other soreness experience

PRMP may cluster with other types of pain, somatic symptoms or other health problems due to common mechanisms or underlying vulnerabilities.

1.2.4.1.1.6.1 Non-music related activity soreness experience

Research suggests non-music related activities of childhood, such as watching TV/Videos (Balague et al. 1999; Kristjansdottir and Rhee 2002; Sjolie 2004; Auvinen et al. 2007), computer use, electronic game use (Jacobs and Baker 2002; Hakala et al. 2006), writing and hand intensive activities (such as needlework, handicraft) (Niemi et al. 1996) and vigorous physical activity participation (Kujala et al. 1999; Auvinen et al. 2007), are all associated with musculoskeletal soreness in children. The lumbar spine is usually the most commonly reported location of musculoskeletal pain in children, followed by the thoracic and cervical spine (Salminen 1984; Balague et al. 1988; Troussier et al. 1994; Balague et al. 1995; Mikkelsson et al. 1997; Mikkelsson et al. 1998). For school and home computer related musculoskeletal soreness in a cross sectional questionnaire survey of 1351 students aged between 6 to 16 years, the neck, low back, mid back were the most commonly reported location followed by right elbow/hand and lower limb (Harris 2010).

Very few music studies reported on non-music activity related soreness. In a case control study of 246 university music students and 416 non-music control university students, significantly more music students reported pain from typing than non-music students (Pratt et al. 1992). The association of pain from typing with PRMP was not investigated. Musicians with playing pain reported the pain experienced after writing was similar to the pain experienced from playing, but as the study was only cross-sectional direction of causation could not be ascertained.

A study of adolescent music and non-music students, found 71% of music students reported hand pain related to music playing, and 26% non-music students reported hand pain due to writing (Fry and Rowley 1989). Music students however were not questioned with regards to writing related hand pain experience and therefore the relationship between writing related hand pain and PRMP was not investigated.

Given children are likely to concurrently participate in non-music related activities, the reported experience of soreness from participation in these non-music related activities may be associated with the reported experience of PRMP. A better understanding this association in young instrumentalists would allow better elucidation of common and music-specific risk factors for PRMP.

1.2.4.1.1.6.2 Previous musculoskeletal soreness

Children and adolescents may experience non-music related musculoskeletal soreness. Several mechanisms may mediate the co-occurrence of pain and in turn may influence the experience and location of PRMP (see 1.2.4.1.1.6.4). No child music study investigated the prevalence and location of other non-music related musculoskeletal soreness. Musculoskeletal pain, headaches and abdominal pains are commonly experienced pains in children (Clark et al. 1996; Szer 1996; Kristjansdottir 1997; Mikkelsson et al. 1997; Egger et al. 1999). Musculoskeletal pain in children may manifest as a consequence of physical factors such as tissue stress or trauma, growing pains, or specific musculoskeletal pathologies, or psychogenic factors such as somatic symptoms related to stress or anxiety (Szer 1996).

1.2.4.1.1.6.3 General health

Studies of adult musicians have reported on the co-experience of general health problems (i.e. non-musculoskeletal pain) and PRMP. Musicians with a greater number of general health problems reported more PRMP compared to musicians with fewer health problems (Fishbein et al. 1988; Abreu-Ramos and Micheo 2007). The scope of the general health problems was wide (a list of 25 problems including eye strain and asthma), potentially inflating the prevalence of general health problems, and the limited statistical analysis reported failed to quantify the association with PRMP.

No child music study has investigated the influence of general health on PRMP risk. There may be shared mechanisms such as individual physical factors (e.g. gender) and psychosocial features (e.g. anxiety) that may be relevant to the reported experience of general health complaints, general musculoskeletal complaints and PRMP, and therefore the association of general health problems with PRMP may be important.

1.2.4.1.1.6.4 Co-occurrence of musculoskeletal soreness at multiple sites

The co-occurrence of musculoskeletal pain at multiple sites is reportedly common in children (El-Metwally et al. 2004) and adolescents (Mikkelsson et al. 1997; Auvinen et al. 2009). The reported experience of ‘other’ musculoskeletal pains was a risk factor for the occurrence and persistence of neck pain in a questionnaire survey of 1756 school children (Stahl et al. 2008). Explanations that have been proposed for co-occurrence of pain (other than pathologies associated with multiple pain sites e.g. idiopathic juvenile arthritis) include: 1) the individual’s general pain vulnerability; 2) shared psychosocial risk factors for pain and 3) shared physical risk factors (Croft et al. 1993; Kroner-Herwig et al. 2011).

An individual's general pain vulnerability

Neurobiological peripheral and central mechanisms of pain perception and processing differ amongst individuals (Woolf 2011). Following initial tissue damage, the nociceptor system is sensitised and the threshold of the nociceptors are lowered (Woolf 2011). Stimulation to the area surrounding the initial damage will elicit a noxious response, and the body withdraws in response to the stimulus, or threat (Graven-Nielsen and Mense 2011). The heightened sensitivity, in the absence of further stimulation, usually returns to baseline levels and normal or high intensity stimulus are again necessary to evoke a similar response (Woolf 2011).

Peripheral sensitisation may explain the experience of pain from normally non-noxious stimuli or exaggerated and prolonged pain response to noxious stimuli. This pain is experienced around the area of initial tissue damage (Woolf 2011). In patients with lateral epicondylalgia the clinical manifestation of this phenomenon may be the local pain and deep tissue tenderness in association with repetitive loading and movement of damaged tissues (Slater et al. 2005). Changes in the central nervous system, central sensitization, may explain the experience of pain independent to an initial nociceptive stimulus (Woolf 2011). The pain is no longer associated with the intensity or duration of a stimulus in the periphery, and the body responds to low threshold stimuli. Clinically, central sensitization pain tends to be widespread (Woolf 2011). Gender influences, as discussed previously, may contribute to the individual's pain vulnerability and the reported experience of multiple pains (Unruh 1996; Fillingim 2003).

Shared psychosocial risk factors for pain

Depressed mood, stress, negative pain beliefs, and the experience of pain by other family members, have been linked to low back pain (Balague et al. 1994; Balague et al. 1995) and neck and upper limb pain in children and adolescents (Mikkelsson et al. 1997; Stahl et al. 2008). In occupational medicine research, a prospective study of 829 workers from diverse occupational groups found psychosocial work demands and high level psychological distress was associated with reported musculoskeletal pain across four anatomic sites. A study of music teachers found high work demand and low level of control was associated with PRMP, although there was no analysis of the relationship with the number of PRMP locations (Fjellman-Wiklund et al. 2003).

Shared Physical Risk Factors

Individuals may participate in one or more activities that involve sustained postures or repeated musculoskeletal loading over the course of a day or the week. Watching TV (Balague et al. 1999; Kristjansdottir and Rhee 2002; Sjolie 2004; Auvinen et al. 2007) and computer use (Jacobs and Baker 2002; Hakala et al. 2006), which involve prolonged sitting by children and adolescents, are known correlates for spinal pain. Similarly, hand intensive activities such as writing and handicraft which require sustained hand grip, are associated with neck and upper limb pain (Niemi et al. 1996). Concomitant participation in these activities may represent cumulative exposure, placing increased demands on the developing musculoskeletal system with the potential for tissue damage and subsequent soreness (Armstrong et al. 1993), thus compounding the risk for musculoskeletal pain.

Summary of PRMP comorbidities - other soreness experience

Given the experience of soreness in one location is associated with the reported experience of soreness at other locations (Croft et al. 1993), it is important to establish a background of the other soreness experience/s (due to trauma, general health problems, or non-music related activity) in the young instrumentalist and examine the association with PRMP. No child music study has investigated PRMP across childhood taking account of other soreness experience.

1.2.4.1.2 Psychosocial factors

Music Performance Anxiety

Music performance anxiety is common amongst child and adult instrumentalists (Caldron et al. 1986; Knishkowy and Lederman 1986; Fry 1987; Fishbein et al. 1988; Kenny et al. 2004). Music performance anxiety, or ‘stage fright’, refers to unwarranted, excessive fearfulness during public performances (Salmon 1990). Symptoms of performance anxiety are generally categorised as cognitive (e.g. catastrophic thoughts), behavioural (e.g. avoidance of performance/auditions) or physiological (e.g. dry mouth, shaking arms/hands, increased heart rate) (Plaut 1990; Salmon 1990). Music performance anxiety has also been associated with negative effects on music performance in adults (Fishbein et al. 1988; van Kemenade et al. 1995). No validated and reliable music performance anxiety assessment tool was available at the time of these music studies. Studies seeking to assess performance anxiety have used general measures of anxiety (e.g. trait anxiety), reports of ‘feeling anxious’, ‘stage fright’ and physiological measures (e.g. elevated heart rate, cortisol levels) (Steptoe and Fidler 1987; van Kemenade et al. 1995; Zaza 1995; Ryan 1998).

High ranked studies suggest performance anxiety is positively associated with PRMP in adult musicians. Increased trait anxiety was associated with increased risk for PRMD amongst professional musicians (Zaza 1995; Zaza and Farewell 1997) and musicians who reported the experience of feeling anxious were 3.14 times more at risk for PRMP than those that did not ($p<0.001$) (Kaneko et al. 2005). Similarly, musicians who reported the experience of stage fright were at more risk of PRMP experience those that did not ($p=0.035$) (Furuya et al. 2006) (Table 1.4).

In low ranked studies, musicians who self-reported stage fright and performance anxiety felt it contributed to their PRMD experience (Caldron et al. 1986; Knishkowy and Lederman 1986; Fry 1987; Fishbein et al. 1988), however the association (of self-reported stage fright and performance anxiety) with PRMP was not formally investigated.

Some aspects of performance anxiety have been investigated in studies of child musicians. In low ranked, well conducted child music studies, physiological aspects of performance anxiety (with symptoms such as shaky hands, dry mouth and increased heart rate) were perceived as a problem by students and 75% reported being nervous during performance (Britsch 2005). Performance anxiety, as measured by questions on symptoms (such as shakiness, dry mouth, perspiration and nervousness), negatively affected performance in 55% (234/425) junior high and high school instrumentalists (Shoup 1995). Conversely, Ryan (1998) reported that whilst 12 year old piano players experienced performance anxiety, as measured by increased heart rate, in different performing situations and reported feelings of anxiety during piano recitals (on interview), perceived anxiety and increased heart rate were not associated with performance quality. However the small sample size

(26) may not have had sufficient power to detect an association. These studies did not examine the association of performance anxiety with PRMP.

The association of performance anxiety with PRMP has not been investigated in children. In light of the positive association with PRMP in adult musicians (Table 1.4), the music performance anxiety in children and its association with PRMP should be considered a priority in future research.

Enjoyment

Enjoyment of music can be considered an intrinsic factor associated with the interest and motivation in learning an instrument, and may contribute to the commitment to continue to learn and achieve in music (McPherson 2000). In a prospective study, 157 students from 8 schools were interviewed prior to starting music tuition to examine if initial motivation and the desire to practice (during music tuition) related to achievement nine months later. Open ended questions were used to define particular interests in learning music found intrinsic reasons “I’ve always liked music and rhythm..” pg. 124 (McPherson 2000) versus extrinsic reasons “….you get to go and have McDonald’s after performance” pg. 124 (McPherson 2000) influenced the individual’s commitment to learn music and their music achievement. In a qualitative grounded theory study (Bragge et al. 2006c), 18 elite adult pianists reported internal, self-generated pressures, such as music pleasure and enjoyment, motivated their performance, and they perceived these subsequently contributed to the development of PRMP. No quantitative studies in adults or in children were found that investigated the association between music enjoyment and PRMP.

Summary of intrinsic factors associated with PRMP

In summary, Table 1.4 shows evidence is available for intrinsic factors in adults, with very little evidence in children. There is some evidence of reasonable quality that female gender is significantly associated with PRMP in children (Lockwood 1988) and older children are more at risk compared to younger children (Bruno et al. 2008).

In adults, there is reasonably strong evidence that other intrinsic factors, namely hypermobility, the experience of other musculoskeletal soreness, previous

PRMP experience and music performance anxiety and enjoyment, are associated with PRMP. There is no evidence of association of these intrinsic factors with PRMP in children.

In adults, there is weaker evidence to support the association of anthropometric measures, non-music related activity soreness and general health problems with PRMP. There is no evidence of association of these intrinsic factors with PRMP in children.

Clearly the relevance of known intrinsic risk factors associated with PRMP in adults needs to be established in children. This thesis investigated the association of potential intrinsic risk factors of gender, age, non-music related activity soreness, the experience of butterflies in the stomach (as a measure of music performance anxiety) and enjoyment with PRMP. The potential association of other intrinsic factors of hypermobility, previous musculoskeletal soreness experience and general health problems with PRMP is acknowledged, however these factors were not examined in this thesis.

1.2.4.2 Extrinsic Factors: Music Related

<u>Instrument type and number of instruments</u>

Although the type of instrument played is consistently reported as a factor associated with PRMP and with PRMP in specific locations (Caldron et al. 1986; Fry 1987; Dawson 1988; Hartsell and Tata 1990; Pratt et al. 1992; Tubiana and Chamagne 1993; Tubiana 1995; Zaza 1995; Betuel and Clairet 1999; Tubiana 1999; Brandfonbrener 2000a; Tubiana 2001), methodological issues and limited statistical analysis in the majority of these studies failed to elucidate a clear association between instrument type and PRMP. Only four adult studies (Fishbein et al. 1988; Middlestadt and Fishbein 1989; Zaza and Farewell 1997; Fjellman-Wiklund et al. 2003), and two studies in children (Lockwood 1988; Burkholder and Brandfonbrener 2004) have reported a significant positive association between instrument type and PRMP (Table 1.4).

Across high and low ranked studies, string instruments were associated with more PRMP than other instrument groups in adults (Fishbein et al. 1988; Manchester and Park 1996; Zaza and Farewell 1997; Fjellman-Wiklund and Sundelin 1998;

Fjellman-Wiklund et al. 2003) and in children (Lockwood 1988; Burkholder and Brandfonbrener 2004). In children, PRMP were more prevalent amongst large string instruments than small string instruments ($p<0.010$) (Lockwood 1988), however only these two instrument groups were compared. Conversely, PRMP in the left forearm and hand were more prevalent among child violinists than the other bowed string instrumentalists ($p<0.005$) (Burkholder and Brandfonbrener 2004), however PRMP comparisons with other instrument groups were not reported.

An investigation the association of PRMP with a comprehensive range of instruments is necessary to establish the unique contribution instruments may have individually or as a group.

No studies investigated the association between the number of instruments played and PRMP. Playing more than one instrument may represent an increase in exposure (Bergqvist et al. 1992; Polanyi et al. 1997) and may potentially increase the risk of PRMP.

Music Practice

Music practice related factors include: years spent playing any and main instrument, total playing time, playing dose (frequency x duration), pattern of playing (e.g. playing less than usual or more than usual, more often, or for longer or more often and longer), taking breaks, longest time spent playing without break, the repertoire, performance of warm up/cool down exercises. While many high and low ranked studies have reported descriptive statistics with respect to these factors, due to methodological issues such as limited measures of practice characteristics and limited statistical analysis, the studies have failed to elucidate any association with PRMP (see Table 1.4).

The number of years spent playing any or main instrument was significantly inversely associated with PRMP in a case control study of professional and university musicians (Zaza and Farewell 1997; Yeung et al. 1999) (Table 1.4). Time spent practising was a common characteristic investigated in many high and low ranked adult and child studies. In professional musicians, every hour of practice, represented a 14% increased risk for PRMP (Roset-Llobet et al. 2000). Musicians with PRMP practiced significantly longer than musicians without PRMP (Hiner et al.

1987), however the association was not quantified. Playing greater than four hours was significantly associated with PRMP in a survey of 203 professional and college musicians (Furuya et al. 2006) (Table 1.4), however the measure of association was not reported.

Repertoire, specifically more difficult repertoire or a change in repertoire, was associated with an increase in PRMP in elite pianists (Bragge et al. 2006c). In a well conducted case control study, performance of warm up exercises, specifically physical warm up (versus scales), was significantly associated with a decrease in PRMP risk (Zaza and Farewell 1997) (see Table 1.4).

In children, descriptive statistics have been reported for factors such as longer practice times, increased practice hours (Fry and Rowley 1989), uninterrupted practice and playing without a break (Lockwood 1988; Bruno et al. 2008) (see Table 1.4). However, limited statistical analysis failed to quantify the association with PRMP for many practice characteristics. For example, in one study music students who played for greater than 60 minutes reported more PRMP than those who played less than 60 minutes, however no p value was reported and there was insufficient raw data to calculate odds ratio (Bruno et al. 2008).

Evidence of the association of music practice characteristics with PRMP in these high and low ranked studies is dependent on the measures used, and appropriate and adequate statistical analysis. Better evidence is needed to clearly establish the association of music practice characteristics with PRMP in children.

Summary of extrinsic music-related factors associated with PRMP

In summary, Table 1.4 shows evidence is available for some extrinsic music related factors in adults, with very little evidence in children.

In adults, strong evidence suggests the number of years spent playing any and the main instrument, the repertoire difficulty and the performance of warm up exercises are associated with PRMP. There is no evidence for these factors in children.

In adults, the evidence to support the association of practice time with PRMP is weak, and there is no evidence in children.

These extrinsic music-related factors represent the child's exposure to instrumental playing. In adults, characteristics of the instrument and music practice may predispose the individual to injury or protect the individual from injury. Although these characteristics are present from a very early age, information regarding the relevance of instrument and music practice characteristics in children for PRMP is unclear and needs to be established.

1.2.4.3 Extrinsic Factors: Non-music related

<u>Non-music related activity exposure</u>

Participation in non-music related activities has been associated with musculoskeletal soreness in children and adolescents. Positive associations have been reported with high exposures to physical activity participation (Kujala et al. 1999; Auvinen et al. 2007); information and communication technology (ICT) use, e.g. computers and electronic games (Jacobs and Baker 2002; Hakala et al. 2006), TV viewing (Balague et al. 1999; Kristjansdottir and Rhee 2002; Sjolie 2004; Auvinen et al. 2007) and with writing and hand intensive activities (such as needlework, handicraft) (Niemi et al. 1996).

The nature and duration of exposure to these non-music related activities are associated with musculoskeletal disorders. For example, increased hours of typing was associated with an increased risk for neck and upper limb problems in adults (Bergqvist et al. 1992; Polanyi et al. 1997) and prolonged duration of laptop use was significantly associated with reports of low back musculoskeletal discomfort in 342 school students (Harris and Straker 2000).

The similarities in task demands of some non-music related activities to musical instrument playing, such as the sustained postures and repetitive hand use seen in computer use (Morse et al. 2000) may potentially increase the load on the musculoskeletal system and therefore contribute to the experience of PRMP.

A few high ranked (Manchester and Flieder 1991; Zaza 1995; Manchester and Park 1996; Fjellman-Wiklund and Sundelin 1998) and low ranked (Fishbein et al. 1988; Middlestadt and Fishbein 1989; Zetterberg et al. 1998) instrumental studies have investigated non-music activity exposure in adults but failed to adequately report the association. Only one adult study reported an association with PRMP (Table 1.4). Zaza (1995) found no association between PRMP and non-music activity participation categorized as leisure activities (hobbies, physical activity), activities of daily living (house cleaning, child care, outside chores) and computer use amongst 278 professional and tertiary music students. In contrast, a case control study of university music students, found students with PRMP spent less time in physical activities compared to music students with no problems. However it was unclear whether this difference in time was significant and any association with time spent in physical activities and PRMP was not quantified (Roach et al. 1994) (Table 1.4).

Two studies have reported an association between non-music activity exposure and PRMP in child instrumentalists. In a case control study of 195 music students aged 10 – 26 years, multivariate analysis found a "lack sports practice" was independently associated with a significantly increased risk of PRMP (OR 2.5, 95% CI 1.3-4.6, p=0.004) (Bruno et al. 2008) (Table 1.4). Shoup (1995) in a cross sectional survey of 425 music students, found students who exercised reported similar rates of PRMP as students who did not exercise, but the power of the study to detect any association was not reported.

Summary of extrinsic non-music related factors associated with PRMP

In summary, Table 1.4 shows there is very little evidence available for extrinsic non- music related factors in adults and in children.

There is strong evidence to support the association of physical activity with PRMP in children and weaker evidence in adults.

Given non-music related activities can have similar task demands to instrumental playing, and the nature and duration of exposure to these activities are associated with the experience of musculoskeletal soreness, exposure levels of non-music related activity in child instrumentalists needs to be established and the association with PRMP investigated.

1.2.4.4 Interaction Risk Factors

Playing posture is influenced by the task demands such as musical instrument, technique and furniture, and the individual's habitual posture (Bejjani and Halpern 1989; Brandfonbrener 2000a). The impact of task demands on posture in adults has been assessed using kinematic and muscle activity analyses. For example, Turner-Stokes (1999) used 3D movement analysis to compare postures on different string instruments of asymptomatic adult musicians and found shoulder elevation was greater on the cello compared to the violin, and elbow flexion range was greater on the violin. A number of well-designed cross sectional studies have found muscle activity varied between specific instruments for adults with and without PRMP (Clapp 1982; Grieco et al. 1989; Philipson et al. 1990; Moulton and Spence 1992), however no association with PRMP was investigated. Evidence that task posture is a risk for pain from other occupations suggests that poor playing technique in musicians may affect the individual's posture and risk of PRMP (Kilbom and Persson 1987).

Several studies with sound methodology have investigated differences in the habitual postures of musicians with PRMP and in musicians without PRMP (Clapp 1982; Grieco et al. 1989; Philipson et al. 1990; Moulton and Spence 1992). Greater muscle activity (upper trapezius and shoulder muscles) was identified in 14 musicians with pain compared to 14 without pain (Moulton and Spence 1992). A difference in motor control was suggested to have either contributed to symptoms or may have resulted from symptom experience. These findings contrasted with results from a cross sectional study of ten violinists (five pain free and five with PRMP) which found no increase in trapezius muscle activity in musicians with pain compared to musicians with no pain (Berque and Gray 2002). The authors suggested trapezius activity was unchanged due to synergistic muscles activation in musicians with pain. However the small sample size may have contributed to the non-significant results. No study has investigated the habitual postures of child instrumentalists (see Table 1.4).

These interaction factors have been suggested as contributing to the development of PRMP in adults, with only two studies providing statistical evidence (Bragge 2006; Wahlstrom Edling and Fjellman-Wiklund 2009) (see Table 1.4). In a qualitative study with one to one interviews with piano teachers of elite pianists, technique ranked among the top five-ranked risk factors perceived by teachers to be associated with PRMD in pianists (Bragge et al. 2006a). In a cross sectional survey of 47 music teachers, teachers playing instruments that involved asymmetric playing postures (for example the violin, viola and flute) reported significantly more musculoskeletal disorders than playing instruments involving symmetric postures (p=0.042). The study's findings were limited by a small sample size and over representation of string players.

No child studies have investigated the association of posture, technique or physical music instruction (versus other educational strategies e.g. mental, by ear) with PRMP. Given childhood is a time when the student may be influenced by instructors and develop lifelong habits, the relationships warrant investigation. Investigation of these interaction factors was beyond the scope of this thesis.

Summary of risk factors associated with PRMP in the literature

Table 1.4 highlights the majority of risk factors proposed for PRMP have been investigated mainly amongst adult musicians. The relevance of these known PRMP risk factors in adults is unclear and yet to be established in children.

1.3 RATIONALE FOR THESIS AND OVERALL DESIGN

There has been considerable research on the prevalence of PRMP in adult musicians, and some investigation into associated risk factors (Fishbein et al. 1988; Zaza 1995; Zaza and Farewell 1997; Brandfonbrener 2000a) but there is very limited research on PRMP in children (Tables 1.2, 1.3 and 1.4).

This thesis is focussed on the experience of PRMP in young instrumentalists aged seven to 17 years, and the potential risk factors associated with PRMP in this young group of musicians. The thesis had two main purposes:

1. Establish the prevalence and location of playing-related musculoskeletal problems (PRMP), both symptoms and disorders, in children learning instrumental music, and

2. Establish relevant potential intrinsic and extrinsic risk factors associated with playing-related musculoskeletal problems in children learning instrumental music.

To achieve the thesis purposes a cross sectional survey study of 731 children was conducted using a questionnaire and anthropometric measures. A number of more specific aims were investigated and the methods and results related to these aims are presented in the 5 chapters following the general methods chapter, with an overall discussion and conclusion presented thereafter. Three of the 5 results chapters have been published as papers in relevant performing arts medicine and music education journals, with a further two currently in review. The chapters have been presented verbatim in the thesis as they were published/submitted, with reference lists for each chapter consolidated into a single list for the thesis.

1.3.1 Overview of Chapter 3: Prevalence of playing-related musculoskeletal symptoms and disorders in children learning instrumental music

Several studies in children have investigated the prevalence of playing-related musculoskeletal problems and potential intrinsic risk factors, such as age and gender. Only nine prevalence studies specifically in primary and secondary school music students have been reported (Fry et al. 1988; Lockwood 1988; Fry and Rowley 1989; Brown 1997; Betuel and Clairet 1999; Burkholder and Brandfonbrener 2004; Britsch 2005; Shoup 2006; Bruno et al. 2008) and a further 5 report some child prevalence data (Fry 1986c; Dawson 1988; Grieco et al. 1989; Roset-Llobet et al. 2000; Dawson 2002). Prevalence rates ranged from 32% for more severe PRMD to 90% for less severe PRMS. Methodological limitations such as heterogeneous case definitions, small sample size and poor response rates may explain the varied rates. Therefore it is important to establish the prevalence of PRMP, both PRMS and PRMD, in a representative sample of young musicians.

The evidence for associations between potential intrinsic factors such as age and gender and PRMP in children is currently unclear due to limited methodological rigour in the available studies. The occupational health and pain literature report the positive association of female gender with WRMD and pain experience (Unruh 1996). Therefore it was important to establish if any gender difference in PRMP existed in the study sample, and if so, then subsequent statistical analysis would need to account for this. Similarly, the reported increase in prevalence of spinal pain across adolescence highlighted the importance to consider the influence of age with PRMP in children. Finally, the impact of PRMS and PRMD with respect to health care utilization or use of medication has not been reported.

This chapter therefore aimed to:

1. Establish the prevalence of playing-related musculoskeletal symptoms (PRMS) and disorders (PRMD), and examine the differences between males and females in child instrumentalists.
2. Evaluate whether the prevalence of PRMS and PRMD changed with age, accounting for gender.
3. For those children who reported the experience of PRMS within the last month, evaluate the frequency of symptoms and examine differences between males and females and across ages.
4. For those children with a PRMD, evaluate how many took medication and sought professional health care and examine differences between males and females and across ages.

This chapter has been published as: Ranelli, S., Straker, L. and Smith, A. Prevalence of Playing-Related Musculoskeletal Symptoms and Disorders in children learning instrumental music. *Medical Problems of Performing Artists. 2008; 23*(4):178–185.

1.3.2 Overview of Chapter 4. Playing-Related Musculoskeletal Problems in child instrumentalists: the influence of gender, age and instrument exposure

Extrinsic music-related factors that may be potentially associated with PRMP include instrument exposure, that is, the type of instrument, the number of instruments played and the amount of time spent playing instruments (Brandfonbrener 2000a). High and low ranked studies have reported instrument-specific PRMP prevalence rates for a wide range of instruments and found high prevalence rates for string instrumentalists (Newmark and Lederman 1987; Fishbein et al. 1988; Zaza and Farewell 1997; Fjellman-Wiklund and Sundelin 1998) and keyboard players (Hochberg et al. 1983; Newmark and Hochberg 1987; Fry 1988; Roset-Llobet et al. 2000; Brandfonbrener 2003). However child studies have not covered instrument groups comprehensively, for example a cross sectional study grouped instruments into string and non-string categories only (Lockwood 1988). Clearly there are marked differences in the task demands within ‘non string’ instruments and important relevant factors that may contribute to PRMP may have been missed.

The Western Australian School of Instrumental Music follows guidelines with respect to the commencement of certain instruments at certain ages. The relationship instrument type and PRMP should consider age because younger children are first taught the violin and viola (through the School of Instrumental Music program) and maybe learning the piano at the same time, or have played the piano from a younger age through private tuition (Whitehead 2003). Subsequently, examining the association of instrument type with PRMP may need to take into account age. PRMP prevalence rates across all instrument type warrants investigation and the influence of gender should also be examined.

This chapter therefore aimed to:

1. Describe extrinsic music-related factors, specifically, practice time, number and type of instruments played, of child instrumentalists.
2. Establish the independent associations of extrinsic music-related factors of practice time, number and type of instruments with PRMP accounting for gender and age.

This chapter has been published as: Ranelli, S., Smith, A. and Straker, L. Playing-Related Musculoskeletal Problems in child instrumentalists: the influence of gender, age and instrument exposure. *International Journal of Music Education. 2011; 29*(1):28-44.

1.3.3 Overview of Chapter 5. Playing-Related Musculoskeletal Problems in children learning instrumental music – the association between problem location and gender, age and music exposure factors.

Descriptive statistics of PRMP location according to type of instrument in child instrumentalists have been reported in high ranked studies (Dawson 2002;

Burkholder and Brandfonbrener 2004) and low ranked studies with sound methodology (Grieco et al. 1989; Roset-Llobet et al. 2000; Britsch 2005; Bruno et al. 2008). However, limited statistical analysis failed to identify potential associated risk factors for PRMP at specific locations.

Potential intrinsic (such as gender and age) and extrinsic music-related factors may explain the experience of PRMP at certain locations (Chong et al. 1989; Brandfonbrener 2000a). Exposure to extrinsic music-related factors can be categorized into: amount (such as time spent playing) or nature of the task (such as type of instrument). Only one adult study (Abreu-Ramos and Micheo 2007) investigated the relationship between PRMP location and type of instrument. No child study has evaluated the potential risk factors (intrinsic and extrinsic music related exposure factors) associated with PRMP in specific locations accounting for age and gender.

This chapter therefore aimed to:

1. Establish the prevalence of PRMP in different locations and determine differences with gender, age and instrument type in child instrumentalists.
2. Examine the independent associations of gender, age and years of music exposure, instrument type, number of instruments played, playing time and years of playing with PRMP in each body location.

This chapter has been published as: Ranelli S., Straker, L. and Smith, A. Playing-Related Musculoskeletal Problems in children learning instrumental music: the association of problem location, and gender, age and music exposure factors. *Medical Problems of Performing Artists.* 2011; 26(3):123-139.

1.3.4 Overview of Chapter 6. The association between music practice characteristics and playing-related musculoskeletal problems in children learning instrumental music.

Other extrinsic music-related factors that may be potentially associated with PRMP include music practice characteristics, such as number of years playing any and main instrument (Zaza and Farewell 1997; Yeung et al. 1999; Roset-Llobet et al.

2000), total playing time (Hiner et al. 1987; Zetterberg et al. 1998; Roset-Llobet et al. 2000), playing frequency and duration (Furuya et al. 2006), pattern of playing, taking breaks, longest time playing without a break, repertoire (Bragge et al. 2006c), warm up (Zaza and Farewell 1997) and cool down.

Very few child studies have investigated practice characteristics comprehensively, and the associations with PRMP remain unclear due to the limited statistical analysis of existing studies (Lockwood 1988; Fry and Rowley 1989; Bruno et al. 2008). This chapter continued to investigate music-related extrinsic factors, specifically aspects of music practice such as frequency and duration, number of breaks taken during practice, longest time spent playing without a break, type of repertoire and performance of warm up/cool down exercises. Additionally, this chapter also investigated intrinsic psychosocial factors, such as the experience of butterflies in the stomach as an indicator of performance anxiety and enjoyment of music.

This chapter therefore aimed to:

1. Describe the extrinsic factors of music practice characteristics of young instrumentalists and determine differences between genders and across ages.

2. Describe further intrinsic characteristics, namely the experience of butterflies in the stomach and enjoyment of playing music in children learning instrumental music.

3. Establish which extrinsic music practice characteristics are associated with PRMP, accounting for age and gender.

4. Establish if intrinsic factors of enjoyment of music and the experience of butterflies in the stomach are associated with PRMP, accounting for age and gender.

5. Establish a model relating significant music practice and intrinsic factors with PRMP accounting for age and gender.

This chapter has been submitted for review as: Ranelli, S., Straker, L. and Smith, A. The influence of music practice on Playing-Related Musculoskeletal

Problems (PRMP) in children learning instrumental music. *International Journal of Music Education-in review*.

1.3.5 Overview of Chapter 7. The experience of non-music activity related soreness is associated with playing-related musculoskeletal problems in child and adolescent instrumentalists.

Extrinsic non-music related activities, such as participation in physical activity, activities of daily living and computer use have been investigated in some studies of adult musicians (Roach et al. 1994; Zaza 1995; Manchester and Park 1996; Abreu-Ramos and Micheo 2007) and child musicians (Shoup 1995; Bruno et al. 2008). No association with PRMP was reported in better quality adult studies (Zaza 1995; Manchester and Park 1996). A lack of sports practice was associated with an increased odds for PRMP in a group of Italian conservatory students aged between 12 and 26 years. However it was unclear if age was accounted for (Bruno et al. 2008).

Participation in non-music activities has been associated with musculoskeletal soreness in children (Niemi et al. 1996; Balague et al. 1999; Kujala et al. 1999; Jacobs and Baker 2002; Kristjansdottir and Rhee 2002; Sjolie 2004; Hakala et al. 2006; Auvinen et al. 2007) and this soreness itself may be a risk factor for PRMP (Kroner-Herwig et al. 2011).

This chapter investigated the exposure to non-music related activities, such as watching TV, computer use and vigorous physical activity, which due to shared similar risk factors (e.g. sustained postures and repetitive hand use with computer use) may contribute to risk for PRMP in children. It also examined the experience of soreness from participation in these non-music activities and the association of one or more soreness experiences with PRMP.

The aims of this chapter therefore were to:

1. Describe children's participation in non-music activities within the last month and evaluate gender and age differences.

2. Describe the experience of non-music activity related soreness and evaluate gender and age differences.

3. Examine the association between non-music activity exposure within the last month and PRMP accounting for age and gender.

4. Examine the association between the non-music activity related soreness and PRMP accounting for age and gender.

This chapter is planned for submission in the Australian Journal of Physiotherapy as: Ranelli S., Straker, L. and Smith, A. The experience of non-music activity related soreness influences Playing-Related Musculoskeletal Problems in child and adolescent instrumentalists.

These results chapters (Chapters 3-7) are followed by an overall discussion chapter (Chapter 8) and are preceded by a general methods chapter (Chapter 2).

Table 1.2 Prevalence of PRMP in children and NHMRC hierarchy of evidence (continued)

Study	Study Design	NHMRC Score	Population	Data Collection	Response Rate (%)	Gender (%Female)	Age Range (yrs)	Case Definition	Prevalence (%)
Betuel and Clairet, 1999 n= 220	cross sectional survey	IV	a range of instrumentalists French	QA	81.5	52	10-14: 15-20 >20	symptoms	50.0 (lifetime)
Britsch, 2005 n= 97	cross sectional survey	IV	student musicians American	QA	38.0	78	9-18	"PRMP"	38.0 (current) 46.0 (lifetime)
Brown, 1997 n= 36	cross sectional survey	IV	youth symphony orchestras	QA	not reported	72	11-18	performance-related pain modified Fry severity scale	81.5 (lifetime)
Bruno, Lorusso and L'Abbate, 2008 n= 195	cross sectional, case control	IV	university music students Italian	QA	87.0	60	11-26	PRMD modified Fry's severity scale	38.4 (4 wk); 46.5 (very mild, 4 wk) 3.8 (severe, 4 wk)
Burkholder and Brandfonbrener, 2004 n= 314	retrospective review	III-2	student musicians American	PE medical notes	not reported	77	5-18	musculoskeletal pain	84.4 (point)
Dawson, 1988 n= 148	retrospective review	III-2	a range of instrumentalists American	PE medical notes	not reported	not reported	10-52	hand and upper extremity problems "overuse" due to music	20.0 (point)
Dawson, 2002 n= 167	retrospective review	III-2	a range of instrumentalists American	PE medical notes	not reported	58	9-18	upper extremity musculoskeletal problems due to music	12.3 (point)

Table 1.2 Prevalence of PRMP in children and NHMRC hierarchy of evidence (continued)

Study	Study Design	NHMRC Score	Population	Data Collection	Response Rate (%)	Gender (%Female)	Age Range (yrs)	Case Definition	Prevalence (%)
Fry, 1987 **n= 1249**	cross sectional survey	IV	university students Australian	PE and QA	100	55	not reported	overuse	9.3 (point)
Fry and Rowley, 1989 **n= 169**	cross sectional survey	III- 3	British 2 schools music & non-music	PE and QA case control	100	63	7-19	"ever experienced pain in hands and arms related to "playing your instrument	71.0 (lifetime)
Fry, Ross and Rutherford, 1988 **n= 98**	cross sectional survey	III-3	Australian schools	QA	100	50	13-18	pain at rest	56.0 (lifetime)
Grieco et al, 1989 **n= 117**	cross sectional cohort	IV	Italian conservatory pianists	QA and EMG	75	56	8 ->25	MSK disorders: “pain and discomfort”	61.5 (lifetime)
Lockwood, 1988 **n= 113**	cross sectional survey	IV	American music students	QA	100	55	14-18	any problem playing instrument modified fry scale	49.0 (lifetime); 32.0 (mild, lifetime) 17.0 (severe, lifetime)
Roset Llobet et al, 2000 **n=1639**	cross sectional survey	IV	a range of instrumentalists Spanish	QA	95	45	7-79	“Pain” Fry severity scale	63.3 (lifetime)
Shoup, 1995 **n= 425**	cross sectional survey	IV	American music students	QA	80	65	15.5 HS; 12.9 JHS	pain	33.2 (lifetime) 19.6 (point)

Table 1.3 Prevalence and Incidence of PRMP in adults and NHMRC hierarchy of evidence (continued)

Study	Study Design	NHMRC Score	Population	Data Collection	Response Rate (%)	Gender (%Female)	Age Range (yrs)	Case Definition	Prevalence (%)/ Incidence
Ackermann and Adams, 2003 **n=32**	cross sectional survey	IV	professional and university students Australian	QA PE	100	72	19-60	performance related pain	88.0 (lifetime)
Abreu-Ramos and Micheo, 2007 **n=75**	cross sectional survey	IV	professionals	QA	90.4	21	22-61	musculoskeletal problems	81.3 (lifetime)
Brandfonbrener, 2002 **n=1300**	retrospective	III-2	range of instrumentalists American	PE	n/a	56	not reported	hand, wrist and arm pain	54.5 (point)
Brandfonbrener, 2009 **n=330**	cross sectional survey	IV	conservatory music students, American	QA	77	54	not reported	playing-related pain	79.0 (lifetime)
Bruno et al, 2008 **n=195**	cross sectional survey	IV	university students Italian	QA	87	60	11-26	PRMD modified Fry's severity	38.4 (4 week)
Caldron et al, 1986 **n=378**	cross sectional survey	IV	professional and university students American	QA	30.3	not reported	17-73	musically related musculoskeletal problems	59.0 (lifetime)

Table 1.3 Prevalence and Incidence of PRMP in adults and NHMRC hierarchy of evidence (continued)

Study	Study Design	NHMRC Score	Population	Data Collection	Response Rate (%)	Gender (%Female)	Age Range (yrs)	Case Definition	Prevalence (%)/ Incidence
Cayea and Manchester, 1998 n=513	retrospective 1982-1996	III-2	university music students American	medical notes	n/a	41	17-34	upper extremity problems	incidence 8.3/100
Chesky et al, 2002 n=739	cross sectional survey	IV	university music students, brass only	QA	not reported	24	34.5 (average)	musculoskeletal problems	61.0 (lifetime)
Davies and Mangion, 2002 n=240	cross sectional survey	IV	professional musicians	QA	45	44	18-72	pain/symptoms	50.0 (point)
Dawson, 1988 n=148	retrospective	III-2	musicians of all levels American	PE medical notes	n/a	not reported	9-52	hand/upper extremity problems	18.2 (5 year)
Dawson, 1995 n=1000	retrospective	III-2	elementary and secondary students, professional	medical notes	100	52	7-86	hand/upper extremity problem	25.2 (point)
Dawson, 1999 n=433	retrospective	III-2	mature instrumentalists	medical notes	32.0	61	50-89	hand/upper extremity problem	27.9 (point)
Dawson, 2001 n=258	retrospective	III-2	dedicated amateur instrumentalists	medical notes	100	47	10-87	hand/upper extremity problem	47.2 (point)

Table 1.3 Prevalence and Incidence of PRMP in adults and NHMRC hierarchy of evidence (continued)

Study	Study Design	NHMRC Score	Population	Data Collection	Response Rate (%)	Gender (%Female)	Age Range (yrs)	Case Definition	Prevalence (%)/ Incidence
Dawson, 2002 n=167	retrospective	III-2	elementary and secondary students, professional	PE medical notes	n/a	58	9-83	upper extremity problems	12.3 (point)
Dawson, 2005 n=51	retrospective	III-2	elementary & secondary students, professionals	medical notes	n/a	61	10-72	intrinsic muscle strain	15.5 (point)
De Smet et al, 1998 n=66	case-control	III-3	level not reported	QA	not reported	50	18-32	overuse	42.5 (lifetime)
Farias et al, 2002 n=341	cross sectional survey,	IV	professionals, students	QA PE	not reported	56	8-70	repetitive strain injury (RSI)	65.1 (lifetime)
Fishbein et al, 1988 n=2212	cross sectional survey	IV	professionals ICSOM	QA	55	36	42 (average)	musculoskeletal symptoms	76.0 (lifetime)
Fjellman-Wiklund and Chesky, 2006 n=520	cross sectional survey	IV	American university guitar students	online survey	not reported	12	33.0 (average)	musculoskeletal problems	81.0 (12 month period)
Fjellman-Wiklund and Sundelin, 1998 n=36	prospective cohort	II	Swedish music teachers	QA PE	not reported	47	1988: 37.4 (av)	musculoskeletal "pain and aches "	1988: 80.0 (point) 1996: 92.0 (point)

Table 1.3 Prevalence and Incidence of PRMP in adults and NHMRC hierarchy of evidence (continued)

Study	Study Design	NHMRC Score	Population	Data Collection	Response Rate (%)	Gender (%Female)	Age Range (yrs)	Case Definition	Prevalence (%)/ Incidence
Fjellman-Wiklund et al, 2003 n=208	cross sectional survey	IV	Swedish music teachers	QA	72.5	42	42.1 (average)	musculoskeletal discomfort	82.0 (lifetime)
Fry, 1986 n=485	cross sectional survey	IV	professionals Australian, American, British	QA PE	100	30	19-70	overuse syndromes Fry severity scale	64.0 (Fry any grade, lifetime) 42.0 (Fry grade 2-5, lifetime)
Furuya et al, 2006 n=203	cross sectional survey	IV	college and professional pianists	QA	78	not reported	not reported	PRMD	77.0 (lifetime)
Grieco et al, 1989 n=117	cross sectional survey	IV	university music students	QA	75	54	8 – >25	complaints	62.0 (lifetime)
Guptill et al, 2000 n=108	cross sectional survey	IV	music majors American	QA	92.3	58	not reported	playing-related physical problems	87.7 (lifetime)
Hartsell and Tata, 1990 n=122	retrospective survey	III-2	university music students	QA	41	71	18-30	music-related problem	65.3 (point)
Heming, 2004 n=59	retrospective	III-2		QA	58	49	16-72	pain, playing-related injury	70.0 (point)

Table 1.3 Prevalence and Incidence of PRMP in adults and NHMRC hierarchy of evidence (continued)

Study	Study Design	NHMRC Score	Population	Data Collection	Response Rate (%)	Gender (%Female)	Age Range (yrs)	Case Definition	Prevalence (%)/ Incidence
Hiner et al, 1987 **n=29**	cross sectional survey	IV	professional violinists International	QA	57	45	18-29	pain, 5 point Likert scale	51.7 (lifetime) 20.9 (1-4 week)
Hochberg et al, 1983 **n=100**	retrospective	III-2	a range of instrumentalists	PE	not applicable	47	16-75	hand complaints: tendon/joint, motor control	45.0 (tendon/joint) (point) 24.0 (motor control) (point)
Kaneko et al, 2005 **n=241**	cross sectional survey	IV	professionals Brazilian	QA	51.3	30	18-73	incapacitating pain	65.0 (lifetime)
Knishkowy and Lederman, 1986 **n=50**	retrospective with follow up	III-2	professionals and music students	PE	not applicable	66	15-60	pain: overuse, peripheral nerve, motor control	51.0 (overuse, point) 6.0 (peripheral nerve, point) 13.0 (motor control, point)
Larsson et al, 1993 **n=660**	cross sectional survey	IV	university music students and staff	QA PE	80	45	14-68	musculoskeletal symptoms:	67.0 (point)
Manchester, 1988 **n=132**	retrospective	III-2	university music students	medical notes	not applicable	67	17-39	hand problems	incidence 8.5/100
Manchester and Fleider, 1991	retrospective	III-2	university music students	medical notes	not applicable	64	17-34	hand problems	incidence 8.5/100

Table 1.3 Prevalence and Incidence of PRMP in adults and NHMRC hierarchy of evidence (continued)

Study	Study Design	NHMRC Score	Population	Data Collection	Response Rate (%)	Gender (%Female)	Age Range (yrs)	Case Definition	Prevalence (%)/ Incidence
n=114									
Manchester and Lustik, 1989 n=49	prospective cohort	II	university music students	QA	57	59	not reported	hand pain	initial 75.0 (point) follow up 16.0 (point)
Manchester and Park, 1996 n=96	retrospective case-control 1989-1992	III-3	tertiary music students	QA PE	53	69	20.8 average	performance-related hand muscle overuse	75.0 (point)
Middlestadt and Fishbein, 1989 n=1378	cross sectional survey	IV	ICSOM 48 orchestras string instruments	QA	53.6	44	not reported	musculoskeletal symptoms	58.0 (point)
Miller et al, 2002 n=92	case control	III-3	conservatory music students (string and keyboard)	QA PE	not reported	62	21 (median)	pain upper limb:	72.0 (point)
Morse et al, 2000 n=954	cross-sectional	IV	working age residents American	telephone interview	36	53	18-70+	upper limb pain	29.0 (12 month period)
Newmark and Hochberg, 1987 n=108	retrospective cohort	III-2	conservatory student and professional musicians	medical notes	n/a	54	16-72	playing-related pain	24.0 (point)

Table 1.3 Prevalence and Incidence of PRMP in adults and NHMRC hierarchy of evidence (continued)

Study	Study Design	NHMRC Score	Population	Data Collection	Response Rate (%)	Gender (%Female)	Age Range (yrs)	Case Definition	Prevalence (%)/ Incidence
Newmark and Lederman, 1987 n=79	cross sectional survey	IV	amateur to professionals	QA	73	41	47 average	new playing-related problem/s	72.0 (point)
Owen, 1985 n=110	retrospective	III-2	amateur to professionals	PE	100	54	12-61	RSI-related injuries	86.0 (point)
Nyman et al, 2007 n=235	cross sectional survey	IV	professional musicians Swedish orchestras	QA and physical measure	78	not reported	not reported	neck-shoulder pain	25.5 (point)
Pak and Chesky, 2001 n=455	cross sectional survey	IV	level not reported	QA	not reported	53	10 - >60	pain	58.7 (lifetime)
Pfalzer and Walker, 2001 n=200	3 year prospective cohort	II	professional pianists	QA PE	61	not reported	not reported	'upper quadrant injuries'	50.0% incidence
Pratt et al, 1992 n=246	cross sectional survey	IV	university students	QA	not reported	not reported	not reported	performance related pain	87.0 (lifetime)
Revak, 1989 n=71	cross sectional survey	IV	university students	QA	31	68	none given	none	42.0 (lifetime)
Roach et al, 1994 n=249	cross sectional survey	III-3	university students	QA	100	60	23.0 average	musculoskeletal joint pain	67.0 (4 wk period)

Table 1.3 Prevalence and Incidence of PRMP in adults and NHMRC hierarchy of evidence (continued)

Study	Study Design	NHMRC Score	Population	Data Collection	Response Rate (%)	Gender (%Female)	Age Range (yrs)	Case Definition	Prevalence (%)/ Incidence
Sakai, 1992 n=40	cross sectional survey	IV	student and professional pianists	QA	not stated	90	16-53	hand pain from playing-related overuse	100 (lifetime)
Sakai, 2002 n=200	cross sectional survey	IV	student and professional pianists	QA	not stated	83	18-66	hand pain from playing-related overuse	100 (lifetime)
Semmler, 1998 n=29	cross sectional survey postal	IV	harpists American	QA	45	not requested	10-75	pain from playing/moving the harp	100 (lifetime)
Shields and Dockrell, 2000 n=159	cross sectional survey	IV	university students	QA	87	80	17-58	playing-related problem and inability to play for > 48 hours	25.8 (lifetime)
Spahn et al, 2002 n=197	cross sectional survey	IV	conservatory students German	QA	36	59	18-32	playing-related health problems	22.0 (physical, lifetime)
Steinmetz et al, 2006 n=31	cross sectional survey	IV	university students (violinists)	QA, PE, EMG		65	16-58	craniomandibular dysfunction/pain	74.0 (point)
Van Reeth et al, 1992 n=44	cross sectional survey	IV	university students and professionals	QA	3	55	16-76	at least one symptom	59.0 (lifetime)

Table 1.3 Prevalence and Incidence of PRMP in adults and NHMRC hierarchy of evidence (continued)

Study	Study Design	NHMRC Score	Population	Data Collection	Response Rate (%)	Gender (%Female)	Age Range (yrs)	Case Definition	Prevalence (%)/ Incidence
Wahlstrom Edling and Fjellman-Wiklund, 2009 n=47	cross sectional	IV	Swedish music teachers	QA	77	60	28-67	musculoskeletal discomfort	77.0 (12 month period)
Warrington et al, 2002 n=140	retrospective 1995-2001	III-2	professionals and amateurs	medical notes	not applicable	56	<25–40+	non-specific pain	24.0 (point)
Yee et al, 2002 n=33	survey video analysis	IV	university students	QA	not stated	100	21.2 average	musculoskeletal symptoms'	91.0 (lifetime)
Yeung et al, 1999 n=39	cross sectional survey	IV	professionals Hong Kong	QA	23	23	26.3 average	playing-related musculoskeletal complaints	64.1 (12 month period)
Zaza and Farewell, 1997 n=110	case control	III-3	professional and university students	QA	67	66	28.7 average	PRMD	39.0 (point)
Zaza, 1992 n=300	cross sectional survey	IV	university instrumental students Canadian	QA	100	49	16-47	playing-related injury that stopped playing for > 1week	43.0 (point)
Zetterberg et al, 1998 n=227	cross sectional survey	IV	university students Swedish	QA	75	51	23.5 average	general pain complaints (Nordic MSK Questionnaire)	89.0 (12 month period)

Table 1.4 Associated factors for PRMP grouped according to intrinsic, extrinsic and interaction factors.

Estimates are expressed where possible as an odds ratio (95%CI) where an OR >1 refers to a positive association with PRMP and OR<1 refers to a negative association. For other statistical tests, a significant p-value (p<0.05) refers to the factor being the greater among musicians with PRMP

Table 1.4 Associated factors for PRMP grouped according to intrinsic, extrinsic and interaction factors (continued)

FACTOR	**Study Design**	**NHMRC Level**	**Association Estimate**	**Direction of Association**
Intrinsic Physical	**Gender (Female)**			
Adults				
Manchester and Lustik, 1989	prospective cohort	II	chi square, p<0.05	↑
Cayea and Manchester, 1998	retrospective cohort	III-2	chi square, p<0.001	↑
Zaza and Farewell, 1997	case control	III-3	OR 2.8 (1.1-7.5) p=0.034	↑
Kaneko et al, 2005	cross sectional survey	IV	chi square, p<0.001	↑
Zaza 1992	cross sectional survey	IV	OR 1.98 (1.0-3.8), p=0.03	↑
Fishbein et al 1989	cross sectional survey	IV	chi square, p<0.05	↑
Pak and Chesky, 2001	cross sectional survey	IV	chi square, p=0.001	↑
Zetterberg et al, 1998	cross sectional survey	IV	chi square, p<0.01	↑
Spahn et al, 2002	cross sectional survey	IV	statistic unreported, p=0.045	↑
Caldron et al, 1986	cross sectional survey	IV	Fisher's exact test, p=0.002	↑

Table 1.4 Associated factors for PRMP grouped according to intrinsic, extrinsic and interaction factors (continued)

FACTOR	Study Design	NHMRC Level	Association Estimate	Direction of Association
Intrinsic Physical (cont)	**Gender**			
Children				
Lockwood, 1988	cross sectional survey	IV	chi square, p<0.04,	↑
Intrinsic Physical (cont)	**Age**			
Adults				
Zaza, 1995	case control	III-3	OR 0.9, no p value reported	↑
Pak and Chesky, 2001	cross sectional survey	IV	chi square, p=0.003	↓
Children				
Bruno, 2008	cross sectional survey	IV	OR 2.2 (1.02-5.69) p=0.04	↑
Dawson, 2002	retrospective cohort	III-2	statistic unreported, no p value reported	↑
Intrinsic Physical (cont)	**Hypermobility**			
Adults				
Zaza and Farewell, 1997	case control	III-3	OR 0.31 (0.10-0.9) p=0.032	↓
Larsson et al, 1993	cross sectional survey	IV	chi square, p=0.001	↓
			chi square, p<0.001	↑

Table 1.4 Associated factors for PRMP grouped according to intrinsic, extrinsic and interaction factors (continued)

FACTOR	Study Design	NHMRC Level	Association Estimate	Direction of Association
Intrinsic Physical (cont)	**Hand Span**			
Adults				
Yoshimura et al, 2006	cross sectional survey	IV	chi square, p<0.001	↑, small right 3-4 span
Intrinsic Physical (cont)	**Arm Length**			
Adults				
Ackermann and Rogers, 2003	cross sectional survey	IV	chi square, p=0.005	↑, decreased right arm length,
Intrinsic Physical (cont)	**BMI**			
Adults				
Zaza and Farewell, 1997	case control	III-3	OR 1.2 (1.05-1.4), p=0.009	↑
Intrinsic Physical (cont)	**Other soreness experiences: Previous PRMP**			
Adults				
Zaza and Farewell 1997	case control	III-3	OR 2.5 (1.02-6.2) p=0.042	↑
Intrinsic Physical (cont)	**Other soreness experiences: Number of PRMP locations**			
Adults				
Kaneko et al, 2005	cross sectional survey	IV	chi square, p<0.001	↑
Miller et al, 2002	cross sectional survey	IV	chi square, p<0.01	↑

Table 1.4 Associated factors for PRMP grouped according to intrinsic, extrinsic and interaction factors (continued)

FACTOR	Study Design	NHMRC Level	Association Estimate	Direction of Association
Intrinsic Physical (cont)	**Other soreness experiences: Non-music activity related soreness**			
Adults				
Pfalzer and Walker, 2001	cross sectional survey	IV	chi square, p=0.012	↑
Miller et al, 2002	cross sectional survey	IV	chi square, p=0.04	↑
Intrinsic Physical (cont)	**General health problems**			
Fishbein et al, 1988	cross sectional survey	IV	chi square, no p value reported	↑
Intrinsic Psychosocial	**Performance Anxiety**			
Adults				
Zaza and Farewell, 1997	case control	III-3	OR 1.03 (1.0-1.1), p=0.05	↑, trait anxiety
Kaneko et al, 2005	cross sectional survey	IV	chi square, p<0.001	↑, ‘feel anxious’
Furuya et al, 2006	cross sectional survey	IV	chi square, p=0.035	↑, ‘stage fright’
Fjellman -Wiklund 2003	cross sectional survey	IV	OR 6.0 (1.1-32.4), no p value reported	↑, high psychological demand
Extrinsic Music Related - Instrument	**Instrument Type**			
Adults				
Zaza and Farewell, 1997	case control	III-3	OR 4.7 (1.5-14.5), p=0.007	↑, string vs. non-string
Manchester and Fleider,1991	retrospective cohort	III-2	chi square, no p value reported	↑, string and keyboard

Table 1.4 Associated factors for PRMP grouped according to intrinsic, extrinsic and interaction factors (continued)

FACTOR	Study Design	NHMRC Level	Association Estimate	Direction of Association
Cayea and Manchester, 1998	retrospective cohort	III-2	chi square, $p<0.001$, $p<0.01$, $p<0.05$	↑, piano > plucked string > bowed string,
Fishbein et al, 1988	cross sectional survey	IV	chi square, no p value reported	↑, strings vs. all other instrument groups,
Fjellman -Wiklund 2003	cross sectional survey	IV	chi square, no p value reported	↑, string vs. non-string
Davies and Mangion, 2002	cross sectional survey	IV	multivariate regression, $p<0.001$	↑, string vs. non-string
Children				
Burkholder and Brandfonbrener, 2004	retrospective cohort	III-2	chi square, $p<0.005$	↑, violin vs. other bowed string,
Lockwood, 1988	cross sectional survey	IV	chi square, $p<0.010$	↑, large strings vs. small strings,
Extrinsic Music Related - Instrument (cont)	**Number of Instruments Played**			
No studies				
Extrinsic Music Related – Music Practice (cont)	**Number of Years Playing Any/Main Instrument**			
Adults				
Zaza and Farewell, 1997	case control	III-3	OR 0.95 (0.91-0.98), $p=0.010$	↓
Yeung et al, 1999	cross sectional survey	IV	OR 0.75 (0.6-1.0), $p=0.018$	↓
Roset Llobet et al, 2000	cross sectional survey	IV	OR 1.76, no p-value reported	↑
Davies and Mangion, 2002	cross sectional survey	IV	multivariate regression, $p<0.001$	↓

Table 1.4 Associated factors for PRMP grouped according to intrinsic, extrinsic and interaction factors (continued)

FACTOR	Study Design	NHMRC Level	Association Estimate	Direction of Association
Extrinsic Music Related – Music Practice (cont)	**Playing/Practice Time**			
Adults				
Roset Llobet et al, 2000	cross sectional survey	IV	OR 1.14, no p value reported	↑
Hiner et al, 1987	cross sectional survey	IV	Fisher's exact test, p<0.04	↑
Extrinsic Music Related – Music Practice (cont)	**Frequency of Practice**			
No studies				
Extrinsic Music Related – Music Practice (cont)	**Duration of Practice**			
Adults				
Furuya et al, 2006	cross sectional survey	IV	chi square, no p value reported	↑
Children				
Fry and Rowley, 1989	case control	III-3	chi square, no p value reported	↑
Extrinsic Music Related – Music Practice (cont)	**Practice Dose (Frequency x Duration**			
No studies				
Extrinsic Music Related – Music Practice (cont)	**Pattern of Practice - increase**			
Adults				
Zetterberg et al, 1998	cross sectional survey	IV	chi square, p<0.02	↑

Table 1.4 Associated factors for PRMP grouped according to intrinsic, extrinsic and interaction factors (continued)

FACTOR	Study Design	NHMRC Level	Association Estimate	Direction of Association
Manchester and Fleider,1991	retrospective cohort	III-2	chi square, no p value reported	↑
Children				
Fry and Rowley, 1989	case control	III-3	chi square, no p value reported	↑
Extrinsic Music Related – Music Practice (cont)	**Taking Breaks**			
No studies				
Extrinsic Music Related – Music Practice (cont)	**Playing without a break**			
Children				
Bruno et al, 2008	cross sectional survey	IV	chi square, no p value reported	↑, >60 minutes
Lockwood, 1988	cross sectional survey	IV	chi square, no p value reported	↑, 'uninterrupted practice'
Extrinsic Music Related – Music Practice (cont)	**Repertoire Difficulty/Change**			
Adults				
Bragge et al, 2006	semi-structured interviews	Qualitative	Not applicable	↑
Extrinsic Music Related – Music Practice (cont)	**Warm Up**			
Adults				
Zaza and Farewell, 1997	case control	III-3	OR 0.37 (0.15-0.91), p=0.030	↓

Table 1.4 Associated factors for PRMP grouped according to intrinsic, extrinsic and interaction factors (continued)

FACTOR	Study Design	NHMRC Level	Association Estimate	Direction of Association
Extrinsic Music Related – Music Practice (cont)	**Cool Down**			
Zaza and Farewell, 1997	case control	III-3	multivariate regression	nil
Extrinsic Non-Music Related	**Watching TV/Videos**			
No Studies				
Extrinsic Non-Music Related (cont)	**Physical Activity**			
Adults				
Roach et al, 1994	cross sectional survey	IV	chi square, no p value reported	↓
Children				
Bruno et al, 2008	cross sectional survey	IV	OR 2.5 (1.3-4.6), p=0.004	↑
Shoup, 1995	cross sectional survey	IV	chi square, no p value reported	nil
Extrinsic Non-Music Related (cont)	**Computer Use**			
No Studies				
Extrinsic Non-Music Related (cont)	**Writing**			
No Studies				
Extrinsic Non-Music Related (cont)	**Electronic Game Use**			
No Studies				

Table 1.4 Associated factors for PRMP grouped according to intrinsic, extrinsic and interaction factors (continued)

FACTOR	Study Design	NHMRC Level	Association Estimate	Direction of Association
Extrinsic Non-Music Related (cont)	**Hand Intensive Activities**			
No Studies				
Interaction Factors	**Teacher**			
Adults				
Bragge et al, 2006	semi-structured interviews	Qualitative	not applicable	↑, teacher expectations
Interaction Factor (cont)	**Technique**			
Adults				
Bragge et al, 2006	semi-structured interviews	Qualitative	not applicable	↑, poor technique
Interaction Factor (cont)	**Posture**			
Adults				
Wahlstrom Edling and Fjellman-Wiklund, 2009	cross sectional survey	IV	chi square, p=0.042	↑, asymmetric posture

CHAPTER 2 METHODS

2.1 DESIGN

A cross-sectional study design combined a questionnaire and anthropometric measures survey to collect data from a large sample of child instrumentalists to address the thesis aims of determining the prevalence and correlates with PRMP in young instrumentalists. Data was collected from August to December 2003.

2.1.1 Sample

731 students (460 females) aged between 7 and 17 years (mean 12.7 yrs, standard deviation (sd) 2.0yrs) participating in the School of Instrumental Music program across government schools in Perth, Western Australia, were surveyed. The School of Instrumental Music (SIM) is the government authority coordinating instrumental music instruction in Western Australian government schools.

2.1.2 Recruitment

Students learning instrumental music were recruited from 11 schools (five secondary schools, five primary schools and a special piano program school) within the Perth metropolitan area. Schools were selected in consultation with the manager of the SIM to be representative based on the criteria and the process outlined in Figure 2.1.

2.1.2.1 Government Schools.

The SIM provides music instruction for orchestral and band instruments to 120 (from a total of 327) primary and 45 (from 74) secondary government schools in Western Australia (WA). Instrumental instruction in WA primary schools is commenced in Year 3 (equivalent of the child turning 8 or 9 years of age) and continues to Year 12 (age equivalent of 17 or 18 years of age and when students leave school). The SIM recommends instrumental tuition for specific instruments are commenced at a psychosocially and physically appropriate age. For example, of the string (bowed) instruments, the violin is the first introduced in Year 3, the viola may be commenced in Year 4 (equivalent of child turning 9 or 10 years of age) with the cello in Year 5 (equivalent of child turning 10 or 11 years of age) and bass in Year 6 (child turning 11 or 12).

The clarinet is the first wind instrument introduced, in Year 4, followed by the flute in Year 5. The guitar is taught from Year 5. The piano is introduced in Year 4 or 5. Children however may have commenced playing an instrument at a younger age with private instruction outside of school. Non-government schools coordinate music programs differently from government schools and differently from one another and were not included in this study.

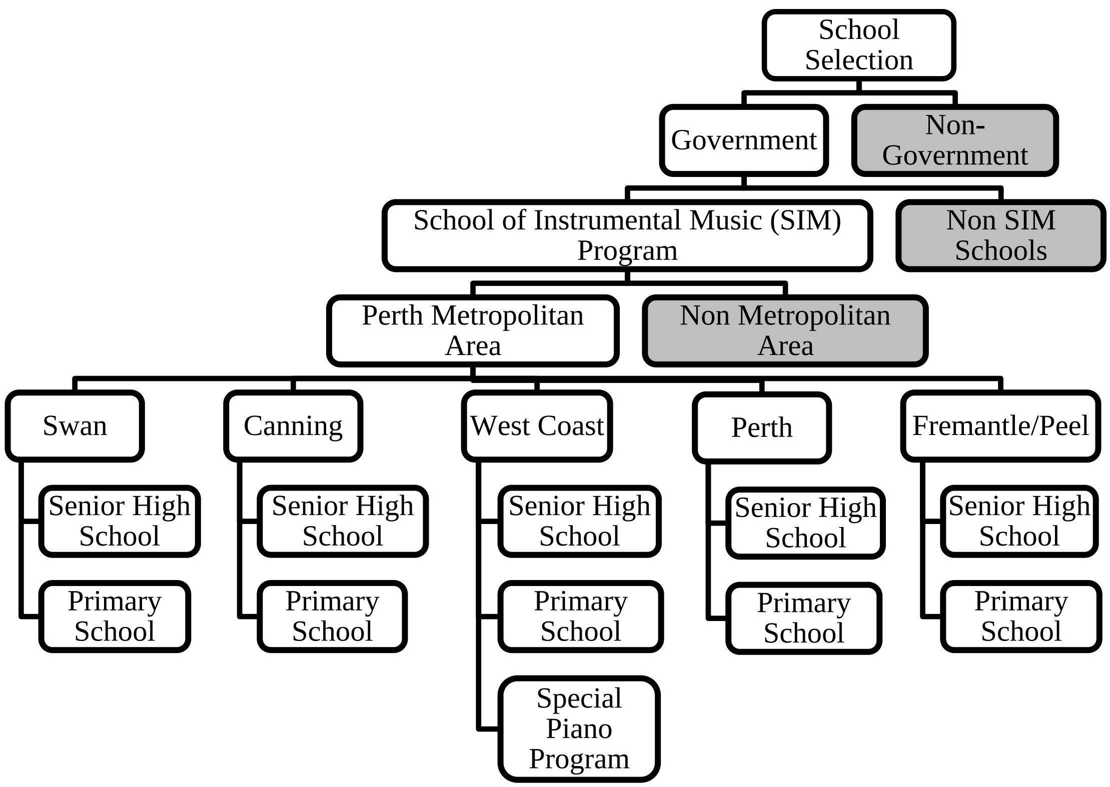

Figure 2.1 School Selection Process

2.1.2.2 Schools from the Perth Metropolitan Area.

Schools within the metropolitan area (versus regional/country Western Australia) were chosen to facilitate data collection.

2.1.2.3 Schools with an established music program,

Schools with an established SIM program and that taught a comprehensive range of instruments with reasonable numbers of instrumentalists were considered. Two government secondary schools provide specialised music programs to the state's most talented instrumentalists. These schools and three other government secondary schools were selected to best represent a large range of instruments and calibre of instrumentalists.

2.1.2.4 Schools from different socioeconomic areas,

Schools were selected from each metropolitan geographical district (Divisions of the Department of Education and Training; West Coast, Fremantle-Peel, Canning, and Swan) to ensure that students from a range socioeconomic areas were represented. Table 2.1 summarises the schools and students for each district.

Table 2.1 Number of schools and students within School Districts

District	**Number Primary Schools**	**Number Secondary Schools**	**Number Primary Students**	**Number Secondary Students**
Canning	57	13	16,287	8,442
Swan	90	20	23,354	14,385
Fremantle/Peel	93	21	28,131	19,011
West Coast	87	20	23,879	15,110
Total	327	74	91,651	56,948

2.1.2.5 Secondary schools and primary schools

Secondary schools, commonly referred to as senior high schools, with the greatest number of students learning instrumental music were selected from each district. The corresponding primary schools which feed into these secondary schools were then selected.

Due to Tertiary Entrance Examinations conducted in fourth term, it was agreed that Year 12 students would not be surveyed.

2.1.2.6 Special school for young piano players

Piano instruction is dealt with differently in the government school's SIM music program. Due to the large area required to accommodate several pianos, piano tuition was concentrated at two primary schools (one in the western suburbs and one in the eastern suburbs) and children from local schools attended for instruction. The school with this special piano program and the greatest number of students was included to ensure a sample of young children learning piano. Many students who play piano do so by private tuition (Whitehead 2002). Students that play piano outside of school have the opportunity through the SIM program to learn another instrument, therefore, the schools selected included students that play the piano but without SIM instruction.

All schools approached, except one, Applecross Senior High School, agreed to participate. Involvement in several other projects at the time was given as their inability to commit to this project. The number of students surveyed at another school within the same district were sufficiently high and therefore another school was not chosen to replace it.

2.1.2.7 Students

6,528 students attended the selected secondary schools and 1,695 attended the selected primary schools. The enrolments at these schools represented 11.5% (6,528/56,948) and 2% (1,695/91,651) respectively of the Perth metropolitan secondary and primary school enrolment. The selected schools represented a higher proportion of students involved in the SIM program in the Perth metropolitan area – 34% (936/6,528) at secondary and 20% (338/1,695) at primary.

Table 2.2 reports the number of children attending the selected schools and numbers of students enrolled in the music program. Tables 2.3 and 2.4 compare the number of students by year for the selected primary and secondary schools respectively.

2.1.2.8 Classes sampled

All instrumental classes at the selected schools were sampled. The non-music students continued to participate in routine class schedules. In the secondary schools surveyed, 201 students were sitting exams, 41 students requested to be excluded from the study and due to the large numbers, absentees were difficult to account for. In primary schools there were 21 students not available to participate in the survey due to necessary school commitments, 8 were absent and 24 requested exclusion from the study.

Table 2.2 Number of students in school and enrolled in the School of Instrumental Music Program

School	District	Total number of students	Number in music program	Number of students participated in survey	Number completed surveys (Response Rate)
Secondary					
Churchlands	West Coast	1324	261 (20%)	17	110 (64%)
Perth Modern	West Coast *	934	245 (26%)	181	169 (93%)
Kelmscott	Canning	1461	101 (7%)	70	68 (97%)
Mt Lawley	Swan	1186	103 (9%)	69	60 (87%)
Rossmoyne	Fremantle/Peel	1623	226 (14%)	167	152 (91%)
Primary					
Churchlands	West Coast	222	60 (27%)	39	39 (100%)
Mt Hawthorn	West Coast *	365	65 (18%)	42	33 (86%)
Kelmscott	Canning	311	52 (17%)	46	46 (100%)
Mt Lawley	Swan	330	70 (21%)	30	21 (67%)
Rossmoyne	Fremantle/Peel	467	71 (15%)	23	13 (56%)
Piano School (Doubleview)	West Coast	-	20 (n/a)	20	20 (100%)

*Formerly Perth District

Table 2.3 Number of primary school music students by year for participating schools

	Year					
School	**3**	**4**	**5**	**6**	**7**	**Total**
Churchlands PS	6	7	6	13	7	39
Mt Hawthorn PS	3	3	1	17	9	33
Kelmscott PS	9	9	6	17	5	46
Mt Lawley PS	2	4	8	2	5	21
Rossmoyne PS	2	3	1	3	4	13
Doubleview	-	4	5	9	2	20
Total	22	30	27	61	32	172

Table 2.4 Number of secondary school music students by year for participating schools

	Year				
School	**8**	**9**	**10**	**11**	**Total**
Churchlands SHS	34	24	23	29	110
Perth Modern SHS	57	52	30	30	169
Kelmscott SHS	29	20	14	5	68
Mt Lawley SHS	28	25	-	7	60
Rossmoyne SHS	75	48	29	-	152
Total	223	169	96	71	559

2.2 DATA COLLECTION

2.2.1 The Questionnaire Survey

The Young People's Activity Questionnaire (YAQ) (Harris and Straker 2000) was adopted for this study and modified with the addition of music specific questions. The music specific questions in the questionnaire were developed based on the aims of the study and included questions identified as those used in previous music research (such as number of years playing music). The survey was piloted with children of various ages (7, 9, 13 and 15) prior to the study commencement to assess question suitability and understanding, questionnaire organization and time taken to complete the survey. The final version, YAQ-m (Appendix VII) was developed following several iterations to address changes in the flow of questions and reword questions appropriately for younger children (e.g. "practice every day" as opposed to "practice daily").

*2.2.1.1 **Playing-Related Musculoskeletal Problems (PRMP)***

The main focus of the survey was the experience of playing-related musculoskeletal problems, both PRMS and PRMD. As mentioned in the introduction, these definitions were developed by musicians (Zaza, 1995) and have been used more consistently in recent music research. Specifically, the experience of PRMS ever, that is, at any point during their playing career, and the experience of PRMS within the past month. The frequency of symptoms in the past month was categorized into monthly, weekly, two to three times weekly and daily. The children who reported PRMS in the last month were directed to a question regarding the experience of a PRMD (symptoms sufficient to prevent them playing their instrument as usual) and subsequent questions pertaining to health service utilisation and the use of medication. Children experiencing a PRMS in the last month also reported the location of their symptoms on a body diagram (neck, mid back, low back, left and right upper and lower limbs, face) and rated the severity of symptoms using a Visual Analogue Scale with the anchors 0, no soreness, and 10, extreme soreness, for the respective location. The number of pain locations was also tallied.

2.2.1.2 Intrinsic risk factors

2.2.1.2.1 Individual Physical

Questions related to the participant's individual characteristics such as gender, date of birth and age, hand dominance and Year level at school were included in the questionnaire. Age in continuous years at the time of questionnaire completion was calculated using individual's date of birth.

Physical attributes (anthropometric measures) such as height, weight and hand span were included in the survey and a wall based tape measure was used to measure height and a digital scale used to measure weight. These measures were recorded by the investigator at the time of survey completion. Hypermobility was not assessed by physical examination due to time constraints. Students instead were asked questions relating to their ability to perform “tricks” with their joints e.g. touch thumb to your forearm, and whether they feel their joints “often feel like they need to click”.

2.2.1.2.2 Individual Psychological

Questions related to the individual’s characteristics such as the experience of anxiety, specifically music performance anxiety, and the experience of enjoyment playing music (“how much do you usually enjoy playing music?” don’t enjoy it, enjoy it a little, enjoy it, enjoy it very much, love it) were included. At the time this study was conducted, there was no self-reported measure of music performance anxiety for children or adolescent musicians in the literature, and therefore the questionnaire asked about the reported experience of butterflies in the stomach before an exam/competition (never, almost never, sometimes, most times, always).While a crude measure, the experience of butterflies is considered a physiological, somatic symptom of anxiety in children. The Music Performance Anxiety Inventory for Adolescents (MPAI-A), a 15 item scale designed to assess the somatic, cognitive and behavioural components of music performance anxiety was subsequently developed and validated (Kenny et al. 2004; Osborne et al. 2005). The first of three questions on the somatic component asks “before I perform I get butterflies in my stomach”, and supports the use of this question in this thesis.

2.2.1.3 Extrinsic Factors-Music specific questions

2.2.1.3.1 Music Experience

Music specific questions covered music experience, such as type of instrument played as main, second and third; number of instruments played (one, two or three), age commenced playing any and main instrument, years spent playing any and main instruments, and the time spent playing during past week (student playing diaries recorded type of playing, practice, rehearsals, recitals, duration and frequency over the day, before, at or after school). The playing times, before school, at school and after school, were entered as minutes and calculated as total playing hours per week.

2.2.1.3.2 Music Practice

Questions related to music practice included frequency of practice in the past month (monthly, once a week, 2-5 times a week, daily); the duration of practice in the last month

(30 minutes or less, 30-60 minutes, 1-2 hours, 2-5 hrs, greater than 5 hrs); longest time played without a break (30 minutes or less, 30-60 minutes, 1-2 hours, 2-5 hrs, greater than 5 hrs); how often breaks were taken, performed warm up, performed cool down (never, almost never, usually, most times, all the time); how students practiced more than usual (didn't, practice more often, practice for longer, practice more often and for longer); and difficulty of repertoire played within the last month (less difficult, about usual, more difficult). These music specific questions were included in this study as they were investigated in some adult and child music research studies with some reported positive associations with PRMP outcomes (see Table 1.4).

2.2.1.4 Extrinsic non-music factors

2.2.1.4.1 Musculoskeletal Symptoms

Problems specific to the musculoskeletal system (muscles bones and joints) were measured by self-report questions related to the experience of "any soreness anywhere". Children reported the location of their symptoms on a body diagram (neck, mid back, low back, left and right upper and lower limbs, face) and rated the severity of symptoms for each location (visual analog scale, 0, no soreness, to 10, extreme soreness). Students were also asked their opinion as to the cause of the soreness.

2.2.1.4.2 Activity Participation Frequency and Duration-Exposure

The remaining questions in the YAQ-m, common to all YAQ versions, included information regarding participation frequency (not at all, monthly, weekly, 2-3xweekly, daily) and duration (usual and longest) (<30 mins, 0-60 mins, 1-2 hours, 2- 5 hours, >5hours): watching television, hand writing, electronic game use, computer use, hand intensive activities such as art, and vigorous physical activities. These activities were categorised as non-music related activities in this thesis.

Data collected using these questions have identified exposure patterns, as measured by frequency and duration, in laptop computer users are associated with reported discomfort in children/adolescents (Harris and Straker 2000). A study examined data collected from the YAQ and data from timed diaries, and showed evidence for the validity of data collected based on self-reported patterns of exposure from a survey (Ciccarelli 2008).

2.2.1.4.3 Non-music activity related soreness experience

A question regarding the experience of soreness from participation in these activities was included to establish the relationship between this variable and the experience of PRMP. Evidence in the pain research suggests the experience of pain at other musculoskeletal sites was associated with the subsequent occurrence of LBP in adults (Papageorgiou et al. 1996; Mikkelsson et al. 1999) and the reported experience of ‘other’ musculoskeletal pains a risk factor for the occurrence and persistence of neck pain in children (Stahl et al. 2008).

2.3 SURVEY PROCEDURES

2.3.1 Protocol

The selected schools were approached by the investigator with the support of the School of Instrumental Music, and invited to participate in the survey.

The investigator discussed the project with each school principal. A detailed protocol for each school was agreed. This usually involved a standardised introduction of the project to the school and a standardised data collection protocol (Table 2.5).

The introduction of the project to the school involved: a brief description of the study in the school newsletter (Appendix Va); posting a letter to the parents of children in selected classes which included a description of the study (Appendix Vb) and a form to request their child be excluded from the study (Appendix Vc) with a reply paid envelope; meeting with the school music teachers (at the school) to outline the project and to schedule classes to be surveyed.

The standardised data collection usually involved: data collection in the fourth term of the school year in 2003, the investigator attended scheduled music lessons and distributed the questionnaires for completion during the class. The teacher was present and the investigator available for clarification. The investigator measured and recorded student weight and height following questionnaire completion (students completed questionnaires at different times).

Agreed protocols were varied in six schools due to intervening circumstances (Table 2.6). Government school teachers participated in industrial action on two occasions which impacted on instrumental teaching schedules and thus, students in two schools were not able to be surveyed during scheduled class times and surveys were sent home to parents or given to students to complete at home.

For the very young students, parents were able to assist in class with the completion of the questionnaire. Questionnaires took approximately 20 minutes to complete. The first author was present to answer queries.

Detailed Protocols for Secondary Schools

Churchlands Senior High School was surveyed in third term (September). Two hundred and sixty one students were enrolled in the music program with 79 students undertaking exams, leaving 182 students eligible for participation and ten students requested to be excluded from the study. Due to concert rehearsal and competitions during class time, the students were given the questionnaires to complete and return. Of the remaining 172 students surveyed, 110 students completed and returned the questionnaire (64% response rate).

Perth Modern Senior High School was surveyed in fourth term (October). Two hundred and forty five students were enrolled in the music program with 59 students undertaking exams. Five students requested to be excluded from the study. One hundred and eighty one students were surveyed during class time by the investigator and 169 surveys were completed appropriately (93%).

Mt Lawley Senior High School was surveyed in fourth term (October). 103 students were enrolled in the program with 8 students undertaking exams. Six students requested to be excluded from the study and 20 year ten students were not available to be surveyed as they were participating in career events. A total 69 students were surveyed by the investigator and 60 surveys completed (87%).

Kelmscott Senior High School was surveyed in fourth term (October). Of the 101 students enrolled in the program with 11 students who were undertaking exams, the school gave permission for 75 students to be surveyed. Five students requested to be excluded from the study. A total 70 students were surveyed by the investigator during class time and 68 surveys completed appropriately (97%).

Rossmoyne Senior High School was surveyed towards the end of fourth term (November) (to accommodate a teacher on work experience from abroad). 226 students were enrolled in the music program with 44 year eleven and twelve students undertaking exams. Fifteen students requested to be excluded from the study. One hundred and sixty seven students were surveyed during class time by the investigator and 152 surveys completed appropriately (91%).

Detailed Protocols for Primary Schools

Churchlands Primary School requested specifically that students be included in the study by means of active consent. This involved parents signing a written consent form (Appendix IId) granting permission for their child to participate in the research. There were 60 students enrolled in the music program, 5 requested to be excluded from the study and consent to complete the survey was received for 39 students. Data collection was in third term (August) and the 39 students completed the questionnaire (65% response rate 39/60 or 71% if include those requested to be excluded, 39/55).

Kelmscott Primary school was surveyed in fourth term (December). Fifty two students were enrolled in the music program. No students requested exclusion from the study. Forty six students (88%) were surveyed and completed the surveys. The remaining 8 students were absent on the days the survey was conducted.

Mt Hawthorn Primary school was surveyed in fourth term (December). Three students chose to be excluded from the study. From the remaining 65 students, 21 Year seven students were absent due to orientation to secondary schools (1 requested to be excluded) on their scheduled survey day. Forty two were surveyed, of which 33 completed the survey (86% response rate).

Mt Lawley Primary School was surveyed in fourth term (November). Seventy students were enrolled in the music program. The study was conducted by mail out due to industrial action. Thirty students responded (43% response rate), 9 requested to be excluded from the study, and 21 surveys were completed.

Rossmoyne Primary school was surveyed in fourth term (December). Seventy one students were enrolled in the music program. Due to industrial action, the study was conducted by mail out with 23 surveys returned (32%). Seven requested to be excluded from the study, 13 were included in the study and three questionnaires were received months after data entry had been completed.

Table 2.5 Summary of Study Protocol

Protocol Summary	
School Consent	Letter to principals and scheduled meetings for consent to participate and agreement of study protocol
Study/Parent Information	Sent to parents by the school on behalf of investigator
Parent Consent	Passive consent – to sign “form to Exclude” and return in stamped self-addressed envelope
Data collection	Fourth term of the school year October-December
Time and Venue	During scheduled instrumental music classes at respective schools (non-music students participated in routine class schedule)
Method	
Questionnaire (QA)	Introduction by investigator, delivered in person and collected at time of completion in class
Physical measures	Height and weight measured by investigator during questionnaire completion

Table 2.6 Modifications to Study Protocol

Summary Protocol Modifications for Schools	
Churchlands SHS	Data collection in third term
	QA sent home due to scheduled concert performances
Churchlands PS	Active consent for participation in study
	Several year seven students absent due to orientation commitments
Mt Lawley SHS	Several year ten students unavailable for participation due to career events.
Mt Lawley PS	QA sent home due to industrial action and interruption in music lessons-returned in stamped self-addressed envelope
Rossmoyne PS	QA sent home due to industrial action and interruption in music lessons-returned in stamped self-addressed envelope

2.4 ETHICAL CONSIDERATIONS

This study was approved by the Curtin University Human Research Ethics Committee (HR 234/2002) (Appendix III).

2.4.1 Consent

Written consent was gained from principals of all schools. Participants and their parents/guardians were provided with information sheets explaining the aims of the study (Appendix Va). Voluntary participation was emphasized and confidentiality and privacy were assured at all times. This study used passive consent for participation, and therefore parents not amenable to their child participating in the study were requested to complete a form declaring intent to withdraw from the study (Appendix Vc). One primary school required signed/active consent forms from parents (Table 2.6) (Appendix Vd).

2.4.2 Data Storage

All questionnaires collected were coded and additional documentation containing participant details stored in secured filing cabinets within the School of Physiotherapy, Curtin University to ensure confidentiality of study participants. Data transferred onto university computers were saved to the hard drive with appropriate back up. The computer systems at Curtin University have software installed to ensure confidentiality.

2.5 DATA ANALYSIS

Descriptive statistics were used to describe the sample characteristics and report the prevalence rates of Playing-Related Musculoskeletal Problems (PRMP), both PRMS and PRMD. The prevalence rates were calculated as a percentage of the whole sample. Chi square analysis was used to examine differences between males and females for categorical variables and examine relationships between categorical covariates and PRMP. ANOVA was used to examine gender differences for continuous variables. Bivariate Pearson correlation analysis examined the relationship between age and continuous variables (e.g. music experience: years playing any and main instrument). Age was parameterized as categorical rather than continuous when exploratory plots indicated a nonlinear relationship with outcome. Instruments were grouped into categories when evaluating the association between instrument class (upper, lower and plucked strings, woodwind, brass, percussion and piano) and PRMP.

Univariable logistic regressions were performed to estimate the unadjusted association of each independent variable for PRMP outcome. Multivariable logistic regression were performed to assess the independent association of all variables with PRMP outcomes accounting for age and gender. Analyses were performed using SPSS versions 10-17.

CHAPTER 3 PREVALENCE OF PLAYING–RELATED MUSCULOSKELETAL SYMPTOMS AND DISORDERS IN CHILDREN LEARNING INSTRUMENTAL MUSIC

3.1 ABSTRACT

Musculoskeletal problems related to playing musical instruments have long been identified with adults, but little is known about their development during childhood. What evidence does exist has not adequately considered risk factors, in particular the effects of gender and age. A cross-sectional questionnaire study gathered data from 731 children enrolled in the instrumental music programs of government primary and secondary schools in Perth, Western Australia. This study, the first in a series investigating risk factors, established the prevalence of playing-related musculoskeletal problems (PRMP), both symptoms (PRMS) and disorders (PRMD), and the association with gender and age. 67% of children reported ever experiencing playing-related musculoskeletal symptoms, with 56% reporting symptoms at least monthly. Females were more likely (odds ratio 1.5, $p=0.03$) to experience symptoms and older children were more likely to have ever experienced symptoms ($p<0.001$). 30% reported the experience of a PRMD, being unable to play their instrument as usual. Females (odds ratio 1.5, $p=0.035$) and older children ($p=0.001$) again more likely to report the experience of a PRMD. For children having reported the experience of PRMS within the last month, 5% took medication to relieve the problem and 4% visited a health professional to seek advice for the problem.

3.2 INTRODUCTION

Common contemporary playing-related health problems include hearing loss, skin abrasion, inflammation problems (Polnauer and Marks 1967; Peachey and Matthews 1978; Stern 1979), dental problems (Herman 1974; Gualitieri 1979) and cardiac abnormalities (Tucker et al. 1971).

Playing-related musculoskeletal problems (PRMP), such as tendonitis, tenosynovitis, peripheral neuropathies and focal dystonias, have been reported for professional musicians and tertiary music students. For some individuals, these problems threaten their livelihood or force career changes. Specialized music medicine centres have been established in Europe, North America and more recently in Australia, to assess, prevent and manage these problems in musicians. Given musicians often commence their careers at a very early age, it is important to understand the prevalence and development of these problems in children. It is therefore surprising that relatively few studies have investigated the presence of PRMPs in school-aged children and none have adequately evaluated risk factors for the development of these problems.

3.2.1 Prevalence of PRMP

Reported prevalence figures for playing-related musculoskeletal problems vary from 40% to 60% for professional musicians (Fry 1986a; Zaza 1995), 9% to 90% for tertiary music students (Fry 1987; Zetterberg et al. 1998) and 20% to 70% in primary and secondary school music students (Fry et al. 1988; Lockwood 1988; Birkedahl 1989; Fry and Rowley 1989; Grieco et al. 1989; Shoup 1995; Brown 1997; Betuel and Clairet 1999; Roset-Llobet et al. 2000).

A systematic review of the prevalence of playing-related musculoskeletal problems identified differences in measure (point prevalence versus period prevalence), study method (questionnaire or physical examination) and case definition contributed to the range of prevalence rates reported within and between the groups of musicians, in addition to study limitations including small sample sizes and low response rates (Zaza 1998). The use of clear case definitions, which excluded the mild aches and pains, was the main recommendation from the review.

3.2.2 Case Definition

Zaza (1995) used semi structured interviews to develop an operational definition for PRMPs. Adult musicians (n=30) defined mild aches and pains experienced during and following playing, that may or may not affect performance as playing-related musculoskeletal symptoms (PRMS), and pain, weakness, lack of control, numbness, tingling, or other symptoms that interfered with the ability to play the instrument as usual, as playing-related musculoskeletal disorders (PRMD). Subsequent studies in adult musicians have used these operational definitions to more accurately report prevalence of playing-related musculoskeletal problems (Zaza and Farewell 1997; Yeung et al. 1999; Ackermann 2003; Bragge 2006).

In contrast, Armstrong (1993) developed a conceptual model for the pathogenesis of general work-related musculoskeletal disorders and advocated the use of case criteria that have a high degree of sensitivity at the expense of specificity. He argued that this would enable interventions to be implemented in the early stages of the development of disorders, to prevent deterioration of symptoms and function. Similarly, Amadio (1990) and Brandfonbrener (2000a) advocated the assessment and treatment of symptoms in musicians early to ensure the best outcome. Physiologically, the body's capacity to perceive mild aches and pains serves as a protective function in response to the threat of injury to tissues and necessary adjustments can be made to avoid continued injury (Wall 1996). Thus continued exposure to risk factors may result in more severe pain and associated tissue dysfunction.

It therefore seems appropriate to investigate both milder *symptoms* (PRMS), as these may provide an early warning, and more disabling *disorders* (PRMD) in children instrumentalists. Playing-Related Musculoskeletal *Problems* (PRMP) encompasses both symptoms and disorders.

3.2.3 Prevalence of PRMP in Children

Although a number of authors have discussed the importance of PRMP in children (Fry 1986c; Birkedahl 1989; Brandfonbrener 1991; Havlik and Upton 1992; Smith 1992; Brown 1997; Manchester 1997; Chamagne 1999; Brandfonbrener 2000a) only five studies have examined the prevalence of PRMP specifically in children (Fry et al. 1988; Lockwood 1988; Fry and Rowley 1989; Shoup 1995; Brown 1997) with a further four reporting some child prevalence data (Fry 1986c; Dawson 1988; Betuel and Clairet 1999; Roset-Llobet et al. 2000). Most of the studies on prevalence of PRMP in children had significant limitations including small sample sizes, recruitment biases and lack of clarity with case definitions.

3.2.4 Risk Factors for PRMP

Analogous to general work-related musculoskeletal disorders, the risk factors associated with PRMPs in musicians are likely to be multifactorial and include intrinsic individual factors, extrinsic playing-related factors and factors relating to the interaction of the individual and extrinsic factors.

Potential intrinsic risk factors identified in music literature include gender, age, predisposing musculoskeletal disorders, hypermobility, anthropometry and psychological factors such as anxiety (Caldron et al. 1986; Fry 1987; Dawson 1988; Hartsell and Tata 1990; Pratt et al. 1992; Tubiana and Chamagne 1993; Shoup 1995; Tubiana 1995; Zaza 1995; Ryan 1998; Betuel and Clairet 1999; Tubiana 1999; Brandfonbrener 2000a; Tubiana 2001; Davies and Mangion 2002).

The type of instrument played is a consistently reported extrinsic factor affecting the frequency of PRMPs (Caldron et al. 1986; Fry 1987; Dawson 1988; Hartsell and Tata 1990; Pratt et al. 1992; Tubiana and Chamagne 1993; Tubiana 1995; Zaza 1995; Betuel and Clairet 1999; Tubiana 1999; Brandfonbrener 2000a; Tubiana 2001). Other extrinsic factors such as the practice schedule; intensity of practice, repertoire performed, physical environment and the music teacher, have contributed to the development of PRMPs in adults.

Interaction risk factors include posture and technique and music instruction. The nature and obvious physical attributes of the instrument influence the awkward postures adopted by the musician, which in turn may be dictated by music instruction (Caldron et al. 1986; Fry 1987; Dawson 1988; Hartsell and Tata 1990; Pratt et al. 1992; Tubiana and Chamagne 1993; Tubiana 1995; Zaza 1995; Betuel and Clairet 1999; Tubiana 1999; Tubiana 2001).

Many adult musicians have accumulated interacting risk factors over the years, therefore significant risk factors for PRMP may be more apparent in younger music students (Brandfonbrener 2000a), yet there is little knowledge about the relationship of risk factors for PRMPs in the child instrumentalist. For the purpose of this paper, potential risk factors such as gender and age will be reviewed.

3.2.4.1 Gender and PRMP

3.2.4.1.1 Professional Musicians

Studies of adult musicians found females were more likely to report PRMP compared to males. Zaza (1997) found that females were more than two times at risk of developing a PRMD than males. Fishbein (1988) in their large sample study demonstrated that females were more likely than males to report medical and musculoskeletal problems. Fry(1986a) found that females and males were similar in reporting problems though a later study found that females generally suffered more overuse problems than males (Fry 1986c). Roset-Llobet(2000);Yeung(1999) and Fjellman-Wiklund(1998) also demonstrated similar trends of females reporting more problems than males, however due to small sample numbers and low response rates these results should be interpreted with care.

3.2.4.1.2 Tertiary Music Students

Manchester (1997) found that females were two times as likely to develop a PRMD compared to males. Studies that investigated PRMS reported females experienced symptoms more than males, however is was not clear if this was statistically significant (Fry 1987; Revak 1989; Pratt et al. 1992; Roach et al. 1994; Cayea and Manchester 1998). Zetterberg (1998) and Guptill (2000) used the operational definition, PRMD, and found no difference between females and males. There is no clear consensus in this group of musicians on gender differences in PRMP.

3.2.4.1.3 Primary and Secondary Music Students

Two studies conducted by Fry found a trend that females were more likely to complain of pain with playing than males but this was not significant (Fry et al. 1988; Fry and Rowley 1989). Lockwood (1988) reported females had more problems than males and this difference was significant ($p=0.04$), however, it was not clear whether this was for symptoms or disorders. Shoup (1995) also reported females demonstrated a trend to report pain associated with playing more than males, though there was no mention of significance. Betuel and Clairet (1999) found females had higher prevalence rates of tendonitis than males, however it is unclear whether these findings are statistically significant. Of the two studies that used physical examination, one failed to report any gender effect (Dawson

1988) and the other demonstrated there was no difference between females (15%) and males (16%) (Fry 1986a).

It is unclear whether gender differences exist amongst playing-related musculoskeletal problems amongst children.

3.2.4.2 Age and PRMP

Unlike other professionals, musicians often begin training as early as four or five years of age (Allieu 1995; Nagel 1998). Consequently, the musician's career may span the childhood years of growth and development as well as later life with the associated aging and degeneration. This has clear implications for the child learning instrumental music and the occurrence of PRMS at an early stage, which if not addressed, may develop into a more serious PRMD.

3.2.4.2.1 Professional Musicians

There are conflicting reports about the association of age and PRMP in adult musicians. Generally, studies that used self-report methods demonstrated a decrease in risk of PRMD as the musician aged (Caldron et al. 1986; Fry 1986a; c; Zaza 1995; Warrington et al. 2002). This may be a result of only healthy musicians being able to continue in their career; a survivor bias effect. There is some evidence for a survivor effect as studies have shown degenerative features normally seen with aging, such as osteoarthritis, were evident in young musicians (Bard et al. 1984). This suggests instrument playing exposure is affecting the musculoskeletal system and may be causing musicians to discontinue their careers.

3.2.4.2.2 Tertiary, Secondary and Primary Music Students

Studies in tertiary, secondary and primary music students have reported no association with age. However many of these studies often failed to accurately report musicians' age and took no account of survivor bias as all were cross sectional studies (Fry 1987; Manchester 1988; Revak 1989; Hartsell and Tata 1990; Pratt et al. 1992; Roach et al. 1994; Zetterberg et al. 1998; Guptill et al. 2000). Most studies specified the age range surveyed and this varied from 7 to 25 years, with the majority of children aged 10 and above. Only Fry, (1988; 1989) and Greico (1989) investigated younger children aged between 8-10 years and 8-25 years respectively. A peak lifetime prevalence of 30% was reported in musicians aged 10 to 20 years with subsequent decrease to 24% in 20 to 30 year group, and 20% in the 30 to 40 year group (Fry 1986c). There was no report of prevalence across age groups categorized by Greico (1989).

Some studies categorized students into specific age brackets (Fry 1986c; Dawson 1988; Grieco et al. 1989; Betuel and Clairet 1999; Roset-Llobet et al. 2000; Warrington et al. 2002), however very few reported prevalence rates across each age category. Betuel and Clairet(1999) categorized musicians surveyed into age groups of less than 15 years, 15 to 20 years and over 20 years and found that older musicians had higher prevalence rates of tendonitis, though it is unclear whether these differences were significant. Roset-Llobet(1999) reported an increase in prevalence of playing-related musculoskeletal problems in the 11-20 year old age group with no statistical evidence of significance. A retrospective review of musicians grouped as less than 25 years, 25-40 years and over 40 years, reported a greater number of younger people were identified with non-specific arm hand pain than older groups with no evidence of statistical significance (Warrington et al. 2002). Lockwood(1988) surveyed students aged 14-18 years , however PRMP across age groups was not discussed. Shoup (1995) surveyed junior high and high school students and reported only average ages in each group and Dawson(1988) reported problems in 22% of school musicians aged nine to 18 years.

No conclusion can be made with regards to what age playing-related musculoskeletal problems in the child learning instrumental music predominate. There is a need to identify the association of age with prevalence of playing-related musculoskeletal problems in children learning instrumental music.

In summary, the literature suggests children learning instrumental music may be at risk of developing PRMS and PRMD, however it does not adequately describe the prevalence of these problems nor does it adequately evaluate risk factors such as gender and age.

3.3 STUDY AIMS

This present study surveyed school aged children learning instrumental music to:

1. Establish prevalence of playing-related musculoskeletal symptoms (PRMS) and disorders (PRMD), and examine differences between males and females,
2. Evaluate whether the prevalence of PRMS and PRMD changes with age, allowing for gender
3. For those children who reported the experience of PRMS within the last month, evaluate the frequency of symptoms and examine differences between males and females and across ages
4. For those children with a PRMD, evaluate how many took medication and sought professional health care and examine differences between males and females.

3.4 METHODS

3.4.1 Sample Schools

A cross-sectional questionnaire and anthropometric measures survey was conducted across government schools in Perth from August to December 2003. The process of school selection is outlined in Figure 1. Government schools participating in the School of Instrumental Music (SIM) program were selected. This program provides free instrumental music tuition to students. Secondary (sometimes called 'senior high') schools were selected from each of the 5 school regions within the Perth metropolitan area to cover a range of socio-economic status. Primary (sometimes called 'elementary') schools which were 'feeder' schools for these secondary schools were then selected. Selected schools were approached and requested to participate. The School of Instrumental Music manager also encouraged schools to participate. One high school declined to participate due to their participation in a number of other studies. No replacement school was invited as the other school within the same region had a sufficiently large sample of instrumental students and had already agreed to participate.

3.4.2 Sample Classes

All instrumental classes conducted at the selected schools were sampled. For inclusion into this study, participants needed to be seven years or older and informed consent from participants and their parent or guardian was obtained. There were no exclusion criteria for this study. In the secondary schools surveyed, 201 students were sitting exams and could not complete the survey, 41 students requested to be excluded from the study and, due to the large numbers, absentees were difficult to account for. In primary schools, 21 students were not available to participate in the survey due to competing school commitments, 8 were absent and 24 requested exclusion from the study. 731 students (460 females) aged between 7 and 17 years (mean 12.7 yrs, sd 2.0yrs) completed the survey.

3.4.3 Questionnaire

The Young people's Activity Questionnaire (Harris and Straker 2000) was adopted and modified for this study. The modified version (YAQ-m) included music specific questions and was refined through several iterations of trialing with children and parents. The survey contained general questions regarding the children's age, gender, year at school, hand dominance and general musculoskeletal complaints. The main focus of the survey was the experience of PRMS during their playing career and specifically within the past month. Frequency of symptoms in the past month was categorized into monthly, weekly, two to three times weekly and daily. Those children who experienced symptoms in the last month were directed to a question regarding the experience of a PRMD (symptoms sufficient to prevent them playing their instrument as usual) and questions pertaining to the use of medication and health service utilisation. Children experiencing a PRMS in the last month also reported the location of their symptoms on a body diagram provided and to rate the severity of symptoms using the Visual Analog Scale of 0, no soreness to 10 extreme soreness for the respective location.

Other music specific questions covered music experience and practice habits. The remaining questions, common to all YAQ versions, covered watching television, participation in physical activities, hand intensive activities such as art, hand writing and use of computers. Children completed the questionnaire in class under the supervision of their normal teacher, with the first author also present to answer any queries.

Questionnaires took approximately 20 minutes to complete. With the very young students, parents were often present for the lesson and were able to assist with the completion of the questionnaire.

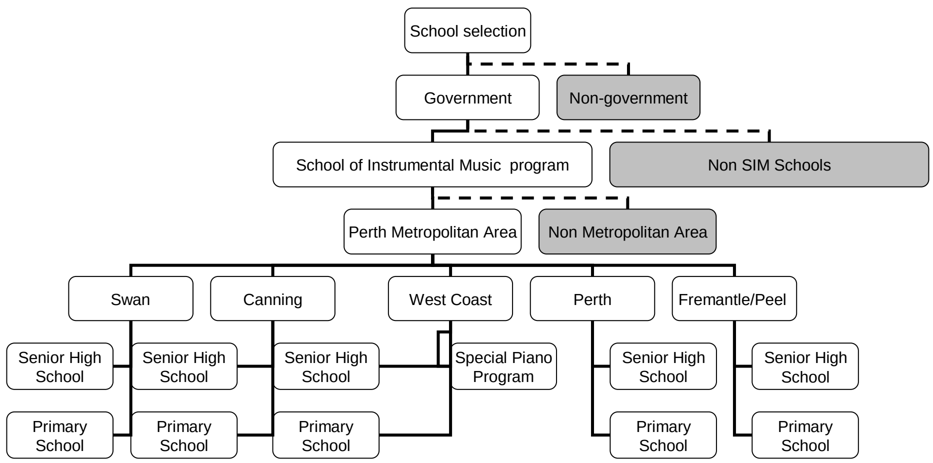

Figure 3.1 Method of School Selection

3.4.4 Data Analysis

The following analyses were performed using SPSS (Versions 14 and 15), with a critical alpha probability of p=.05 used. A descriptive analysis was performed to describe the general demographics of the sample and the prevalence of PRMS and PRMD. Chi squared analysis was used to examine gender specific prevalence rates for PRMS and PRMD and determine differences between males and females. Logistic regression was used to examine the association between prevalence of PRMS and PRMD with age, adjusted for gender. The interaction of age and gender was also investigated. The Mann Whitney U test was used to analyse gender differences in the frequency of symptoms within the last month and the Kruskall Wallis test to analyse differences in the frequency of symptoms within the last month across age groups. A descriptive analysis was performed on children with a

PRMD to describe medication and professional health care usage and a chi square analysis used to determine gender differences.

3.5 RESULTS

3.5.1 Prevalence of PRMP and gender

Sixty seven percent of participants (489/731) reported experiencing PRMS at some point. As shown in Figure 3.2, lifetime prevalence was greater for females 69.6% (320/460) than males 61.2% (169/271) (χ^2=3.9 df (1), p=0.046).

Thirty percent of all the children learning instrumental music (219/731) reported PRMD, that is they were unable to play their instrument as usual at some point due to playing-related discomfort. This represented 53.2% (219/412) of students who reported the experience of PRMS in the last month. More females (32.8%, 151/460) than males (25.0%, 68/271) were unable to play music as usual (χ^2=4.86 df (1), p=0.03) (Figure 3.2).

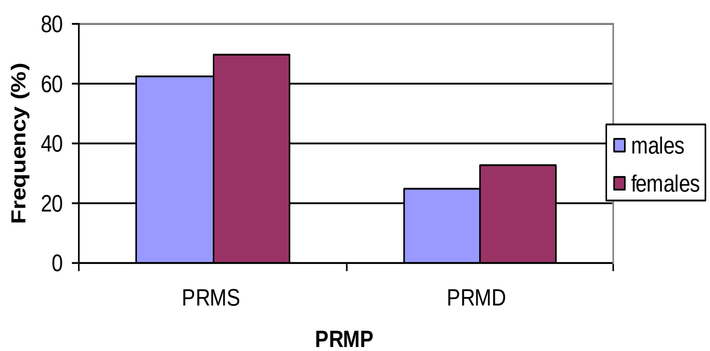

Figure 3.2 Prevalence of Lifetime Playing-Related Musculoskeletal Symptoms and Prevalence of Playing-Related Musculoskeletal Disorders for males and females.

3.5.2 Prevalence of PRMP and age

Figures 3.3 and 3.4 suggest an increase in PRMS with age for both genders and analysis confirmed that older children were more likely to report PRMS. The gender adjusted odds ratio showed the risk for PRMS increased by 20% for each increasing year of age (CI: 1.1-1.3; p<.001). There was no significant interaction effect between age and gender (p=0.18).

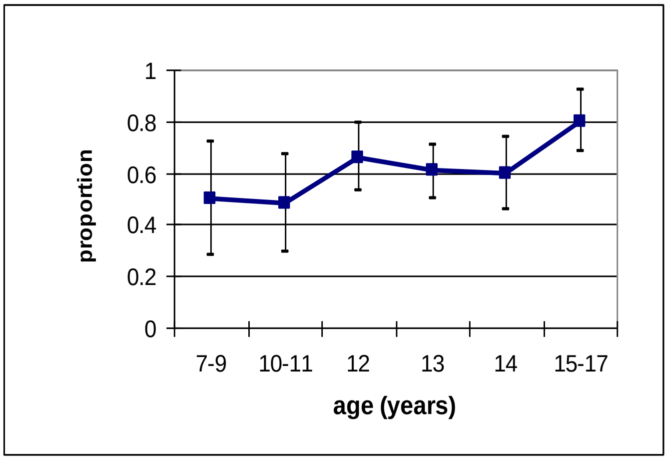

Figure 3.3 Proportion of male children reporting Lifetime Prevalence of Playing-Related Musculoskeletal Symptoms across age groups with 95% confidence intervals.

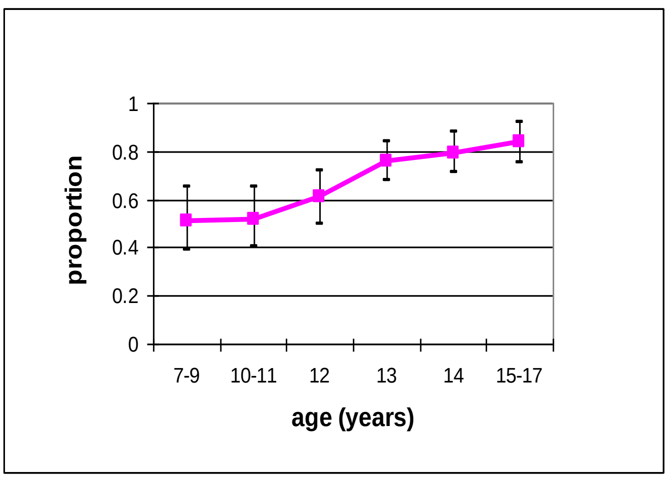

Figure 3.4 Proportion of female children reporting Lifetime Prevalence of Playing-Related Musculoskeletal Symptoms across age groups with 95% confidence intervals.

Figures 3.5 and 3.6 show a trend for increasing PRMD with age, with a 20% increase in risk of PRMD for each increasing year of age (gender adjusted OR=1.2 CI: 1.1-

1.2; p=0.001). Again there was no significant interaction effect between age and gender (p=0.48).

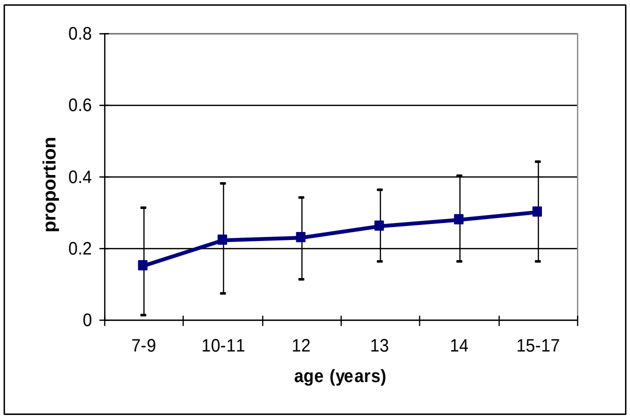

Figure 3.5 Prevalence PRMD across age groups for males (68/271).

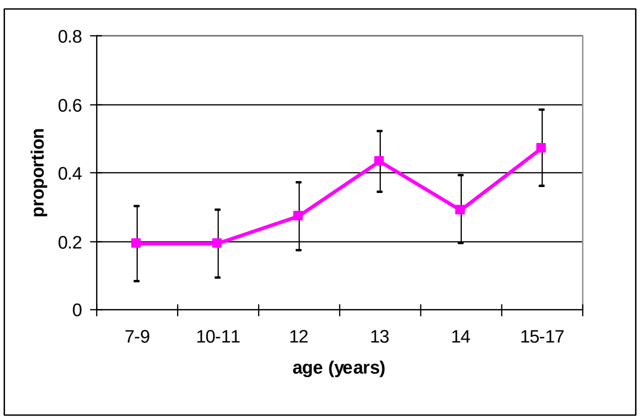

Figure 3.6 Prevalence PRMD across age groups for females (151/460).

3.5.3 Frequency of PRMS across genders and ages

56.4% of all children surveyed (412/731) reported experiencing PRMS within the last month. 49.5% of all males surveyed (134/271) and 60.4% of all females surveyed (278/460) experienced pain in the last month. Of the 134 males that reported pain within the last month 57 (42.5%) reported pain once a month, 44 (32.8%) reported pain once a week, 27 (20.2%) two to three times a week and 6 (4.5%) reported pain daily. Of the 280 females that reported the experience of pain within the last month, 94 (33.8%) reported pain once a month, 104 (37.4%) weekly, 56 (20.2%) reported the experience two to three times a week and 24 (8.6%) reported pain daily (figure 3.7). For those children that reported monthly PRMS, there was no difference in the reported frequency of symptoms between males and females (z=-1.7, p=0.09) or between age groups (χ^2=3.61 df (5), p=0.61).

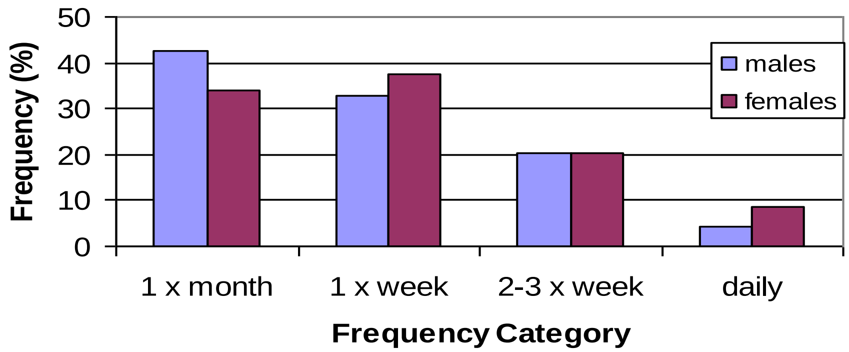

Figure 3.7 Frequency of Playing-Related Musculoskeletal Symptoms within Last Month for males (134/271) and females (278/460).

3.5.4 Impact of Playing-Related Musculoskeletal Disorders

Of the students that reported the experience of a PRMS in the last month 4.6% (19/409) reported taking medication, and 4.2% (17/407) reported visits to health professionals (figure 3.8). Fischer's exact test showed no significant differences between females and males (, p=0.14 and p=0.6 respectively). For those students who reported the experience of a PRMD, this represented 8.3% (18/216) who took medication and 6.9% (15/217) who visited health professionals, again no significant difference between females and males (p=0.2 and p=0.4 respectively).

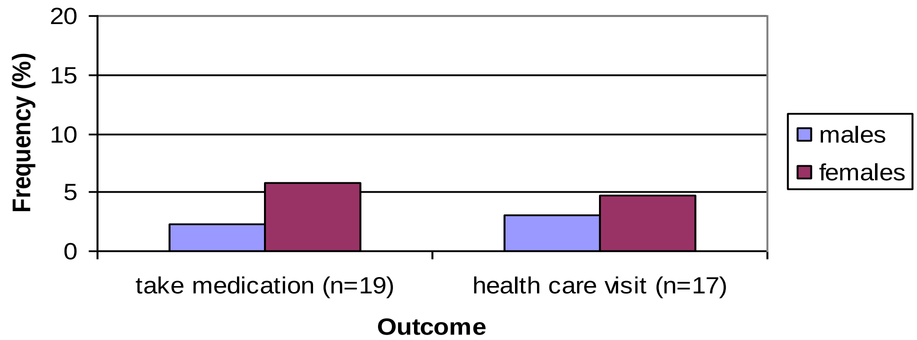

Figure 3.8 Proportion of children with Playing-Related Musculoskeletal Symptoms who took medication (n=19/409) or visited health professionals (n=17/407) for males (n= 3 and 4 respectively) and females (n=16 and 13 respectively).

3.6 DISCUSSION

This study was the first study to investigate both PRMS and PRMD in children instrumentalists. We found a lifetime prevalence of 67% for PRMS in children learning instrumental music with a PRMS month prevalence of 56%. When excluding mild symptoms as suggested by Zaza (1995), 30% of children reported the experience of PRMD – being unable to play their instrument as usual. This represented almost half of those students who reported the experience of PRMS at some point in their playing career. These figures demonstrate that children are experiencing problems very early in their playing careers and they are as common in children as they are in professional and tertiary musicians. Most disconcertingly, for even young children, these problems are severe enough to prevent them playing as usual.

The implications of adopting different case definitions (PRMS and PRMD) amongst children instrumentalists was highlighted by our data. Whilst there is evidence to support the value in reporting more severe problems in adult musicians, we suggest monitoring of milder symptoms in children to facilitate earlier intervention.

Females in our study were more likely to report PRMS (OR 1.5) more than males. Studies in adult musicians have found that females report PRMPs up to two times more than males, and while prior studies in children supported this trend, their sample sizes were small and they were unable to document significance differences (Biro et al. 2006; Juul et al. 2006).

Reasons why girls may experience more PRMS than boys include known differences between genders in age of pubertal maturation, body composition and psychosocial characteristics (Biro et al. 2006; Juul et al. 2006). The gender differences may also be due to differences in the type of instrument played or how it is practiced. The current study collected data on instruments and practice schedules and further analysis will explore gender differences in these factors. Our data shows the gap between genders becomes most apparent in early adolescence, when physical, psychological and behavioural differences may be increasing.

The implication of our findings is that particular attention should directed to understanding PRMS development in females as their higher risks in adulthood may be a result of their adolescent experience.

Older children learning instrumental music reported a higher lifetime prevalence of PRMS and PRMD. This would be expected given the cumulative nature of lifetime prevalence and normal physical, psychological and behavioural developmental changes. For example it is well established that the experience of general musculoskeletal problems, such as spinal pain, increases with age and therefore further analysis would need to consider this as a potential confounding factor. However, the data also suggested a plateau in prevalence rate around early adolescence for females (see figure 3.4). This may be due to a survivor effect, where children who experience significant PRMS in adolescence drop out of the instrumental music program. Longitudinal studies are required to determine whether this is occurring.

While there was a significant association between age level and PRMD in this study it is clear that significant problems are occurring in even the youngest group of children. There could be a number of factors for this. Whilst the School of Instrumental Music provides children with suitably sized instruments, children may be practicing with instruments at home that are not the correct size (for example it is not uncommon that parents may invest in the bigger sized violin for their growing child). Regardless of the reasons, playing-related problems exist in young instrumentalists and therefore these need to be addressed to ensure children can continue playing and avoid potential problems as their career progresses.

This study has several limitations related to its design. As a cross-sectional study, the strongest evidence it can provide is of association. Using self-reported measures of PRMS and PRMD may inflate prevalence and frequency rates compared to physical examination. Whilst the current analysis has provided unique information on the frequency of PRMS and PRMD in children and the associations with gender and age, further analysis should consider type of instrument, nature of practice and psychosocial factors. The study strengths included a large, representative sample, clear case definitions and assessment of the independent effects of age and gender.

3.7 CONCLUSIONS

Playing-related musculoskeletal problems, both symptoms and disorders, are common in children learning instrumental music. PRMS are experienced frequently by a large proportion of children and of greater concern, PRMD are experienced in even young children. Gender and age were associated with PRMPs in children learning instrumental music and therefore need to be examined in further studies in conjunction with other potential risk factors. The high prevalence and disabling impact of playing-related musculoskeletal problems in children suggests a greater understanding of risks is needed to inform prevention initiatives and thus help avoid the development of chronic adult disorders.

3.8 ACKNOWLEDGEMENTS

The authors would like to thank the participating parents and children, their schools, Mary Whitehead, manager of the Western Australian School for Instrumental Music and Instrumental teachers.

CHAPTER 4 PLAYING-RELATED MUSCULOSKELETAL PROBLEMS IN CHILD INSTRUMENTALISTS: THE INFLUENCE OF GENDER, AGE AND INSTRUMENT EXPOSURE

4.1 ABSTRACT

Purpose: Playing-related musculoskeletal problems (PRMP) are common in adult musicians. The limited available evidence suggests PRMP are common in children and adolescents and that risk factors may be similar. The aim of this study was to determine the prevalence of PRMP in children and adolescents and their associations with female gender, age and instrument exposure.

Methods: This study surveyed 731 children learning musical instruments (460 females) ranging in age from 7 – 17 years. Lifetime symptoms, monthly symptoms, and monthly disorders (the inability to play an instrument as usual) were examined. Logistic regression evaluated the independent association of these potential risk factors with PRMP prevalences.

Results: 67% students reported PRM symptoms at some point, 56% reported PRM symptoms within the last month and 30% reported an inability to play as usual within the last month. Female gender was significantly associated with PRMP (OR 1.38-1.56, $p=0.004 – 0.046$), as was age (OR 1.19-0.23, $p<0.001$). After adjustment for gender and age, type of instrument (upper and lower strings, woodwind and brass) were significantly associated with all PRMP ($p<0.005$) and playing three instruments was protective against monthly symptoms (OR 0.43, $p=0.05$).

Conclusions: The high prevalence and disabling impact of playing-related musculoskeletal problems is clearly an important issue for child and adolescent health with gender, age and instrument exposure important factors for risk management.

4.2 INTRODUCTION

Playing-related musculoskeletal problems (PRMP) include muscle, nerve, bone and joint problems such as tendonitis, tenosynovitis, peripheral neuropathy and focal dystonia. These problems are not new, with ‘musician’s cramp’ and ‘pianist’s cramp’ recognized in the 1800s (Poore 1887; Albert 1895) and noted to be similar to those seen in other occupations such as ‘writer’s cramp’ and ‘milking cramp’ (Solly 1867). PRMP are common in adults, with high prevalence rates in professional musicians (40-60%) and tertiary music students (9-90%), and may be severe enough to force career changes. Although PRMP are also known to exist in childhood there is limited evidence with respect to prevalence and risk factors. As musicians typically commence their careers at an early age, it is important to understand PRMP in childhood to help prevent problems in later years.

Twenty per cent (520 500) of Australian children play a musical instrument outside of school hours and 75% of these children receive instrumental tuition (Statistics 2009). Only five studies have examined the prevalence of PRMP specifically in children (Fry et al. 1988; Lockwood 1988; Fry and Rowley 1989; Shoup 1995; Brown 1997) with a further four reporting some child prevalence data (Fry 1986b; Dawson 1988; Betuel and Clairet 1999; Roset-Llobet et al. 2000). Whilst PRMP prevalence rates of 20%- 60% have been reported, most of the studies had significant limitations including small sample sizes, recruitment biases and lack of clarity with case definitions.

PRMPs in adult musicians have been classified into 1) mild aches and pains, experienced during and following playing, that may or may not affect performance (playing-related musculoskeletal symptoms-PRMS); and 2) pain, weakness, lack of control, numbness, tingling, or other symptoms that interfered with the ability to play the instrument as usual (playing-related musculoskeletal disorders-PRMD) (Zaza 1995). Examining symptoms in children may enable earlier detection and prevent the deterioration of symptoms and function and subsequent development of more disabling disorders.

PRMPs pathologies are similar to work-related musculoskeletal disorders (WRMSD). Risk factors are therefore thought to be similar and include intrinsic individual factors (e.g. age, gender), extrinsic playing-related factors (e.g. music exposure) and factors relating to the interaction of the individual and extrinsic factors (e.g. playing posture influenced by physical attributes of instrument). Whilst these factors have been investigated in adult instrumentalists, and subsequent management strategies recommended (Ackermann 2003), it is not clear whether these risk factors are relevant for child instrumentalists.

4.2.1 Risk Factors

The majority of existing studies of children have reported higher prevalences of PRMP for females than males (Fry et al. 1988; Lockwood 1988; Fry and Rowley 1989; Shoup 1995; Betuel and Clairet 1999) but these studies are limited by lack of statistical comparisons and/or poor PRMP definitions. In adults, females were more likely to report PRMPs compared to males (Fry 1986a; c; 1987; Fishbein et al. 1988; Revak 1989; Roach et al. 1994; Fjellman-Wiklund and Sundelin 1998; Yeung et al. 1999; Roset-Llobet et al. 2000; Abreu-Ramos and Micheo 2007) and two times more at risk of developing PRMD (Zaza and Farewell 1997). This trend is also documented in broader pain literature (in adults and children) and occupational health literature.

There is no clear evidence for age as a risk factor for PRMP within childhood. Studies that have considered child age merely reported descriptives (Fry 1986c; Dawson 1988; Grieco et al. 1989; Betuel and Clairet 1999; Roset-Llobet et al. 2000) or overall prevalence rates (Fry and Rowley 1989; Roset-Llobet et al. 2000). A retrospective review of 314 students aged 18 years and younger, found no association between age and playing-related injuries (Burkholder and Brandfonbrener 2004).

In adults, there is no consensus with respect to age as a risk factor for PRMP (Pak and Chesky 2001; Abreu-Ramos and Micheo 2007). However, there is evidence that other musculoskeletal problems such as spinal pain prevalence increase rapidly over adolescence (Balague et al. 1988; Leino et al. 1994; Taimela et al. 1997) and adolescent symptoms link to symptoms in adulthood (Hertzberg 1985; Harreby et al. 1995; Siivola et al. 2004). Therefore it is important to identify any association between age and PRMP over childhood and adolescence.

Music exposure can be categorized into: amount (such as time spent practicing) or nature of the task (such as type of instrument). These factors may be confounded by age and gender. For example, the child instrumentalist may practice for longer as they progress with their instrumental tuition over the years.

Although children's practice time has been documented, no association with PRMPs has been identified (Fry et al. 1988). There are conflicting reports in adult musicians, with an association between practice time and PRMPs found in some studies (Hiner et al. 1987; Manchester and Flieder 1991) but not others (Roach et al. 1994; Yeung et al. 1999).

No study has reported the relationship between the number of instruments played by a child and PRMP. Playing more than one instrument may mean an increase in the amount of time spent practicing which may increase the risk of PRMPs. Conversely, playing a different second or third instrument may add task variety (change in exposure pattern), which in the occupational health literature has been associated with a decrease risk in the development of musculoskeletal disorders (Fernstrom and Aborg 1999; Christensen et al. 2000; Mathiassen et al. 2003; Mathiassen 2006).

Instrument type is consistently cited as the most significant factor affecting the prevalence of PRMP. However, only one childhood study has reported an association between instrument and PRMP. Lockwood (1988) reported PRMPs in all evaluated instrument categories, with large strings (cello and bass) more associated with PRMPs than small strings (violin and viola). However they did not evaluate keyboard risk. Other small childhood studies (Dawson 1988; Fry and Rowley 1989) that have reported prevalence rates by instrument group, but not evidence of an association between instrument type and PRMPs.

Amongst tertiary music students, string, keyboard, woodwind and brass instruments have a high prevalence of problems (Fry 1987; Pratt et al. 1992; Zetterberg et al. 1998). In adults a higher prevalence of PRMPs has been reported in string (Newmark and Lederman 1987; Fishbein et al. 1988; Zaza and Farewell 1997; Fjellman-Wiklund and Sundelin 1998) and keyboard players (Hochberg et al. 1983; Newmark and Hochberg 1987; Fry 1988; Roset-Llobet et al. 2000; Brandfonbrener 2003). Woodwind, brass, guitar often have lower risk with percussion the least risk of problems (Fishbein et al. 1988; Brandfonbrener 2003).

The majority of studies of PRMP prevalence and risk factors have been conducted on adult musicians with very limited evidence on children. To guide prevention and management, better evidence is needed to identify if gender, age and music exposure factors are associated with PRMP in children.

4.3 AIMS

The aims of this study were to:

1. Establish clear prevalence data for PRMP in children and adolescents.
2. Establish the univariable associations of gender, age and music exposure factors (practice time, number and type of instruments) with PRMP.
3. Establish the unique associations of gender, age and music exposure factors (practice time, number and type of instruments) with PRMP after adjustment for other covariates.

4.4 METHODS

4.4.1 Design

A cross-sectional questionnaire and anthropometric measures survey was conducted across government schools participating in the School of Instrumental Music program. One secondary ('senior high') school with a strong instrumental program was selected from each of the five school regions within Perth, Western Australia, to ensure a range of socio-economic areas were represented in the sample and to ensure large instrumental numbers. One region had two schools with strong instrumental programs and both were invited to participate. One school declined to participate due to their participation in other studies. No replacement school was invited as the remaining school had a sufficiently large sample of instrumental students. Primary ('elementary') schools which had high instrumental numbers and were 'feeder' schools for these secondary schools were then selected. Selected schools were approached and requested to participate. The process of school selection is outlined in Figure 4.1.

4.4.2 Sample

731 students (460 females) aged between 7 and 17 years (mean 12.7 yrs, sd 2.0yrs) completed the survey in August to December 2003. All instrumental classes at the selected schools were sampled. Informed assent/consent from participants and their parent or guardian was necessary for participation. There were no exclusion criteria. In the secondary schools surveyed, 201 students were sitting exams and could not complete the survey, 41 students requested to be excluded from the study and, due to the large numbers, absentees were difficult to account for. In primary schools, 21 students were not available to participate in the survey due to competing school commitments, 24 requested exclusion from the study and 8 were absent.

4.4.3 Questionnaire and Survey

A modified version of the Young people's Activity Questionnaire (YAQ-m) (Harris and Straker 2000) was adopted for the study and included music specific questions and was refined through several iterations of trialling with children and parents. The survey contained general questions regarding the children's age, gender, year at school, hand dominance and general musculoskeletal complaints. The main focus of the survey was the experience of PRMS during their playing career and specifically within the past month (monthly, weekly, two to three times weekly and daily categories). Children who experienced symptoms in the last month were then asked if symptoms prevented them playing their instrument as usual (i.e. the experience of a PRMD), lead them to take medication or visit health care providers. Children reported the location of their symptoms on a body diagram and rated the severity of symptoms. Other music specific questions covered music experience and practice habits. The remaining questions, covered watching television, participation in physical activities, hand intensive activities such as art, hand writing and use of computers.

Children completed the questionnaire in class under the supervision of their normal teacher, and with the very young students, parents were often present for the lesson and were able to assist with the completion of the questionnaire. Questionnaires took approximately 20 minutes to complete. Height was measured using a wall based tape measure and weight was measured using a digital scale. The first author was present to perform anthropometric measures and answer any queries.

4.4.4 Data Analysis

Descriptive statistics are presented for life and month prevalence of Playing-Related Musculoskeletal Symptoms (PRMS) and month prevalence of Playing-Related Musculoskeletal Disorders (PRMD) with prevalence rates calculated as a percentage of the whole sample. A series of univariable logistic regression analyses were performed to estimate the unadjusted effect of each independent variable for the three PRMP outcomes. Three multivariate logistic regression analyses (one for each PRMP outcome) were performed to estimate the unique effect of each independent variable after accounting for covariance between variables. Analyses were performed using SPSS software (version 15).

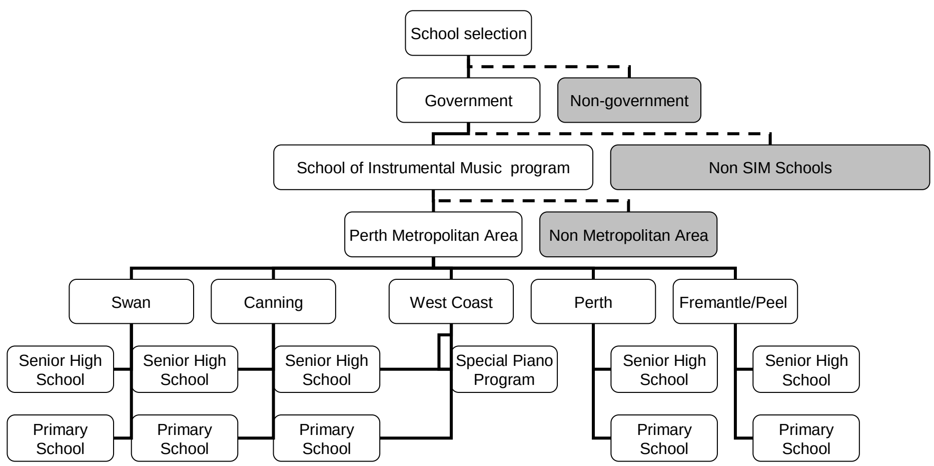

Figure 4.1 School Selection Process

4.5 RESULTS

4.5.1 Prevalence PRMP

489 children (67%) reported a lifetime prevalence of PRMS, and 412 children (56%) reported the experience of symptoms within the past month. 219 children (30%) reported they were unable to play their instrument as usual (i.e. PRMD).

4.5.2 Influence of Gender And Age

There was a significant association observed between gender and all PRMP, with females more likely to report problems than males (unadjusted OR 1.38-1.56, see table 4.3). Estimates remained similar after adjusting for age, (see table 4.4). There was also a significant association observed between age and all PRMP ($p=<0.001$, see table 4.3). Estimates remained similar after adjusting for gender (see table 4.4). There was no significant interaction effect between gender and age for any PRMP ($p=0.138$-$p=0.189$).

4.5.3 Influence of Exposure

4.5.3.1 Practice time

Weekly practice times displayed a right-skewed distribution ranging from 17 minutes to 41 hours, with a median of 5.3 hours and an interquartile range of 4.8 hours. There was a significant association between practice time and symptoms: an increase in practice time of an hour was associated with a 5-7% increase in the odds for lifetime PRMS and monthly PRMS (see table 4.3). After adjusting for other covariates, the association between practice time remained significant for MPRMS only (see table 4.4).

4.5.3.2 Number of instruments played

403 (55%) children played one instrument only, with 280 (38%) playing two instruments and 48 (7%) playing three instruments, with the number of instruments played increasing with age (Figure 4.2). There was no significant unadjusted association between number of instruments and any PRMPs (see table 4.3). In the multivariate regression model, playing three instruments in comparison to only one instrument decreased the odds for lifetime PRMS ($p=0.023$) and monthly PRMS ($p=0.019$) (see table 4.4).

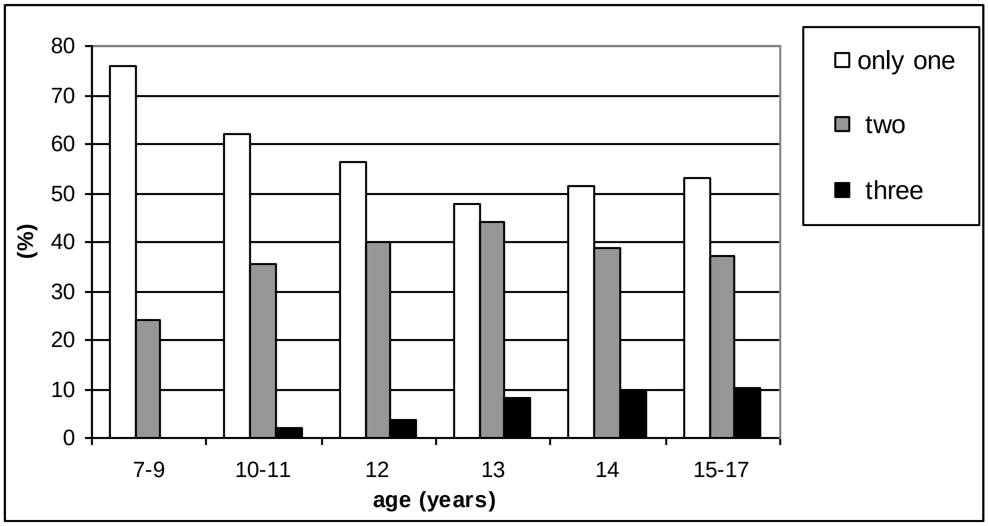

Figure 4.2 Percentage of children playing only one (n=403), two (n=280) or three (n=48) instruments across age groups

4.5.3.3 Instrument type

Piano (42%), violin (19%), clarinet (16%), guitar (15%) and flute (12%) were the most commonly played instruments (Table 4.1). The piano, violin and clarinet were most frequently played as the main instrument, with piano most commonly played as a second (and third) instrument.

4.5.3.4 Prevalence PRMP and Instrument Type

Prevalence of PRMPs for instrument type and category are presented in Table 4.2. Piano demonstrated the lowest prevalence for all three classes of PRMPs and was selected as the referent for subsequent analysis. A number of instruments showed significantly greater unadjusted odds for PRMP as compared to piano (see Table 4.3). The lower string category with the double bass and cello, and woodwind category with saxophone and flute, demonstrated very high odds for all PRMP as compared to piano. After adjusting for other covariates, all contrasts remained significant except for the clarinet and guitar (see Table 4.4).

Table 4.1 Number of children playing instruments at all and as nominated main, second and third instrument, in score order.

	Played at all	Played as main instrument	Played as 2nd instrument	Played as 3rd instrument
piccolo	2	-	2	-
flute	85	61	20	4
oboe	15	13	2	-
clarinet	114	95	15	4
bassoon	11	7	4	-
saxophone	48	36	11	1
French horn	19	19	-	-
euphonium	16	12	3	1
baritone	4	3	1	-
trumpet	52	41	8	3
cornet	1	-	-	1
trombone	32	23	7	2
tuba	8	6	2	-
percussion	46	22	21	3
violin	135	113	22	-
viola	23	18	5	-
cello	58	50	7	1
bass	24	18	6	-
piano	304	130	160	14
guitar	108	63	31	14
harp	1	1	-	-
other	3	-	3	-
Total	**1109**	**731**	**330**	**48**

Table 4.2 Prevalence Estimates and 95% Confidence Intervals for PRMP of instruments and instrument categories (continued)

	Lifetime Playing-Related Musculoskeletal Symptoms		Monthly Playing-Related Musculoskeletal Symptoms		Playing-Related Musculoskeletal Disorders	
	Prevalence proportion	95% Confidence Interval	Prevalence proportion	95% Confidence Interval	Prevalence proportion	95% Confidence Interval
Piano n=130						
Piano n=130	0.52	0.44-0.61	0.44	0.35-0.52	0.18	0.11-0.24
Upper Strings n=131	0.66	0.58-0.74	0.56	0.47-0.64	0.30	0.22-0.38
Violin n=113	0.65	0.57-0.74	0.54	0.45-0.63	0.29	0.21-0.38
Viola n=18	0.67	0.45-0.88	0.67	0.45-0.88	0.33	0.12-0.55
Lower Strings n=68	0.76	0.66-0.87	0.68	0.57-0.79	0.37	0.25-0.48
Cello n=50	0.72	0.60-0.84	0.64	0.51-0.77	0.36	0.23-0.49
Double bass n=18	0.89	0.74-1.00	0.78	0.59-0.97	0.39	0.16-0.61
Woodwind n=212	0.76	0.71-0.82	0.63	0.56-0.69	0.33	0.27-0.39
Clarinet n=95	0.71	0.61-0.80	0.59	0.49-0.69	0.32	0.22-0.41
Flute n=61	0.79	0.68-0.89	0.62	0.50-0.74	0.33	0.21-0.45
Oboe n=13	0.85	0.65-1.04	0.54	0.27-0.81	0.23	0.00-0.46
Bassoon n=7	0.71	0.38-1.05	0.57	0.20-0.94	0.29	0.00-0.62
Saxophone n=36	0.86	0.75-0.97	0.78	0.64-0.91	0.42	0.26-0.58

Table 4.2 Prevalence Estimates and 95% Confidence Intervals for PRMP of instruments and instrument categories (continued)

	Lifetime Playing-Related Musculoskeletal Symptoms		Monthly Playing-Related Musculoskeletal Symptoms		Playing-Related Musculoskeletal Disorders	
	Prevalence proportion	95% Confidence Interval	Prevalence proportion	95% Confidence Interval	Prevalence proportion	95% Confidence Interval
Brass n=104	0.58	0.48-0.67	0.52	0.42-0.62	0.33	0.24-0.42
Trumpet n=41	0.59	0.43-0.74	0.54	0.38-0.69	0.34	0.20-0.49
Trombone n=23	0.65	0.46-0.85	0.52	0.32-0.73	0.30	0.12-0.49
Tuba n=6	0.50	0.10-0.90	0.50	0.10-0.90	0.17	0.00-0.46
French horn n=19	0.63	0.41-0.85	0.58	0.36-0.80	0.42	0.20-0.64
Euphonium n=12	0.42	0.14-0.70	0.33	0.07-0.60	0.25	0.01-0.50
Baritone n=3	0.33	0.00-0.87	0.67	0.13-1.00	0.33	0.00-0.87
Guitar n=63						
Guitar n=63	0.71	0.60-0.83	0.56	0.43-0.68	0.32	0.20-0.43
Percussion n=22						
Percussion n=22	0.68	0.49-0.88	0.59	0.39-0.80	0.32	0.12-0.51

Table 4.3 Unadjusted Logistic Regression Odds Ratio Estimates (95%CI) for all independent variables for the three outcome measures of Playing-Related Musculoskeletal Problems (instruments analysed both separately and as categories) (continued)

COVARIATE		Lifetime Playing-Related Musculoskeletal Symptoms			Monthly Playing-Related Musculoskeletal Symptoms			Playing-Related Musculoskeletal Disorders		
unadjusted OR		Odds Ratio	95% CI	P value	Odds Ratio	95% CI	P value	Odds Ratio	95% CI	P value
Gender (female)		1.38	1.01-1.89	0.046	1.56	1.15-2.11	0.004	1.46	1.04-2.04	0.028
Age (years)		1.23	1.14-1.33	<0.001	1.19	1.11-1.29	<0.001	1.19	1.08-1.29	<0.001
Total practice time (hrs/week)		1.05	1.01- 1.10	0.014	1.07	1.03-1.11	0.001	1.04	0.99-1.08	0.070
Number of instruments played	1	1.0			1.0			1.0		
	2	1.09	0.79-1.52	0.595	1.16	0.85-1.59	0.336	1.23	0.88-1.71	0.227
	3	0.58	0.32-1.07	0.079	0.68	0.37-1.23	0.202	0.84	0.42-1.66	0.607
INSTRUMENT										
PIANO n=130		1.0			1.0			1.0		
UPPER STRINGS n=131		1.74	1.06-2.87	0.029	1.61	0.99-2.63	0.056	1.97	1.10-3.54	0.023
Violin n=113		1.73	1.03-2.91	0.038	1.50	0.91-2.49	0.115	1.92	1.05-3.52	0.035
Viola n=18		1.82	0.65-5.15	0.257	2.56	0.91-7.24	0.076	2.33	0.79-6.84	0.125
LOWER STRINGS n=68		2.96	1.54-5.72	0.001	2.68	1.45-4.95	0.002	2.71	1.39-5.27	0.003
Cello n=50		2.35	1.16-4.75	0.018	2.28	1.16-4.47	0.017	2.62	1.26-5.44	0.010
Double bass n=18		7.29	1.61-33.01	0.010	4.48	1.40-14.36	0.012	2.96	1.04-8.45	0.043

Table 4.3 Unadjusted Logistic Regression Odds Ratio Estimates (95%CI) for all independent variables for the three outcome measures of Playing-Related Musculoskeletal Problems (instruments analysed both separately and as categories) (continued)

COVARIATE	Lifetime Playing-Related Musculoskeletal Symptoms			Monthly Playing-Related Musculoskeletal Symptoms			Playing-Related Musculoskeletal Disorders		
unadjusted OR	Odds Ratio	95% CI	P value	Odds Ratio	95% CI	P value	Odds Ratio	95% CI	P value
WOODWIND n=212	2.95	1.85-4.72	<0.001	2.16	1.38-3.36	0.001	2.29	1.35-3.91	0.002
Clarinet n=95	2.18	1.25-3.82	0.006	1.84	1.08-3.14	0.026	2.15	1.15-4.01	0.016
Flute n=61	3.37	1.67-6.80	0.001	2.12	1.14-3.95	0.018	2.27	1.13-4.57	0.022
Oboe n=13	5.02	1.07-23.52	0.041	1.49	0.48-4.69	0.492	1.40	0.36-5.47	0.633
Bassoon n=7	2.28	0.43-12.18	0.335	1.71	0.37-7.94	0.495	1.86	0.34-10.19	0.474
Saxophone n=36	5.65	2.07-15.45	0.001	4.48	1.90-10.58	0.001	3.32	1.49-7.40	0.003
BRASS n=104	1.24	0.74-2.09	0.411	1.38	0.82-2.32	0.219	2.26	1.23-4.15	0.009
Trumpet n=41	1.29	0.63-2.62	0.486	1.48	0.73-3.00	0.273	2.41	1.10-5.30	0.028
Trombone n=23	1.71	0.68-4.31	0.256	1.40	0.58-3.40	0.461	2.04	0.75-5.51	0.162
Tuba n=6	0.91	0.18-4.69	0.912	1.28	0.25-6.59	0.767	0.93	0.10-8.35	0.949
French horn n=19	1.56	0.579-4.22	0.378	1.76	0.67-4.67	0.255	3.38	1.23-9.35	0.019
Euphonium n=12	0.65	0.20-2.16	0.483	0.64	0.18-2.23	0.484	1.55	0.40-6.18	0.534
Baritone n=3	0.46	0.04-5.15	0.526	2.56	0.23-28.96	0.447	2.33	0.20-26.75	0.498
GUITAR n=63	2.28	1.20-4.35	0.012	1.60	0.87-2.93	0.128	2.16	1.08-4.34	0.030
Guitar n=63	2.28	1.20-4.35	0.012	1.60	0.87-2.93	0.128	2.16	1.08-4.34	0.030
PERCUSSION n=22	1.95	0.75-5.11	0.172	1.85	0.74-4.63	0.189	2.17	0.80-5.92	0.130
Percussion n=22	1.95	0.75-5.11	0.172	1.85	0.74-4.63	0.189	2.17	0.80-5.92	0.130

Table 4.4 Adjusted Logistic Regression Odds Ratio Estimates (95%CI), for multivariate model including all independent variables, for the three outcome measures of PRMP (instruments analysed both separately and as categories) (continued)

COVARIATE		Lifetime Playing-Related Musculoskeletal Symptoms			Monthly Playing-Related Musculoskeletal Symptoms			Playing-Related Musculoskeletal Disorders		
Adjusted OR		Odds Ratio	95% CI	p value	Odds Ratio	95% CI	p value	Odds Ratio	95% CI	p value
Gender (female)		1.39	0.97-2.00	0.057	1.67	1.17-2.37	0.004	1.62	1.10-2.38	0.014
Age (years)		1.22	1.10-1.35	<0.001	1.17	1.06-1.28	0.002	1.17	1.06-1.30	0.003
Total practice time (hrs/week)		1.04	0.99-1.09	0.140	1.06	1.01-1.11	0.025	1.01	0.97-1.06	0.614
Number of instruments played	1	1.0			1.0			1.0		
	2	1.02	0.70-1.49	0.916	1.01	0.76-1.53	0.66	1.26	0.87-1.81	0.222
	3	0.45	0.21-0.89	0.022	0.44	0.22-0.89	0.022	0.68	0.31-1.49	0.332
INSTRUMENT										
Piano n=130		1.0			1.0			1.0		
UPPER STRINGS n=131		2.02	1.18-3.47	0.010	1.67	0.99-2.83	0.053	1.91	1.04-3.50	0.038
Violin n=113		2.13	1.20-5.42	0.009	1.62	0.93-2.80	0.087	1.94	1.03-3.67	0.041
Viola n=18		1.38	0.47-4.05	0.560	1.89	0.65-5.53	0.245	1.65	0.55-4.95	0.376
LOWER STRINGS n=68		3.30	1.64-6.63	0.001	2.93	1.53-5.60	0.001	2.74	1.37-5.46	0.004
Cello n=50		2.55	1.20-5.42	0.015	2.39	1.17-4.87	0.017	2.61	1.22-5.57	0.013
Double bass n=18		8.22	1.77-38.16	0.007	5.47	1.65-18.15	0.005	3.15	1.07-9.26	0.037

Table 4.4 Adjusted Logistic Regression Odds Ratio Estimates (95%CI), for multivariate model including all independent variables, for the three outcome measures of PRMP (instruments analysed both separately and as categories) (continued)

COVARIATE	Lifetime Playing-Related Musculoskeletal Symptoms			Monthly Playing-Related Musculoskeletal Symptoms			Playing-Related Musculoskeletal Disorders		
Adjusted OR	Odds Ratio	95% CI	p value	Odds Ratio	95% CI	p value	Odds Ratio	95% CI	p value
WOODWIND n=212	2.56	1.55-4.21	0.001	1.78	1.11-2.87	0.017	1.85	1.07-3.23	0.029
Clarinet n=95	1.89	1.04-3.42	0.036	1.54	0.87-2.72	0.137	1.71	0.89-3.27	0.106
Flute n=61	2.86	1.35-6.07	0.006	1.65	0.85-3.20	0.139	1.72	0.83-3.54	0.145
Oboe n=13	4.28	0.89-20.37	0.068	1.22	0.38-3.92	0.737	1.09	0.27-4.33	0.903
Bassoon n=7	1.37	0.25-7.54	0.719	0.99	0.21-4.81	0.995	1.14	0.20-6.39	0.882
Saxophone n=36	4.83	1.71-13.65	0.003	4.01	1.63-9.86	0.002	3.11	1.35-7.18	0.008
BRASS n=104	1.10	0.63-1.93	0.737	1.37	0.78-2.40	0.272	2.27	1.20-4.29	0.012
Trumpet n=41	1.17	0.54-2.54	0.690	1.59	0.74-3.45	0.233	2.40	1.03-5.57	0.042
Trombone n=23	1.73	0.65-4.64	0.277	1.78	0.68-4.66	0.244	2.71	0.95-7.74	0.062
Tuba n=6	0.44	0.06-3.03	0.406	0.62	0.09-4.35	0.632	0.78	0.08-7.74	0.832
French horn n=19	1.40	0.50-3.92	0.522	1.64	0.59-4.54	0.342	3.08	1.08-8.76	0.035
Euphonium n=12	0.56	0.16-1.94	0.361	0.57	0.16-2.07	0.389	1.33	0.33-5.46	0.691
Baritone n=3	0.56	0.05-6.67	0.648	2.99	0.25-36.41	0.389	3.08	0.26-36.68	0.374
GUITAR n=63	1.97	0.99-3.89	0.051	1.41	0.74-2.69	0.292	1.78	0.86-3.72	0.122
Guitar n=63	1.99	1.01-3.94	0.048	1.45	0.76-2.77	0.261	1.81	0.87-3.78	0.115
PERCUSSION n=22	1.65	0.61-4.46	0.325	1.61	0.62-4.20	0.328	1.65	0.57-4.79	0.361
Percussion n=22	1.68	0.62-4.55	0.310	1.66	0.63-4.34	0.303	1.66	0.57-4.86	0.352

4.6 DISCUSSION

This study found PRMP to be very common amongst children and adolescents, resulting in the inability to play as usual in a third of the study sample. Females and older children were more likely to experience problems. After adjustment for other covariates, increased practice time was associated with an increased odds of monthly PRMS, playing three instruments was associated with a reduced odds of monthly PRMS, and the odds for all PRMP were significantly different between instrument types.

Prevalence rates in this study concur with those reported in the music literature for children (Fry 1986b; Dawson 1988; Fry et al. 1988; Lockwood 1988; Fry and Rowley 1989; Shoup 1995; Betuel and Clairet 1999; Roset-Llobet et al. 2000)and adults (Fry 1986a; c; Zaza 1995; Zetterberg et al. 1998; Roset-Llobet et al. 2000; Abreu-Ramos and Micheo 2007). This study is the first to establish the prevalence of symptoms and more disabling disorders amongst children and most disconcertingly shows that PRMD prevalence rates are similar to those reported by adults.

This is the first study to provide clear evidence that females are at more risk of PRMP than males in childhood. This gender risk is similar to that reported for PRMP in adult musicians (Fry 1986a; c; Zaza 1995; Abreu-Ramos and Micheo 2007) and for spinal pain in adults (Andersson et al. 1993; Croft et al. 2001)and children (Salminen 1984; Troussier et al. 1999; Watson et al. 2002; Stahl et al. 2008). The consistency of higher risk for a broad range of musculoskeletal disorders in females suggests there may be consistent mechanisms.

This is the first study to adequately document risk of PRMPs across childhood, accounting for gender. Whilst risk increased with age, it is a concern that even very young instrumentalists are experiencing activity limiting problems. Given the experience of back and neck pain in adolescence appears to increase the risk of back and neck pain in adulthood (Hertzberg 1985; Harreby et al. 1995; Siivola et al. 2004), it behoves the health professional, teacher and parent to pay attention to the reporting of PRMS in children to prevent more disabling problems in adulthood.

Practice time was associated with monthly PRMS in the multivariate model. This is consistent with an increase in hours of exposure increasing the risk of developing musculoskeletal disorders reported in the occupational literature (Katz 2000; Blatter and Bongers 2002).

Whilst no prior reports of the association between number of instruments and PRMP were found, we expected an increase in risk due to increased exposure time. This study found children who played three instruments did spend more time practicing than other students and time spent practicing was (independently) associated with monthly problems, yet playing three instruments was associated with a reduced risk of problems. Students in our study who played more than one instrument played different instruments (i.e. from a different instrument category) which may have had different physical task demands. Playing three instruments may therefore have provided physical variety which reduced risk. This inverse relationship has been reported in occupational health literature where variation in exposure decreased the risk for WRMSD (Fernstrom and Aborg 1999; Christensen et al. 2000; Mathiassen et al. 2003; Mathiassen 2006). On the basis of this study, education guidelines should encourage different instrument types be played as a second or third instrument.

This was the first study to comprehensively establish risk associations between instrument/instrument category and PRMP in child instrumentalists. In this study, piano was the most commonly played instrument as a first, second or third instrument, in line with prior reports (Fry 1987; Dawson 1988; Fry and Rowley 1989; Betuel and Clairet 1999; Dawson 2001).Interestingly, the piano was associated with least problems in our study. The piano requires left and right hand and finger movements, with the elbow and shoulder in reasonable, symmetrical postures. This may explain why it was less associated with problems. In contrast Fry and Rowley (1989) reported piano (along with the cello) to be associated with the most problems in children. Amongst adult musicians the piano/keyboard has often been associated with a greater risk of PRMP compared to other instrument groups. At professional and tertiary levels, various practice habits may influence the development of problems such as the difficulty/type of the repertoire played, the duration of practice sessions and frequency of practice sessions. It may be that the cumulative repetitions and prolonged postures of more extensive adult playing times and less physical variation are the reason adults have more problems with piano/keyboards than children in our study.

Upper and lower string players displayed significantly higher odds than piano players for all PRMPs in this study. Disparity between the child and instrument size has been postulated as a reason for increased prevalence of PRMPs in child string players (Lockwood 1988). In this study, upper and lower string players displayed significantly higher odds than piano players for PRMPs, though when lower strings were contrasted to upper strings there was no significant increase in risk (OR 1.41-1.73; p = 0.280-0.109). In adults, string instruments in general, and bowed stringed instruments specifically, are associated with more upper limb problems than keyboard, percussion, woodwind and brass (Middlestadt and Fishbein 1989) The degree of coordination required for very different actions of the left and right upper limb in playing a bowed string instrument may explain why these instruments are associated with more problems (Ackerman and Adams 2005).

Woodwind players and saxophone players in particular, displayed significantly higher odds than piano players for all PRMP in this study. Fry and Rowley (1989) reported very high PRMP prevalence in children playing clarinet and flute, although the small sample size precluded accurate estimation of population prevalence. While appropriately sized woodwind and brass instruments are supplied through the School of Instrumental Music, the weight of the instruments on the developing musculoskeletal system may place the child at risk for developing problems. In adults, woodwind instruments were associated with PRMPs but with lower risk than string instruments (Fishbein et al. 1988; Brandfonbrener 2003). Amongst tertiary music students, woodwind instruments were a similar risk for PRMPs as keyboard and string instruments (Fry 1987; Pratt et al. 1992; Zetterberg et al. 1998).

Brass players, and trumpet players in particular, displayed significantly higher odds than piano players for PRMD in this study. Potential explanatory factors for this finding may be child-instrument size mismatch, the heavy instrument weight and the difficulty of technique required to play the trumpet. In adults, the unique physical demands required to play various brass instruments, i.e. to hold and position the instrument, produce and maintain blowing pressures and manipulate valves and or slides, are thought to contribute to the experience of PRMPs (Chesky et al. 2002)

On the basis of this study, close monitoring of children playing instruments with the highest odds of PRMP, such as cello, bass, saxophone, and trumpet, is recommended. Teachers and parents need to be informed of prevention strategies for PRMPs associated with these instruments

This study has several limitations related to its design. As a cross-sectional study, the strongest evidence it can provide is of association. Using self-reported measures of PRMS and PRMD may inflate prevalence rates compared to physical examination. Whilst the current analysis has provided unique information on the prevalence of PRMS and PRMD in children and the associations with practice time, number and type of instrument played, further analysis will consider location of pain experienced. The study strengths included a large, representative sample, clear case definitions and assessment of the independent effects of age and gender.

4.7 CONCLUSION

Gender, age, practice time and type of instrument played were associated with the reported prevalence of playing-related musculoskeletal symptoms and disorders in children learning instrumental music. The high prevalence of both PRMS and PRMD in children warrants further evaluation of risks to inform teachers, parents and children on prevention initiatives and to prevent the development of chronic disorders in adult musicians.

4.8 ACKNOWLEDGEMENTS

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CHAPTER 5 PLAYING-RELATED MUSCULOSKELETAL PROBLEMS IN CHILDREN LEARNING INSTRUMENTAL MUSIC – THE ASSOCIATION BETWEEN PROBLEM LOCATION AND GENDER, AGE AND MUSIC EXPOSURE FACTORS

5.1 ABSTRACT

Purpose: Playing-related musculoskeletal problems (PRMP) are common in adult musicians and risk factors such as gender and music exposure have been linked to PRMP. Instrument type in particular has been associated with adults experiencing PRMP in specific locations. Emerging evidence suggests PRMP are common in children and adolescents and that risk factors may be similar. Given the experience of spinal pain in adolescence appears to increase the risk of spinal pain in adulthood, it is important to understand patterns of PRMP in child and adolescent instrumentalists. The aim of this study was to determine the prevalence of PRMP, both symptoms and disorders, and PRMP location in children and adolescents and the associations with gender, age and music exposure factors such as type and number of instruments and playing time.

Methods: This study surveyed 731 children (460 females) aged between 7 – 17 years learning instrumental music in government schools in Perth, Western Australia. Lifetime symptoms, monthly symptoms, and monthly disorders (the inability to play an instrument as usual) and PRMP location were examined. Chi square analyses evaluated associations between gender, age, music exposure and PRMP outcomes. Logistic regression evaluated the independent association of these potential risk factors with PRMP prevalence and location.

Results: 67% students reported playing-related musculoskeletal symptoms at some point, 56% reported playing-related musculoskeletal symptoms within the last month and 30% reported an inability to play as usual within the last month. After

adjustment for gender and age, the type of instrument played (upper and lower strings, woodwind and brass) was significantly associated with all PRMP ($p<0.005$) and playing three instruments was protective against monthly symptoms (OR 0.43, $p=0.05$). The right (24%) and left (23%) hand/elbow and neck (16%) were the most commonly reported PRMP locations. Females reported more PRMP at the neck (19%:11%, $p=0.010$), mid back (11%:6%, $p=0.037$), right shoulder (17%:8%, $p=0.001$) and left shoulder (16%:6%, $p<0.001$) than males. Prevalence of PRMP increased with age for neck ($p<0.001$), mid back ($p=0.007$), low back ($p<0.001$) the right hand/elbow ($p=0.008$) and mouth ($p=0.011$). PRMP prevalence for the left hand/elbow and right and left shoulders demonstrated high rates across childhood. Plucked strings demonstrated significantly higher odds ratios for the risk of right (OR 3.13, $p=0.002$) and left (OR 1.96, $p=0.04$) hand PRMP compared to upper strings. Lower strings demonstrated significantly higher odds ratios for right hand (OR 3.06, $p=0.002$), left hand (OR 3.18, $p=0.030$) and right shoulder (OR 2.89, $p=0.003$) PRMP compared to upper strings. Woodwind and piano demonstrated significantly higher odds ratios (95%CI) for the risk of right hand/elbow PRMP (3.08(1.60-5.90), $p=0.001$; 2.18(1.08-4.39), $p= 0.030$ respectively) than brass instrumentalists.

Conclusions: The high prevalence and location of playing-related musculoskeletal problems is clearly an important issue for child and adolescent instrumentalists. Gender, age and music exposure are associated with PRMP risk and need to be addressed by health care providers, music educators, parents and the instrumentalist to ensure personal well-being, optimum performance and musical longevity.

5.2 INTRODUCTION

It is well established that playing-related problems, both physical and psychological, exist among adult instrumentalists. Playing-related musculoskeletal problems (PRMP), which include muscle, nerve, bone and joint problems such as tendonitis, tenosynovitis, peripheral neuropathy and focal dystonia, have been the focus of epidemiological research in performing arts medicine. Given the pathologies of PRMP parallel those of work-related musculoskeletal disorders, it is thought the multifactorial risk factors reported in occupational medicine literature may be important for the development of PRMP in musicians. Intrinsic factors (such as gender, age, hypermobility, performance anxiety), extrinsic exposure factors (such as type of instrument, practice habits, playing environment) and interactive factors (such as playing posture) have been investigated amongst adult musicians. The association of risk factors with PRMP in the adult literature varies, due to different outcome/case definition, study design and statistical power. However, factors such as female gender and type of instrument have been associated with PRMP.

Musicians, unlike other occupations, commence their careers at early ages, yet only a few studies have investigated the prevalence of PRMP and risk factors for PRMP in children or adolescent instrumentalists. These studies have reported prevalence rates in children similar to those in adults. However, the available prevalence evidence is limited and the relevance of known risk factors for adults remains unclear for the child instrumentalist.

In pain literature, the experience of spinal pain in adolescence has been associated with an increased risk of spinal pain in adulthood (Hertzberg 1985; Brattberg 2004). It is therefore imperative to understand PRMP in childhood and establish specific risk factors for the development of PRMP in this group of musicians, in order to prevent problems in later years.

PRMP in adult musicians have been classified into 1) mild aches and pains, experienced during and following playing, that may or may not affect performance (playing-related musculoskeletal symptoms, PRMS); and 2) pain, weakness, lack of control, numbness, tingling, or other symptoms that interfered with the ability to play the instrument as usual (playing-related musculoskeletal disorders, PRMD) (Zaza 1995). Examining PRMS in children may enable earlier detection and prevent the deterioration of symptoms and function, and subsequent development of more disabling disorders.

5.2.1 Prevalence of Playing-Related Musculoskeletal Problems

Lifetime and monthly prevalence rates of 40-70% have been reported amongst professional musicians (Fry 1986a; Zaza 1995), and 9-90% amongst tertiary students (Fry 1987; Zetterberg et al. 1998). A detailed review of prevalence rates amongst different groups of musicians by Ranelli et al. (Ranelli et al. 2008) found similar rates, 20-70%, have been reported amongst children instrumentalists (Fry et al. 1988; Lockwood 1988; Birkedahl 1989; Fry and Rowley 1989; Grieco et al. 1989; Brown 1997; Betuel and Clairet 1999; Roset-Llobet et al. 2000; Britsch 2005). The varied rates may be attributed to differing case definitions, method of data collection (e.g. questionnaire versus physical examination) and small sample sizes. There is a clear need for a large sample study with clear case definitions to provide more definitive symptom and disorder prevalence rates for children.

5.2.2 Risk Factors for Playing-Related Musculoskeletal Problems

5.2.2.1 Gender

The majority of existing studies of children have reported a higher prevalence of PRMP for females than males (Fry et al. 1988; Lockwood 1988; Fry and Rowley 1989; Shoup 1995; Betuel and Clairet 1999; Britsch 2005). These studies were limited by lack of statistical comparisons and/or poor PRMP definitions thus better quality evidence regarding the importance of gender as a risk factor for child instrumentalists is required.

In adults, females were more likely to report PRMP compared to males (Fry 1986a; c; 1987; Fishbein et al. 1988; Manchester 1988; Revak 1989; Roach et al. 1994; Fjellman-Wiklund and Sundelin 1998; Yeung et al. 1999; Roset-Llobet et al. 2000; Kaneko et al. 2005; Abreu-Ramos and Micheo 2007) and two times more at risk of developing PRMD (Zaza and Farewell 1997). This trend is also documented in broader pain literature (in adults and children) and occupational health literature reinforcing the importance of understanding this factor for child instrumentalists.

5.2.2.2 Age

There is no clear evidence for age as a risk factor for PRMP within childhood. Studies that have considered child age merely reported descriptives (Fry 1986c; Dawson 1988; Grieco et al. 1989; Betuel and Clairet 1999; Roset-Llobet et al. 2000) or overall prevalence rates (Fry and Rowley 1989; Roset-Llobet et al. 2000). A cross-sectional survey of 97 students aged between 4-18 years and a retrospective review of 314 students aged 18 years and younger, found no association between age and playing-related injuries (Burkholder and Brandfonbrener 2004; Britsch 2005).

In adults, there is no consensus with respect to age as a risk factor for PRMP (Pak and Chesky 2001; Kaneko et al. 2005; Abreu-Ramos and Micheo 2007). However, there is evidence that the prevalence of other musculoskeletal problems such as spinal pain increases rapidly over adolescence (Balague et al. 1988; Leino et al. 1994; Taimela et al. 1997) and adolescent symptoms have been linked to symptoms in adulthood (Hertzberg 1985; Harreby et al. 1995; Siivola et al. 2004). Therefore it is important to identify any association between age and PRMP over childhood and adolescence.

5.2.2.3 Music Exposure

Music exposure can be categorized into: amount (such as time spent playing) or nature of the task (such as type of instrument). These factors may be confounded by age and gender. For example, the child instrumentalist may practice for longer as they progress with their instrumental instruction over the years.

5.2.2.4 Time spent playing

The time children spent playing musical instruments varied greatly in prior reports as some reported practice times only and others reported total playing time. Mean practice times ranged from 0.8 hours per day in 49 students aged 13-18 years (Fry et al. 1988) to 3.3 hours per day in 169 students aged 7-19 years (Fry and Rowley 1989). However practice times may not capture total exposure, thus others have reported total playing time. Mean total playing time reported ranged from 7.6 hours per week in 425 junior and senior high students (aged 12-18years) (Shoup 1995) to 19 hours per week in 131 secondary school students (aged 12-18 years)(Lockwood 1988). Only Fry (1988) reported a positive association between practice time and PRMP.

Adult studies also reported varied time spent playing. Zaza (1995) surveyed daily playing times which included individual practice, rehearsing and performing and further sought information on how many hours was played on a “busy” and “light” day and practice habits before differing situations (e.g. exams, audition). Professionals spent an average of 27.4 hours per week playing whilst tertiary students spent 17.9 hours per week. A busy day for professionals meant up to 7.4 hours of playing and for students, 4.8 hours. A “light” day involved 3.1 hours for professionals and 2.1 hours for students. Students increased practice time before exams or auditions. There was a positive association for increased playing time and problems, though not significant. Other studies reported time playing as an average per day, such as 2.8 hours per day amongst 227 tertiary music students (Zetterberg et al. 1998), or average per week such as 11.4 hours per week amongst 1639 Spanish tertiary music students and professional musicians as a collective group (Roset-Llobet et al. 2000). The association between practice time and PRMPs was positive in some studies (Hiner et al. 1987; Manchester and Flieder 1991) but not others (Roach et al. 1994; Zaza and Farewell 1997; Zetterberg et al. 1998; Yeung et al. 1999). Musicians have identified the sudden increase in time spent practicing, usually prior to performances and exams for tertiary students, as a risk factor for the experience of increased symptoms (Fry 1987; Newmark and Hochberg 1987; Dawson 1988; Manchester 1988; Amadio and Russotti 1990; Manchester and Flieder 1991). Further evidence is therefore needed to clarify the association of time spent playing and PRMP in children.

5.2.2.5 Number of instruments

No study has reported the relationship between the number of instruments played by a child and PRMP. Playing more than one instrument may mean an increase in the amount of time spent practicing which may increase the risk of PRMPs. Conversely, playing a different second or third instrument may add task variety (change in exposure pattern), which in the occupational health literature has been associated with a decreased risk for the development of musculoskeletal disorders (Fernstrom and Aborg 1999; Christensen et al. 2000; Mathiassen et al. 2003; Mathiassen 2006). Understanding the association between the number of instruments played and PRMP in child instrumentalists is therefore likely to be important to help minimise PRMP in children.

5.2.2.6 Number of years playing main instrument

Whilst Shoup (1995) reported an average of 4.1 years was spent playing the primary instrument (5.1 years for high school and 3.4 years for junior school), no studies in children were found that reported an association between the years spent playing the main instrument and PRMP. However, amongst adult musicians the number of years a musician has played their main instrument has been positively associated with PRMP (Zaza 1995; Roset-Llobet et al. 2000; Yoshimura et al. 2006). Years of instrument playing may therefore be an important risk factor for child instrumentalists but this is currently unknown.

5.2.2.7 Instrument Type

It has been well documented that individual instruments/classes of instruments are associated with specific problems. Postures adopted, weight of the instrument, force required and physiological demands associated with particular instruments are thought to be contributing factors for the risk for PRMP peculiar to an instrument. Brandfonbrener (2000a) highlighted strings and keyboards were at increased risk for PRMP due to the greatest number of repetitive actions. In occupational medicine literature, force, repetition and posture have been identified as the main ergonomic factors to increase the risk of WRMD (Armstrong and Silverstein 1987; Moore et al. 1991; Stock 1991) further supporting the likely importance of instrument type as a risk factor.

However, only one childhood study has reported an association between instrument type and PRMP. Lockwood (1988) reported PRMPs in all evaluated instrument categories, with large strings (cello and bass) more associated with PRMPs than small strings (violin and viola). However they did not evaluate keyboard risk. Other small childhood studies (Dawson 1988; Fry and Rowley 1989; Betuel and Clairet 1999) have reported prevalence rates by instrument group but have not provided evidence of an association between instrument type and PRMP. Fry (1989), in a survey of 168 music students (aged 7 – 19 years), reported most problems in string (76%), woodwind (75%), keyboard (71%) and brass (57%) players. Betuel (1999) reported a high prevalence of spinal pain amongst woodwind and plucked string (harp and guitar) players. Dawson (1988) reported problems in one of 7 woodwind players.

In adults a higher prevalence of PRMPs has been reported in string (Newmark and Lederman 1987; Fishbein et al. 1988; Zaza and Farewell 1997; Fjellman-Wiklund and Sundelin 1998) and keyboard players (Hochberg et al. 1983; Newmark and Hochberg 1987; Fry 1988; Roset-Llobet et al. 2000; Sakai 2002; Brandfonbrener 2003; Bragge 2006). Woodwind and brass players often have lower risk with percussion players at the least risk of problems (Fishbein et al. 1988; Middlestadt and Fishbein 1989; Zaza 1998; Brandfonbrener 2003). Amongst tertiary music students, string, keyboard, woodwind and brass instrumentalists have been reported to have a high prevalence of problems (Fry 1987; Pratt et al. 1992; Zetterberg et al. 1998).

Thus the evidence from occupational literature and adult and tertiary student instrumentalist literature suggests the type of instrument may be an important risk factor for child instrumentalists but this is currently unknown.

5.2.3 Playing-Related Musculoskeletal Problem Locations

5.2.3.1 Number of PRMP locations

No studies in children were found which documented the number of areas in which PRMP were experienced. One adult study reported that 55% (80/145) of musicians with pain reported problems at three or more locations, and found a significant correlation between pain intensity and number of reported pain sites (Kaneko et al. 2005). Other studies merely reported prevalence for one or more musculoskeletal complaints (Fry 1986c; Chesky et al. 2002; Fjellman-Wiklund and Chesky 2006; Yoshimura et al. 2006). No study was found which investigated the association between the number of pain areas and risk factors.

5.2.3.2 PRMP Location

Child instrumentalist studies have reported some information on the location of PRMP. Betuel (1999) reported higher prevalence rates of spinal pain amongst adolescents (76%) than adults (70%) and children (51%). Neck pain was prevalent in wind, guitar and harp players; thoracic pain amongst piano players and lumbar pain in guitar and harp players. Shoup (1995) found most problems occurred in the left wrist, hand and fingers, the right fingers, forearm and elbow followed by the neck in 149 junior and senior high school students. Fry (1989) investigated pain in the hands and arms related to playing (71%) in 168 music students compared to pain in the hands and arms related to hand use such as writing (50%) in 348 non music students. Left (30.5%) upper limb pain, specifically, wrist and fingers, was more prevalent than right upper arm pain (13.8%) in a small group (n=36) of 10-22 year old music students (Brown 1997). However, all of these studies were limited by their data analysis which at best reported prevalence of PRMP location, but no statistical comparisons or evidence of an association between potential risk factors (such as gender or instrument type) and PRMP location.

Numerous studies in adults, professionals and tertiary students, have investigated the location of PRMP and there is overwhelming consensus that the upper extremities and the neck are the most commonly reported problem areas (Fry 1986a; c; Lederman and Calabrese 1986; Fry 1987; Fishbein et al. 1988; Hoppmann and Patrone 1989; Lockwood 1989; Revak 1989; Brandfonbrener 1990; Zaza 1995; Zaza and Farewell 1997; Roset-Llobet et al. 2000; Dawson 2002; Nyman et al. 2007). Only a few studies investigated the association between PRMP in specific locations and risk factors. Nyman (2007), in a cross-sectional survey of 235 professional musicians, found a higher prevalence of neck-shoulder pain in musicians playing in an elevated arm position (greater than 40°) compared to those playing in a neutral arm position. Wahlstrom Edling (2009) found music teachers playing instruments that required asymmetric postures (bowed strings, flute, trombone and guitar) reported significantly greater number of neck, shoulder and back problems compared to teachers playing instruments that required symmetric postures (clarinet, oboe, bassoon, trumpet, piano and percussion). Fjellman-Wiklund (2003) reported the strongest risk factors associated with neck-shoulder discomfort in music teachers (after adjusting for age) were high psychological demand and teaching at more than four schools per week for females, and playing the guitar, manual handling (lifting instruments) and low social support for male teachers.

Some adult studies have described areas of PRMP with respect to specific instruments or instrument class. The majority of studies corroborate findings with regard to most commonly reported areas of pain for instrument type. Piano players most commonly reported problems affecting both hands, the right more than the left, with the specific requirements of repertoire, posture of the wrist and hands, and technique amongst some of the factors thought to contribute to this pattern of involvement (Hochberg et al. 1983; Knishkowy and Lederman 1986; Sakai 1992; Van Reeth et al. 1992; Brandfonbrener 2000a; Dawson 2002; Sakai 2002). For upper string players, the left hand/arm and shoulder were more commonly involved than the right hand/arm, in addition the neck and mid back may be affected (Middlestadt and Fishbein 1989; Brandfonbrener 2000a; Dawson 2002; Ackerman and Adams 2003). Problems in the left upper extremity may be explained by the asymmetric and extreme postures adopted and the specific techniques necessary to produce particular sounds (Brandfonbrener 1990; Wahlstrom Edling and Fjellman-Wiklund 2009). In lower string players, more right hand and right shoulder problems have been reported than the left hand and shoulder, potentially due to the hand grip of the bow and bowing technique (Zaza and Farewell 1997; Zetterberg et al. 1998; Brandfonbrener 2000a). Middlestadt (1989) found the prevalence of right shoulder problems to be high across all upper and lower string instrumentalists and surmised the bowing action common to all instruments placed them equally at risk for right shoulder problems. In the occupational literature EMG studies found high static hand grip force with the arm in elevated positions, increased the load on stabilizing rotator cuff muscles (Sporrong et al. 1996). This supports the pattern of involvement in the bowing arm of stringed instruments.

The problems experienced by plucked string instruments centre around the playing posture, repetitive finger movements and forces required with various techniques. Fjellman-Wiklund (2006) reported a trend for left upper extremity involvement amongst various categories of guitar, the left fingers and left hand amongst acoustic guitarists, electric guitarists and electric bass players and left shoulder problems amongst banjo players. The very flexed wrists and fingers, and the requisite force to pluck, pull or depress strings, or if a pick is used the grasp required between the thumb and index finger, have been associated with distal upper extremity problems. The weight of the guitar and whether the musician is seated or standing may contribute to neck and back pain (Brandfonbrener 1990; Cameron and McCutcheon 1992; Cayea and Manchester 1998; Dawson 2002; Rigg et al. 2003; Fjellman-Wiklund and Chesky 2006). For harpists, the degree of shoulder abduction, wrist hyperextension and the force of pull of the fingers against the strings are thought to contribute to upper extremity and back problems (Brandfonbrener 1990).

In woodwind players, problems are thought to be due to the position of support of the instrument. For example, the right hand, specifically the thumb, is the most common problem for clarinet and oboe players and the left hand for flautists. Other problems in the hand/elbow are thought to be from repetitively closing open holes or due to the force required to depress keys for sound production(Brandfonbrener 1990; 2000a).

Brass instrumentalists have reported high prevalence rates for the low back (20%), left and right wrist and fingers, left and right neck and right shoulder problems. Low brass musicians most commonly reported problems in the low back and right wrist and trombonists reported highest rates for the left shoulder, left hand and wrist (Chesky et al. 2002). Embouchure problems are most common in both brass and woodwind instrumentalists (Brandfonbrener 2000a). For the musician with hypermobile joints, more effort may be required to prevent the collapse of joints under pressure, and this subsequent increase in muscle tension may compound problems (Brandfonbrener 2000a).

The location of PRMP related to specific instrument/instrument class in child instrumentalists is important to inform prevention initiatives, yet is currently unknown.

5.3 AIMS

The majority of studies of PRMP prevalence and risk factors have been conducted on adult musicians with very limited evidence on children. To best inform prevention and management strategies, clear evidence is needed to identify if gender, age and music exposure factors are associated with PRMP in children. Therefore the aims of this study were to:

1. Establish the prevalence of PRMP (lifetime, monthly PRMS and monthly PRMD) and determine its relationship with music exposure factors: type of

instrument, number of instruments played and playing time, adjusting for gender and age

2. Establish the prevalence of PRMP in different locations and determine differences with gender, age and instrument type
3. Examine the independent associations of gender, age and music exposure (instrument type, number of instruments played, playing time and years of playing) with PRMP in each body location

5.4 METHODS

5.4.1 Sample

731 students (460 females) aged between 7 and 17 years (mean 12.7 yrs, sd 2.0yrs) participating in the School of Instrumental Music program across government schools in Perth, Western Australia, were surveyed from August to December 2003. The process of school selection ensured a representative sample from a range of socioeconomic areas, a range of ages and of instruments. Secondary (senior high) schools were selected and invited to participate then their feeder primary (elementary and junior) schools with high instrumental numbers were selected. In total five secondary schools and six primary schools participated. The process has been reported previously (Ranelli et al. 2008) and is summarised in Figure 5.1. All instrumental classes at the selected schools were sampled. The School of Instrumental Music is a program that provides free instrumental instruction to students and has guidelines with respect to the age of commencement for instruments. For example upper strings are commenced from seven years of age (violin at seven and viola at eight years of age), woodwind instruments from the age of 10 years and plucked strings from the age of 11 years. Students however may have commenced playing such instruments at an earlier age through private instruction. This study was approved by the Curtin University of Technology Human Research Ethics Committee (HR234/2002).

5.4.2 Variables

Students completed a music specific version of the Young people's Activity Questionnaire (YAQ) (Harris and Straker 2000). The survey focused on the experience of PRMS, ("any soreness anywhere"), during their playing career and within the past month (once a month, once a week, two to three times a week or daily) and the experience of a PRMD ("instrument playing-related soreness, tingling or weakness which stopped you playing your instrument as well as you usually play?") within the past month. Children reported the location of their symptoms on a body diagram (neck, mid back, low back, left and right upper and lower limbs, face) and rated the severity of symptoms for each location (visual analogue scale, 0, no soreness, to 10, extreme soreness). The number of pain locations was tallied.

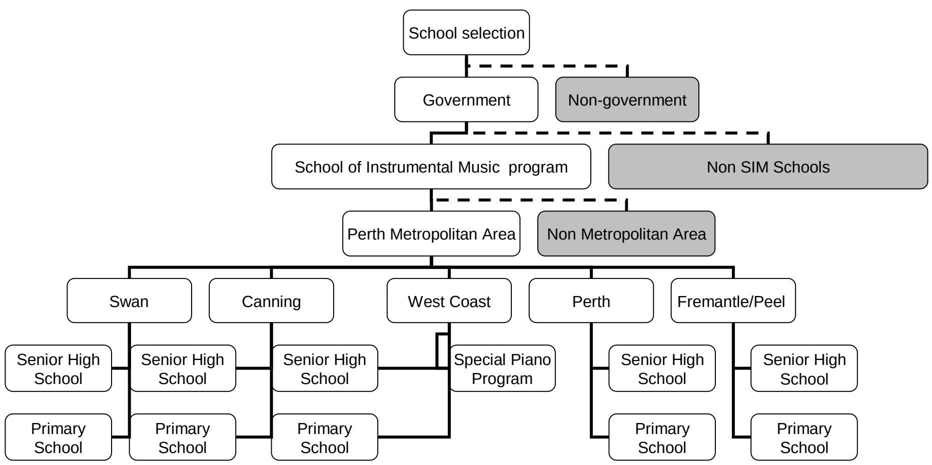

Figure 5.1 Process of school selection.

Other music specific questions covered music experience, such as type of instrument played as main, second and third; number of instruments played (one, two or three), years spent playing any and main instruments and practice habits, such as time spent playing (student playing diaries recorded type of playing, practice, rehearsals, recitals and for how long) (hours per week) and taking breaks (never, almost never, sometimes, most times, always). The remaining general questions covered children's age, gender, year at school, hand dominance and general musculoskeletal complaints, general activity habits such as watching television, participation in physical activities, use of computers and hand intensive activities such as art and hand writing.

For the purpose of this paper, the covariates age, gender, instrument type, number of instruments played time spent playing, time spent playing main instrument and number of PRMP locations were modelled to assess their independent prediction of PRMP location (Table 5.1).

Table 5.1 Covariates examined for Playing-Related Musculoskeletal Problem risk

Covariate		
Age (years)(mean, sd)		
	12.7	(2.0)
Gender	460 (63%)	Female
Instrument Type Main, second or third	See Table 5.2	
Number of instruments		
1	403	(55%)
2	280	(38%)
3	48	(7%)
Number of pain locations		
1	184	(25%)
2	110	(15%)
3 or more	114	(16%)
Time spent playing (hrs/week)		
(median, IQR)	5.3	(4.8)
Time since playing instrument (years)		
Any (mean (sd))	4.7	(2.8)
Main (mean (sd))	3.6	(2.5)

5.4.3 Procedures

Children completed the questionnaire in class under the supervision of their instrumental teacher. For the very young students, parents were able to assist in class with the completion of the questionnaire. Questionnaires took approximately 20 minutes to complete. The first author was present to answer queries and performed height and weight measurements (using a wall based tape measure and a digital scale respectively).

5.4.4 Data Analysis

Descriptive statistics are presented for prevalence rates of Playing-Related Musculoskeletal Problems (PRMP) with prevalence rates calculated as a percentage of the whole sample. Median and interquartile range (IQR) are presented for non-normally distributed outcomes. Chi square analysis was used to examine relationships between categorical covariates and PRMP.

Univariable logistic regression analyses were performed to estimate the unadjusted association of each independent variable for PRMP outcome. Age was parameterized as categorical rather than continuous when exploratory plots indicated a nonlinear relationship with outcome. Instruments were grouped into categories when evaluating the association between instrument class (upper, lower and plucked strings, woodwind, brass, percussion and piano) and PRMP location A series of multivariate, backward stepwise logistic regression analyses (entry level significance set to 0.05 and removal 0.06) (one for each PRMP location) were performed to estimate the association of each variable independent of other covariates. Analyses were performed using SPSS software, version 17 (SPSS Inc., Chicago, IL).

5.5 RESULTS

5.5.1 Prevalence

67% (489) children reported a lifetime prevalence of PRMS, 56% (412) reported the experience of symptoms within the past month and 30% (219) reported a PRMD, that is, they were unable to play their instrument as usual.

5.5.1.1 Gender and Age

After adjusting for age, females remained more likely to report problems than males (OR=1.6-1.7, p=0.004-0.014). Adjusting for gender, increased age remained significantly associated with PRMP (OR=1.2, p=0.003) (Table 5.5). There was no significant interaction effect between gender and age for PRMP (p=0.138-p=0.189).

5.5.2 Music Exposure

5.5.2.1 Time spent playing

Children spent a mean of 5.3 hours (IQR 4.8hours, range 17 minutes-41 hours) playing per week, with no difference between females and males. Playing time per week increased with age (Kruskal-Wallis χ^2=137.77, df (10), p<0.001). An increase in playing time of an hour was associated with a 5-7% increase in the odds for lifetime PRMS (p=0.014) and monthly PRMS (p=0.001)(see Table 5.4). The association between playing time remained significant for monthly PRMS only after adjusting for other covariates (such as gender and age) (see Table 5.5).

5.5.2.2 Number of instruments played

55% (403) children played one instrument only, 38% (280) played two instruments and 7% (48) played three instruments. There was no significant difference between genders in the number of instruments played (Fisher's exact test=0.78, p=0.97). The number of instruments played increased with age (F=9.51, df (2),p<0.001) (Figure 5.2). Playing three instruments in comparison to only one instrument *decreased* the odds for lifetime PRMS (p=0.023) and monthly PRMS (p=0.019) after adjusting for other covariates (see Table 5.5).

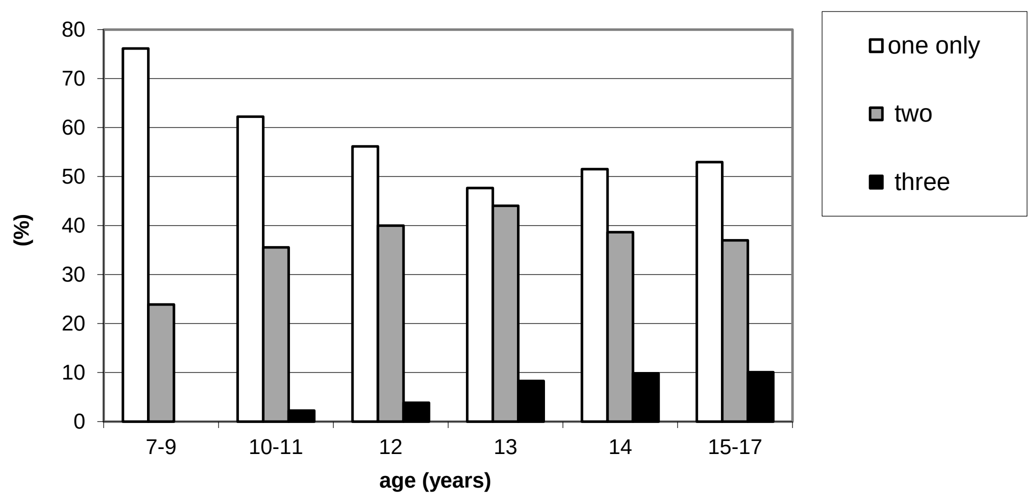

Figure 5.2 Percentage of children playing only one (n=403), two (n=280) or three (n=48) instruments across age groups.

Table 5.2 Number of children playing instruments at all and as nominated main, second and third instrument

Instrument	Played at all	Played as main instrument	Played as 2nd instrument	Played as 3rd instrument
piano	304	130	160	14
violin	135	113	22	-
viola	23	18	5	-
cello	58	50	7	1
bass	24	18	6	-
clarinet	114	95	15	4
flute	85	61	20	4
oboe	15	13	2	-
bassoon	11	7	4	-
saxophone	48	36	11	1
piccolo	2	-	2	-
trumpet	52	41	8	3
trombone	32	23	7	2
tuba	8	6	2	-
euphonium	16	12	3	1
French horn	19	19	-	-
baritone	4	3	1	-
cornet	1	-	-	1
guitar	108	63	31	14
harp	1	1	-	-
percussion	46	22	21	3
other	3	-	3	-
Total	**1109**	**731**	**330**	**48**

5.5.2.3 Instrument type

The most commonly played instruments were piano (42%), violin (19%), clarinet (16%), guitar (15%) and flute (12%) (Table 5.2). The piano, violin and clarinet were most frequently played as the main instrument, with piano most commonly played as a second (and third) instrument.

There was a significant association between gender and type of instrument played for main instrument group (χ^2=63.01, df (6), $p<0.001$) with more females playing upper strings (21.3%:11.1%) and woodwind (33.9%:19.2%) than males, and more males playing brass (24.7%:8.3%) than females (Figure 5.3). The School of Instrumental Music has guidelines with respect to age of commencement of certain instruments, thus there was an association between age and instrument type (F=19.30, df (6), $p<0.001$). For example younger children played upper strings and older children tended to play woodwind, brass and plucked string instruments. The piano was played equally across age groups (Figure 5.4).

5.5.3 Instrument Type and Prevalence of PRMP

Prevalences of PRMP for instrument type and category are presented in Table 5.3. The piano demonstrated the lowest prevalence for all PRMP outcomes and was selected as the referent for subsequent analysis. A number of instruments showed significantly greater unadjusted odds for PRMP as compared to piano (see Table 5.4). The lower string category with the double bass and cello, and woodwind category with saxophone and flute, demonstrated very high odds for all PRMP compared to piano. After adjusting for gender and age and other covariates, all contrasts remained significant except for the clarinet and guitar (see Table 5.5).

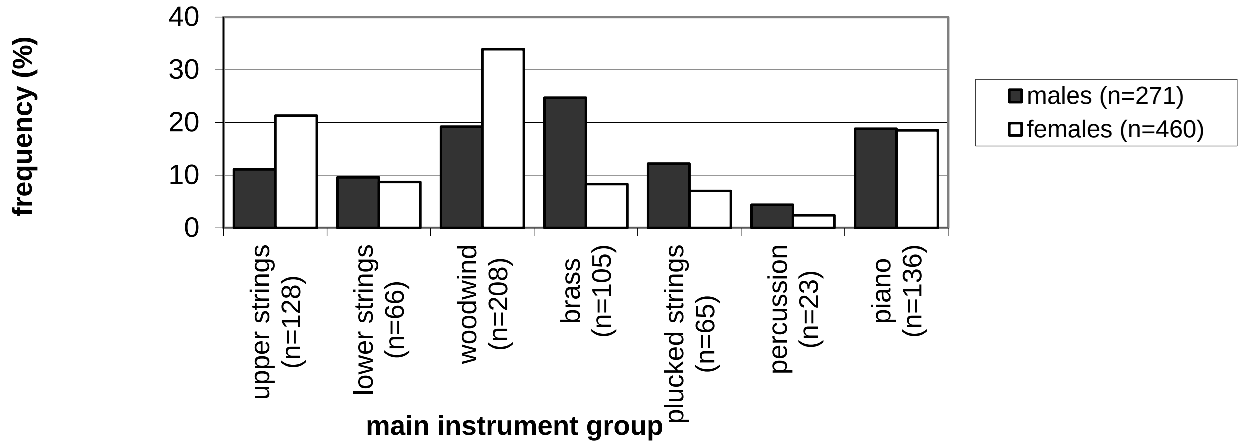

Figure 5.3 Main instrument groups played and gender

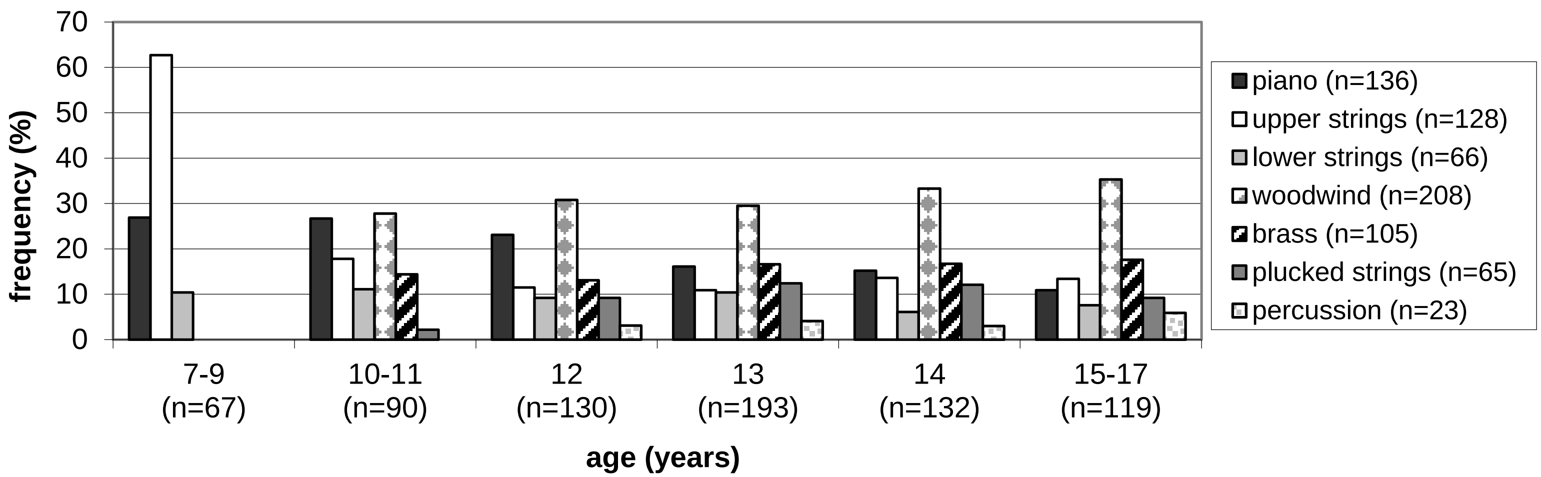

Figure 5.4 Main instrument groups played across age groups.

Table 5.3 Prevalence estimates and 95% confidence intervals for Playing-Related Musculoskeletal Problems related to specific instruments and instrument categories (continued)

	Lifetime Playing-Related Musculoskeletal Symptoms		Monthly Playing-Related Musculoskeletal Symptoms		Playing-Related Musculoskeletal Disorders	
Instrument Type	Prevalence proportion	95% Confidence Interval	Prevalence proportion	95% Confidence Interval	Prevalence proportion	95% Confidence Interval
Piano n=130	0.52	0.44-0.61	0.44	0.35-0.52	0.18	0.11-0.24
Upper Strings n=131	0.66	0.58-0.74	0.56	0.47-0.64	0.30	0.22-0.38
Violin n=113	0.65	0.57-0.74	0.54	0.45-0.63	0.29	0.21-0.38
Viola n=18	0.67	0.45-0.88	0.67	0.45-0.88	0.33	0.12-0.55
Lower Strings n=68	0.76	0.66-0.87	0.68	0.57-0.79	0.37	0.25-0.48
Cello n=50	0.72	0.60-0.84	0.64	0.51-0.77	0.36	0.23-0.49
Double bass n=18	0.89	0.74-1.00	0.78	0.59-0.97	0.39	0.16-0.61
Woodwind n=212	0.76	0.71-0.82	0.63	0.56-0.69	0.33	0.27-0.39
Clarinet n=95	0.71	0.61-0.80	0.59	0.49-0.69	0.32	0.22-0.41
Flute n=61	0.79	0.68-0.89	0.62	0.50-0.74	0.33	0.21-0.45
Oboe n=13	0.85	0.65-1.04	0.54	0.27-0.81	0.23	0.00-0.46
Bassoon n=7	0.71	0.38-1.05	0.57	0.20-0.94	0.29	0.00-0.62
Saxophone n=36	0.86	0.75-0.97	0.78	0.64-0.91	0.42	0.26-0.58

Table 5.3 Prevalence estimates and 95% confidence intervals for Playing-Related Musculoskeletal Problems related to specific instruments and instrument categories (continued)

Instrument Type	Lifetime Playing-Related Musculoskeletal Symptoms		Monthly Playing-Related Musculoskeletal Symptoms		Playing-Related Musculoskeletal Disorders	
	Prevalence proportion	95% Confidence Interval	Prevalence proportion	95% Confidence Interval	Prevalence proportion	95% Confidence Interval
Brass n=104	0.58	0.48-0.67	0.52	0.42-0.62	0.33	0.24-0.42
Trumpet n=41	0.59	0.43-0.74	0.54	0.38-0.69	0.34	0.20-0.49
Trombone n=23	0.65	0.46-0.85	0.52	0.32-0.73	0.30	0.12-0.49
Tuba n=6	0.50	0.10-0.90	0.50	0.10-0.90	0.17	0.00-0.46
French horn n=19	0.63	0.41-0.85	0.58	0.36-0.80	0.42	0.20-0.64
Euphonium n=12	0.42	0.14-0.70	0.33	0.07-0.60	0.25	0.01-0.50
Baritone n=3	0.33	0.00-0.87	0.67	0.13-1.00	0.33	0.00-0.87
Guitar n=63	0.71	0.60-0.83	0.56	0.43-0.68	0.32	0.20-0.43
Percussion n=22	0.68	0.49-0.88	0.59	0.39-0.80	0.32	0.12-0.51

*Note that analyses were performed on instruments as categories (e.g., upper strings and lower strings) and then on all individual instruments (e.g., violin, viola).

Table 5.4 Unadjusted logistic regression odds ratio estimates (95%CI) for all independent variables for the three outcome measures of Playing-Related Musculoskeletal Problems (instruments analysed both separately and in categories) (continued)

COVARIATE		Lifetime Playing-Related Musculoskeletal Symptoms			Monthly Playing-Related Musculoskeletal Symptoms			Playing-Related Musculoskeletal Disorders		
unadjusted OR		Odds Ratio	95% CI	P value	Odds Ratio	95% CI	P value	Odds Ratio	95% CI	P value
Gender (female)		**1.38**	1.01-1.89	0.046	**1.56**	1.15-2.11	0.004	**1.46**	1.04-2.04	0.028
Age (years)		**1.23**	1.14-1.33	<0.001	**1.19**	1.11-1.29	<0.001	**1.19**	1.08-1.29	<0.001
Total practice time (hrs/week)		**1.05**	1.01- 1.10	0.014	**1.07**	1.03-1.11	0.001	1.04	0.99-1.08	0.070
Number of instruments played	1	1.0			1.0			1.0		
	2	1.09	0.79-1.52	0.595	1.16	0.85-1.59	0.336	1.23	0.88-1.71	0.227
	3	0.58	0.32-1.07	0.079	0.68	0.37-1.23	0.202	0.84	0.42-1.66	0.607
INSTRUMENT*										
PIANO n=130		1.0			1.0			1.0		
UPPER STRINGS n=131		**1.74**	1.06-2.87	0.029	1.61	0.99-2.63	0.056	**1.97**	1.10-3.54	0.023
Violin n=113		**1.73**	1.03-2.91	0.038	1.50	0.91-2.49	0.115	**1.92**	1.05-3.52	0.035
Viola n=18		1.82	0.65-5.15	0.257	2.56	0.91-7.24	0.076	2.33	0.79-6.84	0.125
LOWER STRINGS n=68		**2.96**	1.54-5.72	0.001	**2.68**	1.45-4.95	0.002	**2.71**	1.39-5.27	0.003
Cello n=50		**2.35**	1.16-4.75	0.018	**2.28**	1.16-4.47	0.017	**2.62**	1.26-5.44	0.010
Double bass n=18		**7.29**	1.61-33.01	0.010	**4.48**	1.40-14.36	0.012	**2.96**	1.04-8.45	0.043

Table 5.4 Unadjusted logistic regression odds ratio estimates (95%CI) for all independent variables for the three outcome measures of Playing-Related Musculoskeletal Problems (instruments analysed both separately and in categories) (continued)

COVARIATE	Lifetime Playing-Related Musculoskeletal Symptoms			Monthly Playing-Related Musculoskeletal Symptoms			Playing-Related Musculoskeletal Disorders		
unadjusted OR	Odds Ratio	95% CI	P value	Odds Ratio	95% CI	P value	Odds Ratio	95% CI	P value
WOODWIND n=212	**2.95**	1.85-4.72	<0.001	**2.16**	1.38-3.36	0.001	**2.29**	1.35-3.91	0.002
Clarinet n=95	**2.18**	1.25-3.82	0.006	**1.84**	1.08-3.14	0.026	**2.15**	1.15-4.01	0.016
Flute n=61	**3.37**	1.67-6.80	0.001	**2.12**	1.14-3.95	0.018	**2.27**	1.13-4.57	0.022
Oboe n=13	**5.02**	1.07-23.52	0.041	1.49	0.48-4.69	0.492	1.40	0.36-5.47	0.633
Bassoon n=7	2.28	0.43-12.18	0.335	1.71	0.37-7.94	0.495	1.86	0.34-10.19	0.474
Saxophone n=36	**5.65**	2.07-15.45	0.001	**4.48**	1.90-10.58	0.001	**3.32**	1.49-7.40	0.003
BRASS n=104	1.24	0.74-2.09	0.411	1.38	0.82-2.32	0.219	**2.26**	1.23-4.15	0.009
Trumpet n=41	1.29	0.63-2.62	0.486	1.48	0.73-3.00	0.273	**2.41**	1.10-5.30	0.028
Trombone n=23	1.71	0.68-4.31	0.256	1.40	0.58-3.40	0.461	2.04	0.75-5.51	0.162
Tuba n=6	0.91	0.18-4.69	0.912	1.28	0.25-6.59	0.767	0.93	0.10-8.35	0.949
French horn n=19	1.56	0.579-4.22	0.378	1.76	0.67-4.67	0.255	**3.38**	1.23-9.35	0.019
Euphonium n=12	0.65	0.20-2.16	0.483	0.64	0.18-2.23	0.484	1.55	0.40-6.18	0.534
Baritone n=3	0.46	0.04-5.15	0.526	2.56	0.23-28.96	0.447	2.33	0.20-26.75	0.498
GUITAR n=63	**2.28**	1.20-4.35	0.012	1.60	0.87-2.93	0.128	**2.16**	1.08-4.34	0.030
PERCUSSION n=22	1.95	0.75-5.11	0.172	1.85	0.74-4.63	0.189	2.17	0.80-5.92	0.130

*Note that analyses were performed on instruments as categories and then on individual instruments. For guitar and percussion, values for both analyses were identical.

Table 5.5 Adjusted logistic regression odds ratio estimates (95%CI) for multivariate models including all independent variables for the three outcome measures of Playing-Related Musculoskeletal Problems (continued)

COVARIATE		Lifetime Playing-Related Musculoskeletal Symptoms			Monthly Playing-Related Musculoskeletal Symptoms			Playing-Related Musculoskeletal Disorders		
Adjusted OR		OR	95% CI	p value	OR	95% CI	p value	OR	95% CI	p value
Gender (female)		1.39	0.97-2.00	0.057	**1.67**	1.17-2.37	0.004	**1.62**	1.10-2.38	0.014
Age (years)		**1.22**	1.10-1.35	<0.001	**1.17**	1.06-1.28	0.002	**1.17**	1.06-1.30	0.003
Total practice time (hrs/week)		1.04	0.99-1.09	0.140	**1.06**	1.01-1.11	0.025	1.01	0.97-1.06	0.614
Number of instruments played	1	1.0			1.0			1.0		
	2	1.02	0.70-1.49	0.916	1.01	0.76-1.53	0.66	1.26	0.87-1.81	0.222
	3	**0.45**	0.21-0.89	0.022	**0.44**	0.22-0.89	0.022	0.68	0.31-1.49	0.332
INSTRUMENT*										
PIANO n=130		1.0			1.0			1.0		
UPPER STRINGS n=131		**2.02**	1.18-3.47	0.010	1.67	0.99-2.83	0.053	**1.91**	1.04-3.50	0.038
Violin n=113		**2.13**	1.20-5.42	0.009	1.62	0.93-2.80	0.087	**1.94**	1.03-3.67	0.041
Viola n=18		1.38	0.47-4.05	0.560	1.89	0.65-5.53	0.245	1.65	0.55-4.95	0.376
LOWER STRINGS n=68		**3.30**	1.64-6.63	0.001	**2.93**	1.53-5.60	0.001	**2.74**	1.37-5.46	0.004
Cello n=50		**2.55**	1.20-5.42	0.015	**2.39**	1.17-4.87	0.017	**2.61**	1.22-5.57	0.013
Double bass n=18		**8.22**	1.77-38.16	0.007	**5.47**	1.65-18.15	0.005	**3.15**	1.07-9.26	0.037
WOODWIND n=212		**2.56**	1.55-4.21	0.001	**1.78**	1.11-2.87	0.017	**1.85**	1.07-3.23	0.029
Clarinet n=95		**1.89**	1.04-3.42	0.036	1.54	0.87-2.72	0.137	1.71	0.89-3.27	0.106

Table 5.5 Adjusted logistic regression odds ratio estimates (95%CI) for multivariate models including all independent variables for the three outcome measures of Playing-Related Musculoskeletal Problems (continued)

COVARIATE	Lifetime Playing-Related Musculoskeletal Symptoms			Monthly Playing-Related Musculoskeletal Symptoms			Playing-Related Musculoskeletal Disorders		
Adjusted OR	OR	95% CI	p value	OR	95% CI	p value	OR	95% CI	p value
Flute n=61	**2.86**	1.35-6.07	0.006	1.65	0.85-3.20	0.139	1.72	0.83-3.54	0.145
Oboe n=13	4.28	0.89-20.37	0.068	1.22	0.38-3.92	0.737	1.09	0.27-4.33	0.903
Bassoon n=7	1.37	0.25-7.54	0.719	0.99	0.21-4.81	0.995	1.14	0.20-6.39	0.882
Saxophone n=36	**4.83**	1.71-13.65	0.003	**4.01**	1.63-9.86	0.002	**3.11**	1.35-7.18	0.008
BRASS n=104	1.10	0.63-1.93	0.737	1.37	0.78-2.40	0.272	**2.27**	1.20-4.29	0.012
Trumpet n=41	1.17	0.54-2.54	0.690	1.59	0.74-3.45	0.233	**2.40**	1.03-5.57	0.042
Trombone n=23	1.73	0.65-4.64	0.277	1.78	0.68-4.66	0.244	2.71	0.95-7.74	0.062
Tuba n=6	0.44	0.06-3.03	0.406	0.62	0.09-4.35	0.632	0.78	0.08-7.74	0.832
French horn n=19	1.40	0.50-3.92	0.522	1.64	0.59-4.54	0.342	3.08	1.08-8.76	0.035
Euphonium n=12	0.56	0.16-1.94	0.361	0.57	0.16-2.07	0.389	1.33	0.33-5.46	0.691
Baritone n=3	0.56	0.05-6.67	0.648	2.99	0.25-36.41	0.389	3.08	0.26-36.68	0.374
GUITAR n=63	1.97	0.99-3.89	0.051	1.41	0.74-2.69	0.292	1.78	0.86-3.72	0.122
	1.99	1.01-3.94	0.048	1.45	0.76-2.77	0.261	1.81	0.87-3.78	0.115
PERCUSSION n=22	1.65	0.61-4.46	0.325	1.61	0.62-4.20	0.328	1.65	0.57-4.79	0.361
	1.68	0.62-4.55	0.310	1.66	0.63-4.34	0.303	1.66	0.57-4.86	0.352

*Instruments were analysed both separately and in categories. Significant covariates appear in boldface

5.5.4 PRMP Location

5.5.4.1 Number of reported PRMP locations

25% (184) children reported a PRMP at one location, 15% (110) children reported PRMP at two locations and 16% (114) reported PRMP at three or more locations (Figure 5). There was no association between gender and reported number of PRMP locations (χ^2=1.345 df(2); p=0.510) although there was for age. Children who reported 3 or more complaints were 0.5 years older than children who reported PRMP at one location (standard error 0.22, p=0.018). Children who reported the experience of PRMD recorded more PRMP locations than children who reported monthly PRMS (χ^2=15.512 df(2); p<0.001). This trend was significant for females (χ^2=22.03, df(2); p<0.001) but not males (χ^2=4.049, df(2); p=0.132) (Figure 5.6).

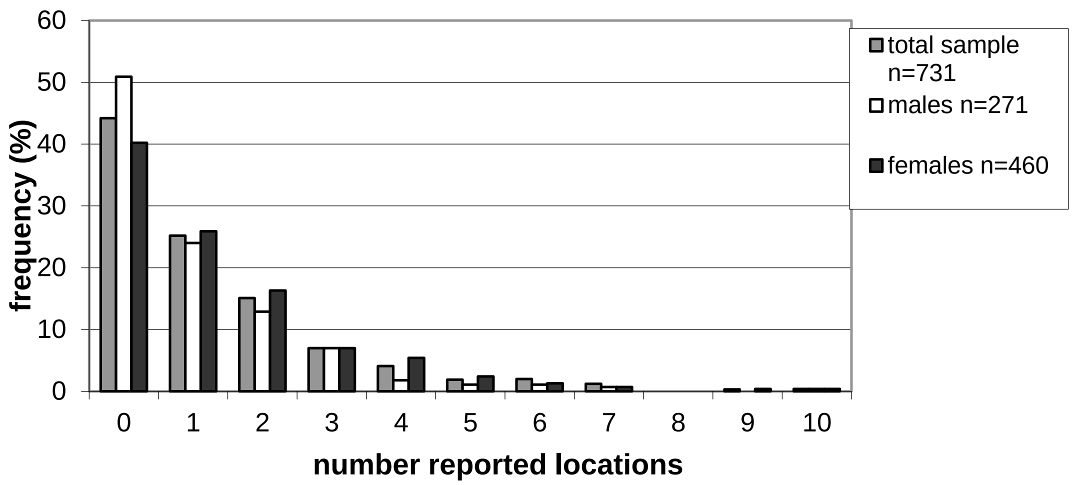

Figure 5.5 Number of reported Playing-Related Musculoskeletal Problem locations (p = 0.510).

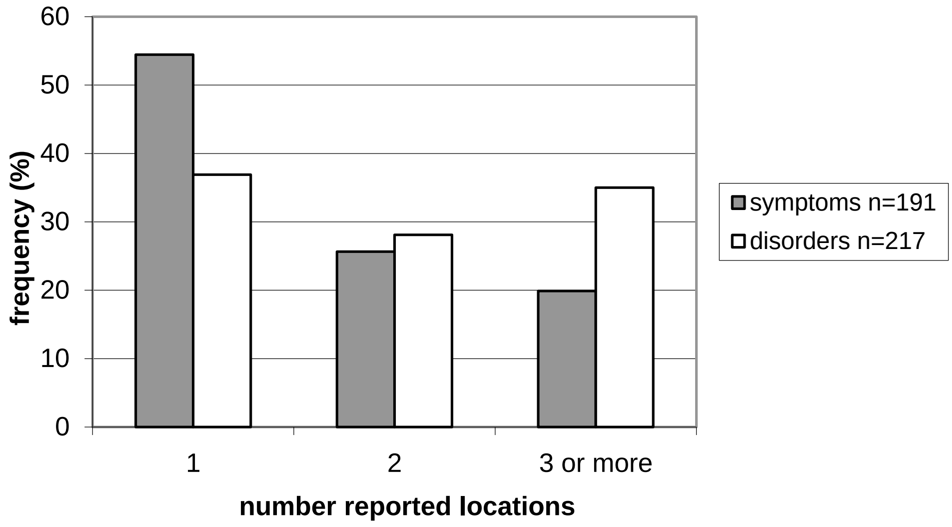

Figure 5.6 Number of reported Playing-Related Musculoskeletal Problem locations in children who reported just symptoms (PRMS) versus disorders (PRMD) ($p<0.001$).

5.5.4.2 Prevalence of PRMP in different body locations

The most commonly reported locations for PRMPs were the right (24%) and left (23%) hands, followed by the neck (16%) and the right shoulder (14%) (Table 5.6). Females reported more PRMP at all locations than males, with the exception of the mouth (Table 5.6), and there were significant differences at the neck (18.7%:11.4%; χ^2=6.680 df(1);p=0.010), mid back (10.9%:6.3%; χ^2=4.328 df(1);p=0.037), right shoulder (17.0%:8.1%; χ^2=11.281 df(1);p=0.001) and left shoulder (16.1%:5.5%; χ^2=17.76 df(1);p<0.001).

Table 5.6 Prevalence of Playing-Related Musculoskeletal Problems in different body locations

location	total		males		females	
	number	%(/731)	number	%(/271)	number	%(/460)
neck	117	16.0	31	11.4	86	18.7*
mid back	67	9.2	17	6.3	50	10.9*
low back	81	11.1	25	9.2	56	12.2
left shoulder arm	89	12.2	15	5.5	74	16.1*
left hand elbow	169	23.1	60	22.1	109	23.7
right shoulder arm	100	13.7	22	8.1	78	17.0*
right hand elbow	176	24.1	60	22.1	116	25.2
left leg	15	2.1	7	2.6	8	1.7
right leg	9	1.2	3	1.1	6	1.3
mouth	61	8.3	29	10.7	32	7.0

*Significant differences ($p < 0.05$) between genders

Spinal PRMP (neck, mid back and low back) increased with age (Figure 5.7 illustrates neck PRMP across childhood). Gender adjusted odds ratios showed the risk for neck, mid back and low back PRMP increased by 27%, 23% and 38% respectively for each additional year of age (95% CI 1.13-1.60, p<0.001- p=0.006). There was no significant interaction effect between age and gender (0.65<p<0.718/p=0.651-0.718). Upper limb PRMP showed variable patterns with age. Problems increased with age for the left shoulder (gender adjusted odds ratio showed the risk for left shoulder PRMP increased by 14% for each additional year of age (95%CI 1.01-1.29, p=0.038)) (see Figure 5.7), right hand/elbow (gender adjusted odds ratio showed the risk for right hand/elbow PRMP increased by 14% for each additional year of age (95%CI 1.04-1.25, p=0.007)). Problems peaked in mid childhood for left hand/elbow and there was no change with age for right shoulder (p=0.672). There was no significant interaction effect between age and gender for any upper limb PRMP (p=0.083-0.907). Mouth PRMP also increased with age (gender adjusted odds ratio showed the risk for mouth PRMP increased by 22% for each additional year of age (95% CI 1.05-1.43, p=0.012)). Lower limb PRMP were very low across all age groups.

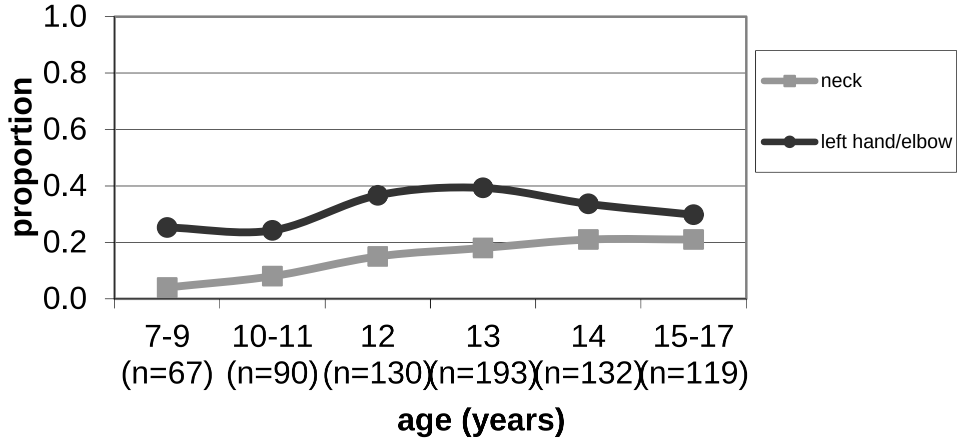

Figure 5.7 Proportion estimates for neck and left hand Playing-Related Musculoskeletal Problems across age groups.

5.5.5 Instrument Type and PRMP Location

The prevalence of PRMP in different locations for each type of instrument is illustrated in Figures 5.8, 5.9 and 5.10. Upper string players reported most problems in the neck (25%), followed by the left hand/elbow (24.2%) and left shoulder (22.7%). Lower string players reported most problems in the right shoulder (34.8%), right hand/elbow (33.3%) and left hand/elbow (28.8%). Plucked strings reported most problems in the left hand/elbow (38.5%) and right hand/elbow (33.8%). Upper strings and plucked strings demonstrated significantly higher odds ratios (95%CI) for the risk of neck PRMP than lower strings (OR = 7.00 (2.06-23.84), p=0.002; 3.82 (1.00-14.58), p=0.050 respectively). Plucked strings demonstrated significantly higher odds ratios (95%CI) for the risk of right hand/elbow (3.13 (1.53-6.40), p=0.002) and left hand/elbow (1.96 (1.03-3.72), p=0.04) PRMP compared to upper strings. Lower strings demonstrated significantly higher odds ratios (95%CI) for right hand (3.06 (1.50-6.24), p=0.002), left hand (3.18 (1.12-9.020), p=0.030) and right shoulder (2.89 (1.44-5.79), p=0.003) PRMP compared to upper strings.

Woodwind players reported most problems in the right hand/elbow (30.3%), neck (18.8%), left hand/elbow (17.8%) and mouth (12.5%). Brass players reported most problems in the mouth (17.1%) and left hand/elbow (16.2%) with lower prevalence rates in all other locations. Percussionists reported most problems in the right hand/elbow (26.1%), left hand/elbow (21.7%) and neck (21.7%) with no reported problems in either shoulder. Piano players reported most problems in the left hand/elbow (25.7%) and right hand/elbow (23.5%) and neck (11.8%) and lower prevalence rates in other locations. Woodwind and piano demonstrated significantly higher odds ratios (95%CI) for the risk of right hand/elbow PRMP (3.08(1.60-5.90), p=0.001; 2.18(1.08-4.39), p= 0.030 respectively) than brass instrumentalists.

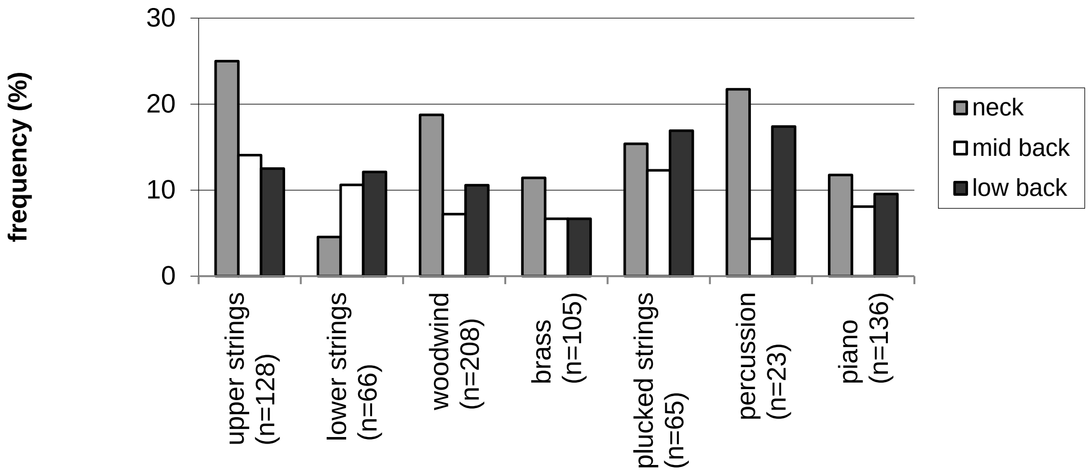

Figure 5.8 Prevalence of spinal Playing-Related Musculoskeletal Problem across instrument categories.

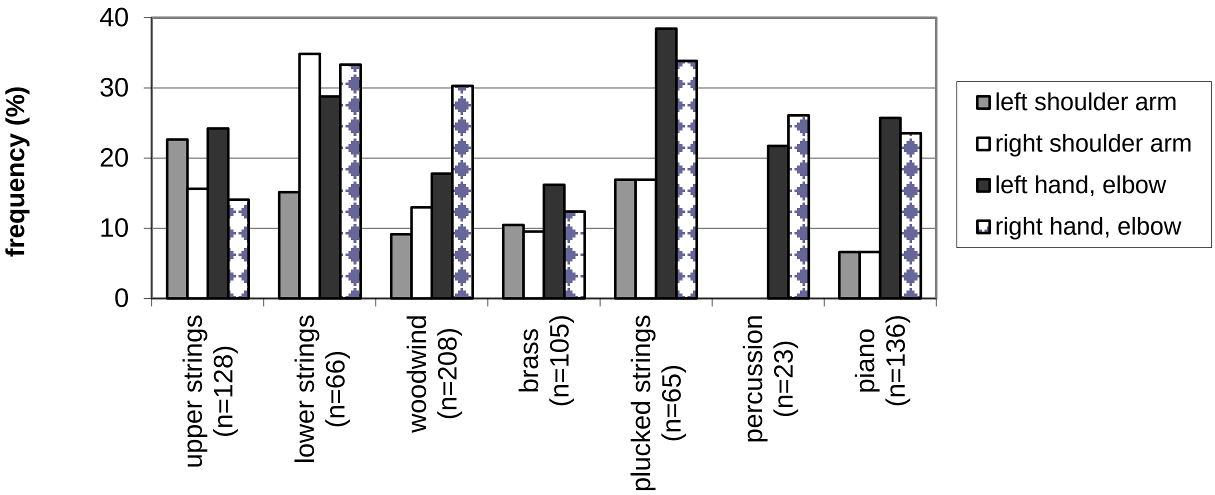

Figure 5.9 Prevalence of upper limb Playing-Related Musculoskeletal Problem across instrument categories.

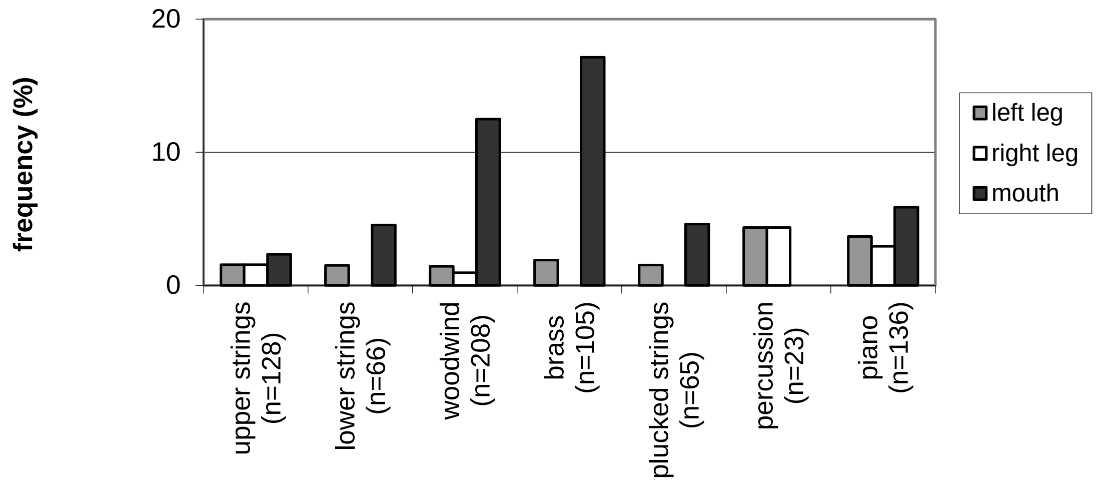

Figure 5.10 Prevalence of lower limb and mouth Playing-Related Musculoskeletal Problem across instrument categories.

5.5.6 Overall Models for PRMP in Each Location

Final models were created to examine the independent association of all covariates for PRMP in each location. Age and gender were significant predictors for some upper limb locations only. Instrument type and number of PRMP locations were significant independent predictors for PRMP in most locations. Even after adjusting for other covariates, similar statistically significant patterns of differences were observed between instrument type and PRMP location (Table 5.7).

Table 5.7 Significant predictors of playing-related musculoskeletal problems at different locations (Wald statistic and p value)

Covariate	Location							
	Neck	Mid back	Low back	Left shoulder	Left hand	Right shoulder	Right hand	Mouth
Age	-	-	-	-	7.9 p=0.005	-		-
Gender	-	-	-	11.5 p=0.001	-	6.1 p=0.014	-	5.6 p=0.018
Instrument type	23.7 p=0.001	-	-	19.6 p=0.003	15.0 p=0.020	9.1 p=0.003	20.3 p=0.002	19.8 p=0.003
Number of instruments played	-	-	-	-	-	-	-	-
Number of PRMP locations	73.2 p<0.001	60.8 p<0.001	57.9 p<0.001	33.7 p<0.001	66.9 p<0.001	50.1 p<0.001	49.2 p<0.001	-
Playing time	5.4 p=0.021	-	-	5.8 p=0.016	-	-	-	-
Number of years playing main instrument	-	-	11.8 p=0.001	-	-	-	-	-

5.6 DISCUSSION

This is the first study in children and adolescents to take account of gender and age in establishing relevant risk factors for the development of PRMP. Females and older children were more likely to experience problems. Adjusting for other covariates, increased time spent playing was associated with an increased odds of monthly PRMS, playing three instruments was associated with a reduced odds of monthly PRMS and the odds of all PRMP varied significantly with the type of instrument. Age, gender, instrument type, playing time and number of years the main instrument had been played and number of PRMP were significant independent predictors for PRMP in certain locations.

5.6.1 Gender and Age

This study found that children experienced PRMS at rates similar to adults, and alarmingly 30% experienced a PRMD. Female children and adolescents were at more risk of developing problems than their male counterparts. This finding concurs with studies of adult musicians (Fry 1986a; c; Zaza 1995; Abreu-Ramos and Micheo 2007) and of spinal pain in adults (Andersson et al. 1993; Croft et al. 2001) and children (Salminen 1984; Troussier et al. 1999; Watson et al. 2002; Stahl et al. 2008). The consistency of higher risk for a broad range of musculoskeletal disorders in females suggests there may be consistent mechanisms. Clearly this group of children should be monitored for the development of problems and managed early to prevent more severe problems.

Problems were experienced in the very young and the risk for development of problems increased with age after accounting for gender. It is clear from the pain literature that episodes of adolescent neck and back pain are associated with an increased risk for the experience of neck and back pain in adulthood (Hertzberg 1985; Harreby et al. 1995; Siivola et al. 2004). It is therefore imperative that children be educated with respect to potential problems and be encouraged to discuss the experience of any problems as they arise. In this way, the child can be examined, assessed for risk factors and managed in the most effective manner to prevent the development of disabling disorders as their music instruction progresses.

5.6.2 Music Exposure

Playing time was associated with monthly PRMS in the multivariate model. This is consistent with an increase in hours of exposure increasing the risk of developing musculoskeletal disorders reported in the occupational literature (Katz 2000; Blatter and Bongers 2002). Playing time therefore needs to be carefully managed for child instrumentalists to minimize their risk of PRMP.

Whilst no prior reports of the association between the number of instruments played and PRMP were found, we expected an increase in risk due to increased exposure time. This study found children who played three instruments did spend more time practicing than other students and time spent practicing was (independently) associated with monthly problems. However, playing three instruments was associated with a *reduced* risk of problems. Students in our study who played more than one instrument played different instruments (i.e. from a different instrument category) which may have had different physical task demands. Playing three instruments may therefore have provided physical variety which reduced risk. This inverse relationship has been reported in occupational health literature where variation in exposure decreased the risk for work-related musculoskeletal disorders (Fernstrom and Aborg 1999; Christensen et al. 2000; Mathiassen et al. 2003; Mathiassen 2006). On the basis of this study, education guidelines should encourage different instrument types be played as a second or third instrument.

This was the first study to comprehensively establish risk associations between instrument/instrument category and PRMP in child instrumentalists. In this study, piano was the most commonly played instrument as a main, second or third instrument, in line with prior reports (Fry 1987; Dawson 1988; Fry and Rowley 1989; Betuel and Clairet 1999; Dawson 2001). Interestingly, the piano was associated with least problems in our study. The piano requires left and right hand and finger movements, with the elbow and shoulder in reasonable, symmetrical postures. This may explain why it was less associated with problems. In contrast, Fry and Rowley (1989) reported piano (along with the cello) to be associated with the most problems in children. Failure to account for important covariates may have been the reason they reported different findings. Amongst adult musicians the piano/keyboard has often been associated with a greater risk of PRMP compared to other instrument groups. At professional and tertiary levels, various practice habits may influence the development of problems such as the difficulty/type of the repertoire played, the duration of practice sessions and frequency of practice sessions. It may be that the cumulative repetitions and prolonged postures of more extensive adult playing times and less physical variation are the reason adults have more problems with piano/keyboards than children in our study.

Upper and lower string players displayed significantly higher odds than piano players for all PRMP in this study. Disparity between the child and instrument size has been postulated as a reason for increased prevalence of PRMPs in child string players (Lockwood 1988). In this study, upper and lower string players displayed significantly higher odds than piano players for PRMP, though when lower strings were contrasted to upper strings there was no significant increase in risk (OR 1.41-1.73; p = 0.280-0.109). In adults, string instruments in general, and bowed stringed instruments specifically, have been associated with more upper limb problems than keyboard, percussion, woodwind and brass (Middlestadt and Fishbein 1989). The degree of coordination required for very different actions of the left and right upper limb in playing a bowed string instrument may explain why these instruments are associated with more problems (Ackerman and Adams 2005).

Woodwind players, and saxophone players in particular, displayed significantly higher odds than piano players for all PRMP in this study. Fry and Rowley (1989) reported very high PRMP prevalence in children playing clarinet and flute, although the small sample size precluded accurate estimation of population prevalence. While appropriately sized woodwind and brass instruments are supplied through the School of Instrumental Music, the weight of the instruments on the developing musculoskeletal system may place the child at risk for developing problems. In adults, woodwind instruments have been associated with PRMP but with lower risk than string instruments (Fishbein et al. 1988; Brandfonbrener 2003). Amongst tertiary music students, woodwind instruments were a similar risk for PRMP as keyboard and string instruments (Fry 1987; Pratt et al. 1992; Zetterberg et al. 1998).

Brass players, and trumpet players in particular, displayed significantly higher odds than piano players for PRMD in this study. Potential explanatory factors for this finding may be child-instrument size mismatch, the heavy instrument weight and the difficulty of technique required to play the trumpet. In adults, the unique physical demands required to play various brass instruments, i.e. to hold and position the instrument, produce and maintain blowing pressures and manipulate valves and or slides, are thought to contribute to the experience of PRMP (Chesky et al. 2002).

On the basis of this study, close monitoring of children playing instruments with the highest odds of PRMP, such as cello, bass, saxophone, and trumpet, is recommended. Teachers and parents need to be informed of prevention strategies for PRMPs associated with these instruments.

5.6.3 Location of Playing-Related Musculoskeletal Problems

This was the first study to document the prevalence of PRMP location in children and its association with symptoms versus disorders. Children who reported the experience of PRMD recorded more locations than those who reported PRMS. No study of adults which investigated this relationship was found. The final regression models demonstrated that the number of location where PRMP was experienced was a significant independent factor for predicting risk of developing problems in other locations. Once problems arise, the intricate balance and coordinated movement required for performance is interrupted and a cascade effect may promote problems elsewhere. It is imperative that children be assessed and treated appropriately to avoid compensatory mechanisms which inevitably produce less efficient performance and increase risk of further problems.

No study was found which had previously investigated the location of PRMP and the association with gender, across childhood and type of instruments. This study identifies that female gender was a significant predictor for left and shoulder problems, age was a significant predictor for left hand/elbow pain and instrument type and number of PRMP locations were significant predictors for neck, left and right shoulder and hand/elbow and mouth PRMP locations. The necessity of combined static postures distally and dynamic postures proximally in one upper extremity and for the converse (static postures proximally and highly repetitive movements distally) in the contralateral limb, represent demands that are unique to the type of instrument for the instrumentalist. Regardless of other factors such as repertoire, and potential for children to adapt to their instrument, we have clear evidence that instrument type is an important risk factor for the development of

PRMP in children and adolescents and prevention initiatives must be implemented to prevent more disabling disorders later and potential career termination due to problems.

Generally, the patterns of location of problems in this study are disconcertingly similar to those reported in the literature for adults. High prevalence rates of upper limb problems appear early and remain high across childhood. Studies on neck and shoulder pain and leisure activities amongst high school students have reported hobbies involving dynamic loading of the shoulder, such as racquet sports, decreased the risk for neck and shoulder pain. Ongoing analyses will investigate the participation in physical activities, hand intensive activities and information technology use and their association with PRMP.

In adult piano players, hand problems are most commonly reported, the right more affected than the left. Repetitive techniques required for complex repertoires and the force applied to the keys are thought to be contributing factors (Brandfonbrener 1990; 2000a). In our study the left hand was affected marginally more than the right. It may well be that children and adolescents have learned how to abduct the thumb and little finger of the right hand, reaching keys with relative ease. However, attention to left hand technique and necessary adaptation may result in the experience of symptoms. As mentioned, children in this study may not be playing complex repertoire that adult pianists perform and therefore less likely to have associated problems in the right hand.

The left hand/elbow, left shoulder and the neck were most commonly reported problem locations for upper strings in this study and this is consistent with the patterns seen in adults. The asymmetrical and sustained posture of the neck and the left shoulder, despite adequately sized instruments and the propensity for adaptation to the instrument, may contribute to these problems. The extreme flexion of the left wrist, hand and fingers and the stretching of fingers to reach the strings especially small 4^{th} and 5^{th} fingers, and the force necessary to depress strings may increase the risk for developing problems in the left hand(Brandfonbrener 2000a).

In lower strings, the right shoulder, right hand/elbow and left hand/elbow were the most commonly reported problems in our study. This is again in agreement with the adult literature. Requirements of the left hand and wrist for cello and bass are similar to upper strings, and though not as flexed, repetitive and forceful movements are required, which may explain the pattern of involvement. However the left shoulder and elbow are not sustained in extreme positions and subsequently not as affected as in upper strings. The right bowing shoulder and hand were often involved. The hand is affected perhaps owing to the bow grip. The right shoulder is involved probably from due to the repetitive range of motion and the bow reaction forces from contact with the strings (Brandfonbrener 1990) and further due to the potentially increased load on the rotator cuff due to the high static hand grip force on the bow (Sporrong et al. 1996). We expected children who played bass to be at greater risk of spinal pain and left shoulder pain given the potential for instrument mismatch in the developing child, however this was not the case and strategies implemented by the School for Instrumental Music may be successfully helping to prevent mismatch problems for the growing child.

For plucked strings, left and right hand/elbows were affected, the left more so than the right. The shoulders were affected equally and the low back was the most commonly reported spinal pain. This again is in agreement with the adult literature. In our study the guitar represented the majority of plucked string instruments. As mentioned previously, the way in which the guitar is held and played is associated to the development of problems (Brandfonbrener 1990). The sustained, asymmetric postures of the left wrist, repetition and force of left hand and left finger movements and the techniques and associated forces through the right wrist, hand and fingers contribute to bilateral hand problems in the child, even with appropriately sized guitars. Our study did not seek information with respect to a seated or standing position, or the use of a neck strap, however the use of neck straps could be encouraged and alternating seating and standing postures recommended to help prevent spinal pain.

Woodwinds in our study had right hand/elbow problems most commonly, followed by neck and the left hand/elbow. As mentioned previously, problems generally arise due to the support of the instrument, right thumb for clarinettists and oboists, left hand for flautists, and due to the frequency and difficulty of repetitive finger movements. External supports such as a neck strap are used with some larger instruments like the bassoon and bass clarinet, though not with the smaller instruments, and the majority of weight is taken through the right thumb. It may be important to recommend use of neck strap in the growing child and assess the feasibility of a splint for the thumb to assist in support of the instrument. Preventative exercises to strengthen thumb stabilisers (abductor pollicis longus and adductor pollicis) should also be considered. In the child with underlying thumb hypermobility education with respect to the use of supportive aids may be necessary as an interim strategy or long term intervention.

Brass instrumentalists had mouth problems most commonly, followed by left and right hand/elbow and neck and left shoulder, consistent with adult findings by Chesky (2002). Clearly embouchure issues need to be addressed early in children to prevent serious dental and facial problems occurring, especially as such problems contribute to the child's perceived physical appearance, self-esteem and ability to tackle issues in adolescence.

Percussionists in our study had problems most commonly in the right and left hand/elbow, followed by neck and low back. The adult literature describes problems pertaining to percussionists as unique to the variety of instruments in this category. Risks may develop from how an instrument is held and jarring from impact of hands/upper limb; the position of grasp/grip, the repertoire, the number of repetitions used and the properties of instrument sticks or whatever used to impact against instrument (e.g. symbols) (Zaza et al. 2000). In our study, children demonstrated patterns of involvement probably due to weight of the instruments and unique playing postures of individual instruments.

Sustained awkward postures, repetitive and forceful movements necessary to play instrumental music present challenges for the developing musculoskeletal system, especially during periods of growth. To prevent and minimise PRMP development during childhood, there needs to be some flexibility with respect to playing posture, transition to larger sized instruments and the provision and revision of external supports for the child and adolescent instrumentalist.

5.6.4 Limitations and Strengths

This study has several limitations related to its design. As a cross-sectional study, the strongest evidence it can provide is of association. Using self-reported measures of PRMS and PRMD may inflate prevalence rates compared to physical examination. Whilst the current analysis has provided unique information on the prevalence of PRMS and PRMD in children and the associations with playing time, number and type of instrument played, further analysis will consider other aspects of music habits and other activities such as the use of information technology and participation in physical activity. The study strengths included a large, representative sample, clear case definitions and assessment of the independent effects of age and gender along with various music exposure factors.

While longitudinal studies are needed to determine true incidence of PRMP and better establish associated risks, this study has highlighted important evidence for the health of the child and adolescent instrumentalist. Music educators, parents, health care practitioners and last, but certainly not least, the child musician, need to be aware of the high risk of PRMP and address identified risk factors. This will help ensure the longevity of a music career for the individual and benefit the community as a whole.

5.7 CONCLUSION

Gender, age, playing time and type of instrument played were associated with the reported prevalence and location of playing-related musculoskeletal symptoms and disorders in children learning instrumental music. The high prevalence of both PRMS and PRMD in children warrants further evaluation of risks to inform teachers, parents and children on prevention initiatives and to prevent the development of chronic disorders in adult musicians.

5.8 ACKNOWLEDGEMENTS

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CHAPTER 6 THE INFLUENCE OF MUSIC PRACTICE ON PLAYING-RELATED MUSCULOSKELETAL PROBLEMS IN CHILDREN LEARNING INSTRUMENTAL MUSIC

6.1 ABSTRACT

There is evidence supporting the benefits of music education to students and the community at large. Studies have identified aspects of music practice, such as an increase in frequency and intensity of practice, are associated with problems in adult musicians with limited evidence in children. The aim of this study was to describe the music practice of child instrumentalists and determine associations with playing-related musculoskeletal problems (PRMP), accounting for gender and age. 731 children learning musical instruments (460 females) ranging in age from 7 – 17 years were surveyed and music experience, music practice and intrinsic factors (e.g. the experience of butterflies in stomach before a concert/exam) were investigated. Logistic regression evaluated the independent association of these potential correlates with PRMP. Music experience (number of years playing main instrument) was significantly negatively associated with PRMP (OR 0.88, p=0.003). Pattern of playing was significantly associated with PRMP, specifically playing less than usual (OR 2.1, p=0.002) and playing more than usual for longer and more often (OR 2.7, p <0.001), compared to playing about usual. The experience of butterflies in the stomach during exams/competitions most times (OR 2.1, p=0.029) and always (OR 2.4, p=0.027) compared to never, was significantly associated with PRMP.

This study concludes music practice influences the development of playing-related problems in child instrumentalists and is an important issue for music education. Evidence based guidelines may be recommended to help prevent problems and optimize music performance and music education development

6.2 INTRODUCTION

Playing-related musculoskeletal problems (PRMP) are common amongst child instrumentalists, and while this is now well known in the performing arts medicine literature, PRMP may be less recognized in music education. Playing-related musculoskeletal problems include playing-related musculoskeletal *symptoms* (PRMS) (mild aches and pains that may be experienced during or after playing and may or may not affect performance) and playing-related musculoskeletal *disorders* (PRMD) (pain, weakness, or lack of control, tingling, numbness or symptoms that interfere with the ability to play as usual) (Zaza 1995). They are prevalent amongst professional musicians (Fishbein et al. 1988; Zaza 1995), music teachers (Fjellman-Wiklund and Sundelin 1998) and tertiary music students (Manchester 1997; Zetterberg et al. 1998; Guptill et al. 2000) and what may be surprising to music educators is that they are also prevalent in child instrumentalists with 20 to 70 percent reporting problems (Lockwood 1988; Ranelli et al. 2008).

Playing-related musculoskeletal problems have been reported since the early 1800s, where they were seen to be similar to work-related musculoskeletal disorders such as writer's and milker's cramp (Poore 1887) with similar, multiple risk factors (Larsson et al. 1993b; Bejjani et al. 1996; Brandfonbrener 2000a). In occupational medicine, conceptual models were developed to better understand causal relationships between risk factor exposure and development of disorders and guide interventions and recommendations to address (modifiable) risk factors. Research on adult musicians has adopted these models and identified individual intrinsic factors (such as age and gender, music performance anxiety), extrinsic factors (such as music practice habits and type of instrument played) and intrinsic-extrinsic interaction factors (such as playing posture, technique and student-teacher interaction) which influence the development of PRMP (Brandfonbrener 1991; Pratt et al. 1992; Zaza and Farewell 1997; Zaza et al. 1998; Rauscher and Zupan 2000; Roset-Llobet et al. 2000). However as music education usually commences early in childhood the influence of these risk factors on the development of PRMP in children needs to be well understood. Despite the clear need, there is limited evidence for the importance of various risk factors for children, making it difficult for music educators to help minimize the risk of child instrumentalists developing PRMP.

6.2.1 Intrinsic Risk Factors

The few studies on PRMP in children have identified females and older children experience more problems (Fry 1987; Fry et al. 1988; Lockwood 1988; Fry and Rowley 1989; Shoup 1995; Betuel and Clairet 1999; Ranelli et al. 2008; Ranelli et al. 2011a).

Music performance anxiety, or ‘stage fright’, refers to unwarranted, excessive fearfulness during public performances (Salmon 1990). Symptoms of performance anxiety are generally categorised into cognitive (e.g. catastrophic thoughts), behavioural (e.g. avoidance of performance/auditions) and physiological (e.g. dry mouth, shaking arms/hands, increased heart rate) (Plaut 1990; Salmon 1990). Much of the literature in music performance anxiety has concerned adults and focused on the development of validated measurement methods and the association with trait anxiety, social phobia and performance situations (e.g. practice versus public or concert performances and solo versus group performance). Music performance anxiety has also been associated with negative effects on music performance in adults (Fishbein et al. 1988; van Kemenade et al. 1995).

In professional musicians, Zaza (1995) and Zaza and Farewell (1997) reported increased trait anxiety was associated with increased risk for PRMD. In other adult studies, musicians who self-reported stage fright and performance anxiety felt it contributed to their PRMD experience (Caldron et al. 1986; Knishkowy and Lederman 1986; Fry 1987; Fishbein et al. 1988). In children, performance anxiety (with symptoms such as shaky hands, dry mouth and increased heart rate) is perceived as a problem for students and has been reported to be common with 75% reporting being nervous during performance (Britsch 2005). Shoup (1995) reported performance anxiety negatively affected performance in 55% (234/425) junior high and high school instrumentalists. In contrast Ryan (1998) found that while all 12 year old piano players experienced performance anxiety, perceived anxiety and increased heart rate were not associated with performance quality. The association of performance anxiety with PRMP has not investigated in children.

Enjoyment of music can be considered to be an intrinsic factor associated with the interest and motivation in learning an instrument and contributes to the commitment to continue to learn and achieve in music (McPherson 2000). In a grounded theory study of 18 elite adult pianists Bragge (2006c) found internal, self-generated pressures, such as music pleasure and enjoyment, motivated performance and subsequently contributed to the development of PRMP. No studies in children were found that investigated the association between music enjoyment and PRMP.

6.2.2 Extrinsic Risk Factors

Prior research on child instrumentalists has shown that the type of instrument played influences the experience of PRMP (Lockwood 1988; Ranelli et al. 2011a). The lower string instrument group (bass and cello) was associated with greatest risk of problems compared to upper string category (Lockwood 1988) and the piano (Ranelli et al. 2011a). Research on adult musicians has investigated the importance of music practice (such as years spent playing, frequency and duration of practice sessions, warm ups, breaks taken, cool down and repertoire) in terms of PRMP, however there is very limited information on child instrumentalists.

Learning to play music requires repetitive, specific movement patterns involving sensory-motor skills. Practice or rehearsal is essential to acquire, refine and maintain necessary skills (Duke et al. 2009). Indeed expert performance is often the consequence of high daily levels of supervised practice from a very young age for over a decade (Ericsson et al. 1993). Considerable music education and music psychology research has focused on the processes associated with teaching and learning music (e.g. pedagogical techniques of modelling, how to teach pitch and sight reading) (Heuser and McNitt-Gray 1998). More recently descriptive studies have investigated a broad range of issues related to learning and musical performance such as; task –appropriate strategies, psychological traits (e.g. self-efficacy), technique and practice habits (e.g. from memory, by ear, by improvisation) (Sloboda 1988; McPherson 1995; McPherson and McCormick 2006).

McPherson (2005) studied 157 beginning instrumentalists for 3 years and looked at the amount of practice (average was 20 minute sessions, five times a week) and type of practice strategies (rehearsed music, sight-read, play from memory, play be year and improvise) and found effective, successful music learning was related to practice strategies and not the amount of time spent practicing. This is supported by other studies that found the practice habits of young children are less formal than those of older children and that the quality of practice, not quantity, was important for optimized learning and performance (Williamon and Valentine 2000; Rohwer and Polk 2006; Duke et al. 2009).

Essentially, music practice studies have focused on effective and efficient music practice for optimal music performance. Only one study reported on a relationship between music practice and PRMP, showing PRMP impacted on music performance and music practice (Williamon and Thompson 2006). No studies investigated whether poor music practice may result in PRMP and subsequent poor music performance in children although there is evidence from adults that years of practice, music practice dose, change in practice, taking breaks, warm ups and cool down may be important.

6.2.3 Music Practice and PRMP

Amongst adult musicians, some studies have reported a positive association between the number of years playing the main instrument and PRMP, however the studies did not mention adjusting for age of the musician (Newmark and Hochberg 1987). Other studies have reported an inverse relationship, with musicians who have played their instrument for many years reporting fewer problems compared to those having played for less years (Zaza and Farewell 1997). Others have found no association (Kaneko et al. 2005; Abreu-Ramos and Micheo 2007; Brandfonbrener 2009). No studies could be found examining the association between years of instrument playing and PRMP in children.

Several studies in adult musicians have reported on usual average and maximum amount of practice and PRMD. Some studies found an increase in risk of problems with longer practice times (Lockwood 1988; Grieco et al. 1989; Revak 1989; Manchester and Park 1996; Roset-Llobet et al. 2000; Britsch 2005; Furuya et al. 2006) and others have found no association (Zaza 1992; Roach et al. 1994; Zetterberg et al. 1998; Yeung et al. 1999). In occupational medicine literature, task frequency and duration contribute to musculoskeletal disorder risk. The dose-response relationship between these risk factors and problems are not clear due at least in part to the varied measures of exposures. However some studies on computer use have investigated the association of hours of keyboard use and musculoskeletal disorders and found an increased risk for neck and upper limb problems with increased hours of typing (Bergqvist et al. 1992; Polanyi et al. 1997). The risk for problems amongst computer workers was shown to double with four or more hours of computer work per day (Blatter and Bongers 2002). No study was found that investigated the relationship between the usual practice dose (frequency and duration) and PRMP in children.

An increase in the amount of practice, e.g. prior to a concert, has been associated with PRMP in adult musicians (Knishkowy and Lederman 1986; Newmark and Hochberg 1987; Newmark and Lederman 1987; Dawson 1988; Amadio and Russotti 1990) and student musicians (Fry et al. 1988; Lockwood 1988; Fry and Rowley 1989; Grieco et al. 1989), mirroring increased musculoskeletal problems in athletes following changes in training (Sward et al. 1990; Kujala et al. 1992; Grimmer et al. 2000; Emery 2005). Similarly, in tertiary students, Manchester and colleagues (Manchester 1988; Manchester and Flieder 1991; Manchester and Park 1996) reported PRMP peaked at times of the year that coincided with increased exposure related to practice for recitals/exams. Interestingly, Manchester and Flieder (1991) also found PRMP peaked early in the school year suggesting unaccustomed exposure may be important also. An increased dose of practice may be advantageous creating adaptive changes in the musculoskeletal system or alternatively it may result in irreversible structural change with deleterious long term effects (Bejjani and Nilsson 1984; Bejjani and Halpern 1986). Studies in adults and children have not investigated how musicians might practice more than usual-more often, for longer or a combination of the two.

Changes in the nature of practice such as repertoire (Fry 1987; Fry et al. 1988; Brandfonbrener 2000a), teacher (Fry 1987; Brandfonbrener 1991; Manchester and Flieder 1991) and technique (Newmark and Hochberg 1987; Revak 1989; Manchester and Flieder 1991; Brandfonbrener 2000a) have been reported to influence PRMP in adult music students and professional musicians. A change in repertoire to a more challenging, technically difficult piece represents an increase in task demand, which in occupational literature is associated with musculoskeletal disorders (Moore et al. 1991; Stock 1991). Many studies have found musicians reported problems following a change in repertoire (Fry 1987; Fry et al. 1988; Brandfonbrener 2000a) or teacher (Fry 1987; Brandfonbrener 1991; Manchester and Flieder 1991). In contrast Zaza (1995) showed new repertoire to be univariably associated with a decrease in PRMD risk (though not after adjusting for age and gender). These studies did not mention whether the repertoire was more difficult or easier. There were no studies in children found that documented an association between repertoire change and PRMP.

In occupational health literature, pause breaks have been associated with decreased risk of musculoskeletal disorders (Sundelin and Hagberg 1989). In contrast, Zaza (1995) showed taking breaks was associated with increased risk for problems amongst adult musicians. In her study breaks were reportedly taken most commonly after 20 minutes, 45 minutes and after 1 hour, with a 5-10 minute break duration most common. Bruno (2008) found playing for lengthy periods (greater than 60 minutes) without breaks was associated with problems in tertiary piano players. Lockwood (1988) reported that more asymptomatic child musicians never rested during practice and surmised children with pain needed to take a break.

Muscle exercise and stretching is widely used to prevent injury and prepare for sporting task performance (Shellock and Prentice 1985; Safran et al. 1988). Whilst stretching alone does not prevent injuries (Herbert and Gabriel 2002; Shrier 2004) a systematic review of randomized controlled trials on the effects of warm up, found that aerobic warm up significantly reduced risk of injury compared to warm up with a stretching focus (Fradkin et al. 2006). Zaza (1995) identified physical and musical warm up and cool down and found physical warm up was associated with a decreased risk for PRMD in adult musicians. No study in children could be found which investigated the association between warm up/cool down practices and PRMP.

Established risk factors for PRMP in adult musicians, such as music practice and performance anxiety are yet to be investigated in children. Children’s early exposure to potential risk factors such as music practice may be important for the development of problems in childhood, as well as the development of practice behaviours which influence vulnerability to problems in adulthood. Understanding the influence of music practice on PRMP would inform evidence-based guidelines which could be used by music educators and health professionals to reduce health problems and help ensure longevity of the young musician’s playing career.

6.3 AIMS

This study aimed to:

1. Describe the music practice characteristics of children learning instrumental music and determine if differences exist between genders and across ages
2. Describe the intrinsic characteristics of the experience of butterflies during a concert and enjoyment of playing music in children learning instrumental music
3. Establish which music practice characteristics are associated with PRMP, accounting for age and gender
4. Establish if intrinsic factors such as enjoyment of music and the experience of butterflies in the stomach anxiety are associated with PRMP, accounting for age and gender.
5. Establish a model relating significant music practice and intrinsic factors with PRMP accounting for age and gender

6.4 METHODS

6.4.1 Design and Sample

731 students (460 females) aged between 7 and 17 years participating in the School of Instrumental Music program in Perth government schools, completed a cross-sectional questionnaire and anthropometric measures survey in August to December 2003. To ensure large instrumental numbers and a range of socio-economic areas were represented in the sample, one secondary school with a strong instrumental program was selected from each of the five school regions within Perth, Western Australia and 'feeder' primary schools with high instrumental numbers were subsequently selected. All instrumental classes at the selected schools were sampled and there were no exclusion criteria. Further sample details are reported in a previous paper (Ranelli et al. 2011a). Participants and their parent or guardian provided informed assent/consent.

6.4.2 Survey Questionnaire

The survey, a modified music focused version of the Young Peoples Activity Questionnaire (YAQ-m) (Harris and Straker 2000), included music specific questions and contained general questions regarding the children's age, gender, year at school, hand dominance, general musculoskeletal complaints and activity participation (watching television, participation in physical activities, hand intensive activities such as art, hand writing and use of computers). The survey focused on the experience of PRMS to date and specifically within the past month. For those who experienced symptoms in the last month they were asked whether the symptoms prevented them playing their instrument as usual, that is, the reported experience of a PRMD. Children detailed the location of their symptoms on a body diagram and rated the severity of symptoms on a 0 – 10 scale (zero, no symptom).

Other music specific questions covered music experience, age commenced playing any and main instrument, type and number of instruments played and their past week's practice schedule. Questions pertaining to music practice habits included frequency of practice in the past month (monthly, once a week, 2-5 times a week, daily); the duration of practice in the last month (30 minutes or less, 30-60 minutes, 1-2 hours, 2-5 hrs, greater than 5 hrs); longest time played without a break (30 minutes or less, 30-60 minutes, 1-2 hours, 2-5 hrs, greater than 5 hrs); how often they took breaks, performed warm up, performed cool down (never, almost never, usually, most times, all the time); how students practiced more than usual (didn't, practice more often, practice for longer, practice more often and for longer); and difficulty of repertoire played within the last month (less difficult, about usual, more difficult).

At the time this study was conducted, there was no self-reported measure of music performance anxiety for children or adolescent musicians in the literature. Therefore, the question pertaining to music performance anxiety asked about the reported experience of butterflies before an exam/competition (never, almost never, sometimes, most times, always) and while a crude measure, it is considered a physiological symptom of anxiety in children. The Music Performance Anxiety Inventory for Adolescents (MPAI-A) was subsequently developed and validated (Kenny et al. 2004; Osborne et al. 2005). The 15 item scale was designed to assess the somatic, cognitive and behavioural components of music performance anxiety and demonstrated reliability and validity using standardized psychometric measures of related constructs and established that music performance anxiety in children and adolescents was best predicted by trait anxiety and gender. The first of three questions on the somatic component asks “before I perform I get butterflies in my stomach”, supporting the use of this question in the current study.

The question “how much do you enjoy playing music?” (don’t enjoy it, enjoy a little, enjoy it, enjoy a lot, love it) was included to establish the intrinsic experience of music enjoyment in students.

The questionnaire was completed in a scheduled music class with the supervision of the instrumental teacher. With the very young students, parents (often present for the lesson) were able to assist with the questionnaire. The questionnaires took approximately 20 minutes to complete. A wall based tape was used to measure height and a digital scale to measure weight. The first author performed anthropometric measures and was available during questionnaire completion to answer queries.

6.4.3 Data Analysis

A descriptive analysis was performed to characterise the music experience, music practice and intrinsic factors of the sample. Chi square analysis was used to examine differences between males and females for categorical variables and ANOVA was used to examine gender differences for continuous variables. Bivariate Pearson correlation analysis examined the relationship between age and continuous variables of music experience (years playing any and main instrument). A series of univariable logistic regressions were performed to estimate the unadjusted effect of music experience, music practice and intrinsic factor variables for PRMP outcomes (i.e. PRMS and PRMD). Multivariable logistic regression were performed to assess the independent association of all variables (music experience, music practice, intrinsic factors) for PRMP outcomes accounting for age and gender. A final multivariable logistic regression examined the covariates significantly associated with PRMP outcomes adjusted for age and gender.

6.5 RESULTS

6.5.1 Music Practice, Anxiety and Enjoyment and PRMP Prevalence

Descriptive statistics for music practice and intrinsic factors of the participants are listed in Table 6.1. To ensure adequate numbers for analysis, original categories of variables were combined where appropriate (Table 6.1). 67% (489) children reported a lifetime prevalence of PRMS, 56% (412) reported the experience of symptoms within the past month and 30% (219) reported a PRMD, that is, they were unable to play their instrument as usual within the last month.

6.5.2 Music Practice Characteristics and PRMP

6.5.2.1 Music Experience

The average age when a child first started playing a/any musical instrument was 8.50 years (sd 2.19) with no differences between males and females. The average age when a child commenced playing their main instrument was 9.53 years (sd 2.24) with no differences between males and females. The number of years a child spent playing any musical instrument was on average 4.66 years (sd 2.80, range 0-13) and the number of years spent playing their main instrument was on average 3.62 years (sd 2.49, range 0-12) with no differences between males and females. As would be expected, there was a significant moderate-strong positive relationship between age and years spent playing any instrument ($r = 0.626$, $p<0.001$) and a significant moderate positive relationship between age and years spent playing main instrument ($r = 0.515$, $p<0.001$). Univariable analysis showed number of years playing any instrument was associated with an increased risk for PRMP ($p<0.02$), however adjusting for age, this risk decreased slightly and was no longer significant (Table 6.3). In contrast, univariable analysis demonstrated no significant association between number of years spent playing main instrument and PRMP (Table 6.2). However adjusting for age, the association became significant for PRMD ($p<0.014$) (Table 6.3).

Table 6.1 Children's music practice and intrinsic factors (continued)

COVARIATE	Original Categories	N	(%)	Re-categorised	N	(%)
MUSIC PRACTICE						
Frequency: How often played musical instrument last month	1x month	11	(1.5)			
	1x week	48	(6.6)	< daily	274	(37.5)
	2-3 x week	215	(29.4)			
	daily	456	(62.5)	daily	456	(62.5)
Duration: How long usually play instrument each time	<30 minutes	284	(39.4)	<30 minutes	284	(39.4)
	30-60 minutes	337	(46.8)	30-60 minutes	337	(46.8)
	1-2 hours	72	(10.0)			
	2 – 5 hours	18	(2.5)	≥ 60 minutes	99	(13.8)
	5+ hours	9	(1.3)			
Exposure – dose (frequency x duration)				daily, <30 min	142	(19.7)
				<daily, < 30	142	(19.7)
				<daily, ≥ 30 min	126	(17.5)
				daily, ≥ 30 min	109	(43.0)
Have you been playing more or less than usual in the last month	much less	51	(7.0)	Pattern of playing		
	a little less	130	(17.9)			
	about usual	231	(31.9)	About usual	231	(32.0)
	a little more	218	(30.1)	< usual	181	(25.1)
	a lot more	95	(13.1)	> usual and longer	84	(11.7)

Table 6.1 Children's music practice and intrinsic factors (continued)

COVARIATE	Original Categories			Re-categorised		
		N	(%)		N	(%)
How do you practice more than usual	don't	412	(57.1)	> usual and more often	83	(11.5)
	play longer	84	(11.7)			
	play more often	83	(11.5)	> usual and longer and more often	142	(19.7)
	play longer and more often	142	(19.7)			
How often usually take breaks when practice music in the last month	never	135	(18.6)	never- almost never	309	(42.6)
	almost never	174	(24.0)			
	sometimes	273	(37.6)	sometimes	273	(37.6)
	most times	102	(14.0)	most times-always	144	(19.8)
	always	42	(5.8)			
Longest time played without a break in last month	<30 minutes	123	(16.9)	< 30 minutes	123	(16.9)
	30-60 minutes	266	(36.5)	30–60 minutes	266	(36.5)
	1-2 hours	237	(32.6)			
	2 – 5 hours	91	(12.5)	> 1 hour	339	(46.6)
	5+ hours	11	(1.5)			
How often perform warm up exercises	never	201	(27.6)	never-almost never	302	(41.5)
	almost never	101	(13.9)			
	sometimes	159	(21.9)	sometimes	159	(21.9)
	most times	154	(21.2)	most times-always	266	(36.6)
	always	112	(15.3)			

Table 6.1 Children's music practice and intrinsic factors (continued)

COVARIATE	Original Categories			Re-categorised		
		N	(%)		N	(%)
How often do cool down exercises	never	550	(75.5)	never-almost never	661	(90.7)
	almost never	111	(15.2)			
	sometimes	44	(6.0)	sometimes	44	(6.0)
	most times	15	(2.1)	most times-always	23	(3.2)
	always	8	(1.1)			
Repertoire Difficulty	much easier	32	(4.5)	much-a little easier	68	(9.5)
	a little easier	36	(5.0)			
	about usual	284	(39.7)	about usual	284	(39.7)
	a little difficult	300	(41.9)	a little – a lot more difficult	364	(50.8)
	a lot more difficult	64	(8.9)			
INTRINSIC FACTORS						
Feeling of butterflies when play in concert/competition	never	142	(19.9)	never – almost never	164	(37.0)
	almost never	122	(17.1)			
	sometimes	186	(26.1)	sometimes	186	(26.1)
	most times	133	(18.7)	most times	133	(18.7)
	always	130	(18.2)	always	130	(18.2)
How much do you enjoy music	don't enjoy it	24	(3.3)	don't enjoy it	24	(3.3)
	enjoy it a little	82	(11.4)	enjoy it	287	(39.8)
	enjoy it	205	(28.4)			
	enjoy it very much	182	(25.2)	enjoy very much/love it	411	(56.9)
	love it	229	(31.7)			

6.5.2.2 Music Practice Dose

The dose of music practice the sample children were exposed to is shown in Table 1. The category “daily, < 30 minutes” was the most common combination students practiced and was chosen as the referent as this represented a practical minimum amount to practice which would ensure a safe training effect. The remaining combinations were seen to represent a potential increase in risk for problems (either due to unaccustomed practice or increased practice). There was a significant association between gender and dose (χ^2= 10.44, df(3), p=0.015) with more females than expected playing in dose categories other than daily, > 30 minutes. There was a significant association between age and dose, with older children playing for longer sessions (> 30 minutes) on a daily basis and younger children playing for less than 30 minutes daily (F= 35.73, df(2), p<0.001). Univariable analysis demonstrated practicing for more than 30 minutes, daily or less than daily, increased the risk for all PRMP compared to practicing less than 30 minutes daily (p=0.003-0.046) (Table 6.2). After adjusting for gender, the association remained significant for PRMD and for PRMS in the practicing more than 30 minutes daily category. After adjusting for age, there was no significant association for any PRMP (p= 0.062-0.194) (Table 6.3).

6.5.2.3 Change in pattern of Music Practice within last month

Table 6.1 shows the percentage of children who had a change in their pattern of practice within the last month. Students most commonly reported playing more than usual in the last month to prepare for impending concerts (22.4%), learning new repertoire of music (22.2%) and for exams (19%). For the pattern of practicing within the last month, “about usual” practice within the last month was chosen as the referent category and other categories represented a decrease or increase in exposure. There was no significant association between gender and pattern of practice. There was a significant association between age and pattern of practice (F=9.03 df3; p<0.001) with older children practicing for longer and more often when they practiced more than usual. Univariable analysis demonstrated practicing less than usual (p =0.002 – 0.018) and practicing more than usual, longer and more often (p<0.001), increased the risk for all PRMP compared to practicing about usual (Table 6.2) (Figure 6.1). After adjusting for gender and age, the association remained significant for all PRMP in these categories (Table 6.3).

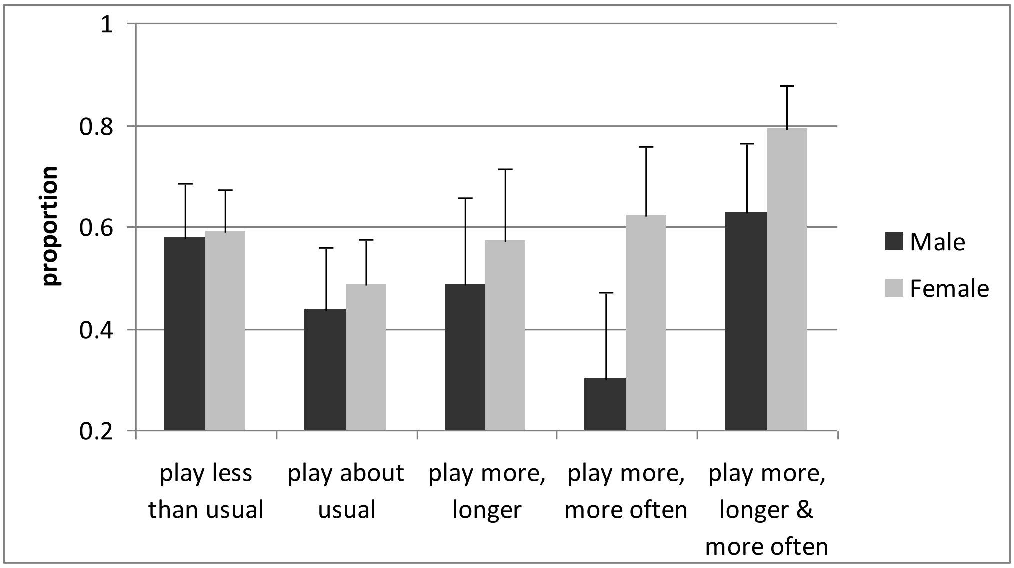

Figure 6.1 Proportion (Upper band of 95% confidence interval) of students with Monthly PRMS across pattern of music practice categories.

6.5.2.4 Breaks During Music Practice

19.8% (144) reported they took breaks most times to always when practicing music (Table 6.1). There was a significant association between gender and taking breaks during practice (χ^2 =13.78; df 2; p=0.001) with more females taking breaks compared to males. There was no significant difference across age groups (F=1.77 df2, p=0.171). Taking breaks when practicing was significantly associated with an increased risk for all PRMP compared to never/almost never taking a break (p=0.026-0.047, Table 6.2). After adjusting for age and gender, taking breaks when practicing was no longer significantly associated with an increased risk for PRMP (p=0.080-0.411) (Table 6.3).

46.6% (339) of children reported they practiced for longer than one hour without a break within the last month (Table 6.1). There was no difference between males and females. There was a significant difference across age groups (F=46.88 df1, p<0.001) with older children playing longer without a break (Figure 6.2). Playing more than 1 hour without a break compared to playing less than 30 minutes demonstrated an increased risk for all PRMP (Table 6.2) (Figure 6.3), and remained significant for monthly PRMS after adjusting for age and gender (p=0.004, Table 6.3).

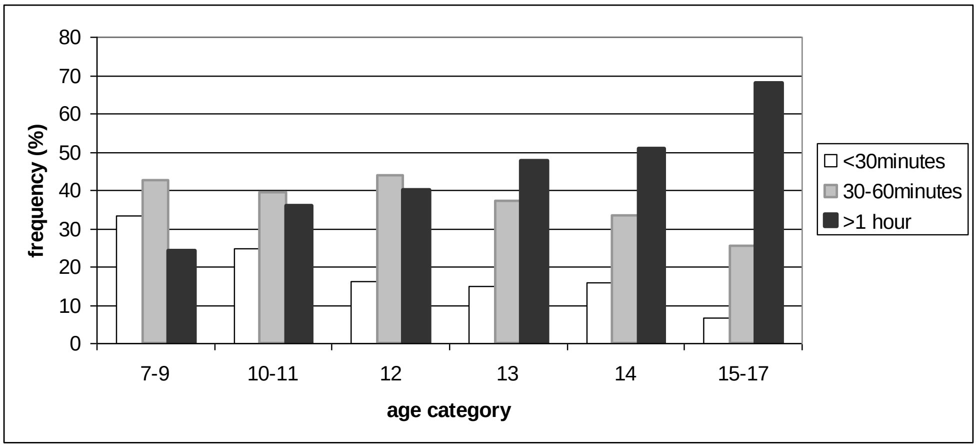

Figure 6.2 Longest time spent practicing without a break across age groups

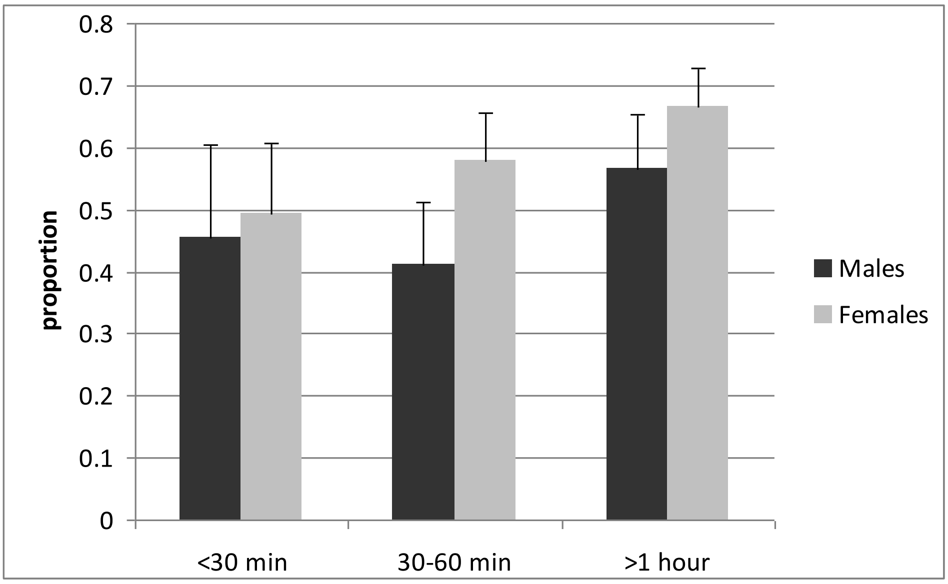

Figure 6.3 Proportion (Upper band of 95% Confidence Interval) of students with Monthly Playing-Related Musculoskeletal Symptoms across longest time practicing without a break categories

6.5.2.5 Warm Up Exercises and Cool Down Exercises

36.7% (266) reported they performed warm up exercises most times to always prior to playing (Table 6.1). There was no difference between males and females or across age groups. Univariable analysis demonstrated no association of warm up exercises and any PRMP (p=0.205-0.800) (Table 2). Only 9.2% (67) performed cool down exercises following any instrumental practice/performance. There was no difference between males and females or across age groups. Univariable analysis demonstrated no association of cool down exercises and any PRMP (p=0.333-0.761) (Table 6.2).

6.5.2.6 Difficulty of Repertoire

50.8% (364) reported the repertoire of music practiced to be more difficult than usual in the last month (Table 6.1). There was no significant association between gender and repertoire difficulty. There was a significant association between age and repertoire difficulty ($F=9.51$ df 2; $p<0.001$) with older children reporting the repertoire played within the last month to be more difficult than usual. Univariable analysis demonstrated no association of repertoire difficulty and any PRMP.

6.5.3 Intrinsic Factors and PRMP

6.5.3.1 Anxiety

263 students (36.0%) reported they experienced the feeling of butterflies most times to always when playing in a concert or competition (Table 6.1). There was a significant association between gender and the experience of butterflies ($\chi^2=32.32$ df4, $p<0.001$) with more females reporting the experience of butterflies than males. There was a *significant association between age and reported experience of the feeling of* butterflies ($F=9.012$ df3; $p<0.001$) with older children reporting the experience of butterflies than younger children. Univariable analysis demonstrated the experience of butterflies most times and always increased the risk for all PRMP ($p <0.001 – 0.016$) compared to never-almost never experiencing butterflies (Table 6.2). After adjusting for gender and age, the association remained significant for MPRMS and PRMD ($p<0.001$-0.007) (Table 6.3).

6.5.3.2 Enjoy music

56.9% (411) students reported they enjoyed playing music very much/loved playing music (Table 6.1). There was no association between gender or age groups and the reported enjoyment of music. Univariable analysis demonstrated no significant association for the reported enjoyment of music and risk for PRMP (Table 6.2).

6.5.4 Multivariable Model

Covariates that were significantly associated with problems were examined and for those that remained significant after adjusting for age and gender, they were included in a final model (Table 6.4). The number of years playing main instrument remained significantly associated with a decrease in risk for development of PRMD (p=0.003). The pattern of playing within the last month, specifically, playing more than usual for longer and more often, remained significantly associated with an increase in risk for all PRMP compared to playing about usual ($p < 0.001$-0.001) and playing less than usual compared to about usual, remained significant for PRMD (p=0.002). The experience of butterflies in the stomach during exams/competitions most times (p=0.029) and always (p=0.027) compared to never feeling butterflies, remained significantly associated with an increase in risk for PRMD.

Table 6.2 Unadjusted Odds Ratios (95% Confidence Intervals) for relationships between music habits and monthly playing-related musculoskeletal symptoms (MPRMS) and playing-related musculoskeletal disorders (PRMD) (continued)

COVARIATE	MPRMS				PRMD			
Univariable Unadjusted OR	Odds Ratio	95%	CI	p value	Odds Ratio	95%	CI	p value
Age (years)	1.15	1.03	1.28	0.014	1.19	1.05	1.35	0.006
Gender (female)	1.52	1.08	2.13	0.015	1.49	1.03	2.17	0.036
Years playing any instrument	1.10	1.04	1.16	0.001	1.07	1.01	1.13	0.019
Years playing main instrument	1.05	1.00	1.11	0.012	0.99	0.93	1.06	0.922
Time spent practicing	1.07	1.03	1.11	0.001	1.04	0.99	1.08	0.070
Frequency: How often played musical instrument last month								
1xmonth	1				1			
1x week	1.10	0.30	4.11	0.883	0.43	0.09	2.14	0.304
2-3 x week	1.64	0.48	5.52	0.428	1.14	0.28	4.65	0.855
daily	1.58	0.48	5.24	0.457	0.84	0.21	3.37	0.805
Re-categorised Frequency								
< daily	1				1			
daily	0.95	0.70	1.28	0.727	1.05	0.76	1.46	0.764
Duration: How long usually play instrument each time								
<30 minutes	1				1			
30-60 minutes	1.62	1.18	2.23	0.003	1.59	1.11	2.27	0.011
1-2 hours	1.62	0.95	2.74	0.075	1.94	1.12	3.37	0.018
2 – 5 hours	1.03	0.40	2.67	0.954	0.65	0.18	2.31	0.503
5+ hours	2.06	0.51	8.39	0.314	4.05	1.06	15.51	0.041

Table 6.2 Unadjusted Odds Ratios (95% Confidence Intervals) for relationships between music habits and monthly playing-related musculoskeletal symptoms (MPRMS) and playing-related musculoskeletal disorders (PRMD) (continued)

COVARIATE	MPRMS				PRMD			
Univariable Unadjusted OR	Odds Ratio	95%	CI	p value	Odds Ratio	95%	CI	p value
Exposure – dose (frequency x duration)								
daily, <30 min	1				1			
<daily, <30 min	1.25	0.79	1.99	0.343	1.42	0.82	2.47	0.210
<daily, ≥ 30-60 min	1.64	1.01	2.66	0.046	1.95	1.12	3.38	0.018
daily, ≥30 min	1.84	1.23	2.75	0.003	1.98	1.23	3.17	0.005
Frequency of breaks during practice in the last month								
Never	1				1			
Almost never	1.45	0.92	2.28	0.107	1.41	0.84	2.39	0.196
Sometimes	1.72	1.13	2.60	0.011	1.56	0.96	2.52	0.071
Most times	1.83	1.08	3.08	0.024	1.91	1.08	3.39	0.027
Always	1.91	0.94	3.89	0.073	2.15	1.02	4.53	0.043
Re-categorised - Break frequency								
Never -almost never	1				1			
Sometimes	1.40	1.01	1.94	0.047	1.27	0.89	1.83	0.192
Most times-Always	1.50	1.01	2.25	0.048	1.62	1.06	2.47	0.026
Re-categorised - Longest time played instrument without a break in last month								
< 30 minutes	1				1			
30-60 minutes	1.17	0.76	1.79	0.473	0.99	0.61	1.61	0.977
> 1 hour	1.83	1.21	2.78	0.004	1.38	0.87	2.19	0.166

Table 6.2 Unadjusted Odds Ratios (95% Confidence Intervals) for relationships between music habits and monthly playing-related musculoskeletal symptoms (MPRMS) and playing-related musculoskeletal disorders (PRMD) (continued)

COVARIATE	MPRMS				PRMD			
Univariable Unadjusted OR	Odds Ratio	95%	CI	p value	Odds Ratio	95%	CI	p value
Have you been playing more or less than usual in the last month recode								
About usual	1				1			
Much less- A little less	1.61	1.09	2.38	0.018	2.04	1.31	3.16	0.002
A little more- A lot more	1.83	1.30	2.59	0.001	1.93	1.30	2.86	0.001
How do you practice more than usual								
Don’t	1				1			
Play longer	1.07	0.67	1.71	0.785	0.96	0.57	1.64	0.887
Play more often	0.95	0.59	1.52	0.824	0.81	0.46	1.40	0.445
Play longer and more often	2.53	1.67	3.85	<0.001	2.16	1.46	3.21	<0.001
Pattern of playing (if playing more than usual, how?)								
About usual	1				1			
< usual	1.61	1.09	2.38	0.018	2.04	1.31	3.16	0.002
> usual and longer	1.31	0.79	2.17	0.285	1.35	0.76	2.42	0.308
> usual and more often	1.17	0.71	1.93	0.547	1.13	0.62	2.07	0.687
> usual and longer and more often	3.12	1.98	4.90	<0.001	3.04	1.92	4.81	<0.001

Table 6.2 Unadjusted Odds Ratios (95% Confidence Intervals) for relationships between music habits and monthly playing-related musculoskeletal symptoms (MPRMS) and playing-related musculoskeletal disorders (PRMD) (continued)

COVARIATE	MPRMS				PRMD			
Univariable Unadjusted OR	Odds Ratio	95%	CI	p value	Odds Ratio	95%	CI	p value
How often perform warm up exercises								
Never	1				1			
Almost never	1.29	0.79	2.09	0.309	1.07	.063	1.82	0.805
Sometimes	1.15	0.75	1.74	0.524	1.08	0.68	1.72	0.742
Most times	1.14	0.75	1.74	0.541	1.43	0.91	2.26	0.120
Always	1.22	0.76	1.94	0.413	1.11	0.67	1.85	0.692
Warm up exercises Re-categorised								
Never-Almost never	1				1			
Sometimes	1.05	0.72	1.55	0.788	1.06	0.69	1.62	0.800
Most times-Always	1.08	0.77	1.50	0.658	1.26	0.88	1.81	0.205
How often do cool down exercises								
Never	1				1			
Almost never	1.09	0.72	1.64	0.696	1.23	0.79	1.90	0.352
Sometimes	.84	0.46	1.56	0.583	1.15	0.59	2.22	0.683
Most times	.51	0.18	1.46	0.210	0.89	0.28	2.85	0.850
Always	2.31	0.46	11.52	0.309	4.10	0.97	17.36	0.055
Cool down exercises Re-categorised								
Never – almost never	1				1			
Sometimes	0.83	0.45	1.53	0.551	1.11	0.58	2.13	0.761
Most times-Always	0.83	0.36	1.90	0.652	1.53	0.65	3.58	0.333

Table 6.2 Unadjusted Odds Ratios (95% Confidence Intervals) for relationships between music habits and monthly playing-related musculoskeletal symptoms (MPRMS) and playing-related musculoskeletal disorders (PRMD) (continued)

COVARIATE	MPRMS				PRMD			
Univariable Unadjusted OR	Odds Ratio	95%	CI	p value	Odds Ratio	95%	CI	p value
Piece of music playing in last month more or less difficult than usual								
Much easier	1				1			
A little easier	0.52	0.20	1.40	0.196	0.64	0.22	1.82	0.399
About usual	0.61	0.28	1.32	0.209	0.71	0.33	1.54	0.387
A little difficult	0.67	0.31	1.43	0.298	0.82	0.38	1.77	0.610
A lot more difficult	1.24	0.50	3.09	0.641	1.58	0.67	3.81	0.307
Repertoire difficulty Re-categorised								
Much easier-A little easier	1				1			
About usual	0.87	0.51	1.48	0.605	0.89	0.50	1.60	0.703
A little difficult-A lot more difficult	1.05	0.62	1.77	0.858	1.17	0.66	2.05	0.595
Feeling of butterflies when play in concert/competition								
Never	1				1			
Almost never	2.08	1.27	3.40	0.004	1.96	1.06	3.64	0.032
Sometimes	1.73	1.11	2.70	0.015	2.42	1.38	4.24	0.002
Most times	2.40	1.48	3.89	<0.001	3.47	1.94	6.21	<0.001
Always	3.36	2.03	5.54	<0.001	4.09	2.29	7.31	<0.001

Table 6.2 Unadjusted Odds Ratios (95% Confidence Intervals) for relationships between music habits and monthly playing-related musculoskeletal symptoms (MPRMS) and playing-related musculoskeletal disorders (PRMD) (continued)

COVARIATE	MPRMS				PRMD			
Univariable Unadjusted OR	Odds Ratio	95%	CI	p value	Odds Ratio	95%	CI	p value
Re-categorised experience butterflies								
Never-almost never	1				1			
Sometimes	1.24	0.85	1.80	0.270	1.71	1.11	2.65	0.016
Most times	1.71	1.12	2.61	0.013	2.46	1.55	3.91	<0.001
Always	2.39	1.53	3.73	<0.001	2.90	1.83	4.60	<0.001
How much do you enjoy music?								
Don’t enjoy it	1				1			
Enjoy it a little	0.67	0.26	1.75	0.414	0.65	0.25	1.69	0.377
Enjoy it	0.52	0.21	1.26	0.145	0.60	0.25	1.44	0.251
Enjoy it very much	0.61	0.25	1.50	0.280	0.65	0.27	1.58	0.339
Love it	0.85	0.35	2.06	0.715	0.91	0.38	2.18	0.836
Music enjoyment Re-categorised								
Don’t enjoy it	1				1			
Enjoy it a little /Enjoy it	0.56	0.23	1.34	0.190	0.61	0.26	1.45	0.265
Enjoy it very much/ love it	0.73	0.31	1.75	0.480	0.79	0.34	1.85	0.585

Table 6.3 Adjusted Odds Ratios (95% Confidence Intervals) for variables significantly associated with PRMP in univariable analysis (continued)

COVARIATE	MPRMS				PRMD			
Univariable adjusted age and gender OR	Odds Ratio	95%	CI	P value	Odds Ratio	95%	CI	P value
Age (years)	1.15	1.03	1.28	0.014	1.19	1.05	1.35	0.006
Gender (female)	1.52	1.08	2.13	0.015	1.49	1.03	2.17	0.036
Years playing any instrument	1.03	0.94	1.09	0.449	0.99	0.93	1.07	0.899
Years playing main instrument	0.97	0.90	1.04	0.340	0.91	0.84	0.98	0.014
Time spent practicing	1.06	1.01	1.11	0.025	1.01	0.97	1.06	0.614
Exposure – dose (frequency x duration)								
daily, <30 min	1				1			
<daily, <30 min	1.12	0.69	1.80	0.648	1.29	0.74	2.27	0.367
<daily, ≥ 30-60 min	1.27	0.77	2.10	0.348	1.56	0.89	2.75	0.122
daily, ≥30 min	1.39	0.91	2.12	0.130	1.52	0.93	2.49	0.096
Re-categorised - Break frequency								
Never-Almost never	1				1			
Sometimes	1.28	0.91	1.79	0.153	1.19	0.81	1.69	0.411
Most times-Always	1.34	0.89	2.03	0.162	1.47	0.96	2.27	0.080
Re-categorised - Longest time played instrument without a break								
< 30 minutes	1				1			
30-60 minutes	1.06	0.69	1.65	0.785	0.90	0.55	1.48	0.682
> 1 hour	1.50	0.97	2.32	0.068	1.13	0.70	1.82	0.621

Table 6.3 Adjusted Odds Ratios (95% Confidence Intervals) for variables significantly associated with PRMP in univariable analysis (continued)

COVARIATE	MPRMS				PRMD			
Univariable adjusted age and gender OR	Odds Ratio	95%	CI	P value	Odds Ratio	95%	CI	P value
Pattern of playing (if playing more than usual, how?)								
About usual	1				1			
< usual	1.46	0.98	2.18	0.063	1.88	1.20	2.94	0.006
> usual and longer	1.37	0.82	2.28	0.224	1.39	0.77	2.50	0.272
> usual and more often	1.09	0.66	1.82	0.736	1.07	0.58	1.96	0.840
> usual and longer and more often	2.71	1.71	4.31	<0.001	2.65	1.66	4.25	<0.001
Feeling of butterflies when play in concert/competition								
Never-almost never	1				1			
Sometimes	1.06	0.72	1.56	0.777	1.53	0.98	2.38	0.063
Most times	1.38	0.89	2.14	0.151	2.08	1.29	3.36	0.003
Always	1.89	1.19	2.99	0.007	2.41	1.50	3.89	<0.001

Table 6.4 Multivariable Model for Music Practice and Intrinsic variables associated with PRMP (continued)

Final Model for PRMP	MPRMS				PRMD			
	Odds Ratio	95%	CI	p value	Odds Ratio	95%	CI	p value
Age (years)	1.17	1.06	1.30	0.003	1.20	1.07	1.36	0.003
Gender (female)	1.50	1.06	2.09	0.021	1.19	0.82	1.75	0.361
Years playing main instrument	0.96	0.89	1.04	0.286	0.88	0.81	0.96	0.003
Dose (frequency x duration)								
Daily, < 30 minutes	1				1			
< daily, < 30 minutes	1.05	0.63	1.76	0.846	1.04	0.57	1.91	0.893
< daily, ≥ 30 minutes	1.08	0.63	1.85	0.784	1.33	0.71	2.46	0.369
Daily, ≥ 30 minutes	1.12	0.70	1.81	0.632	1.39	0.80	2.43	0.243
Pattern of practicing within last month								
About usual	1				1			
< usual	1.38	0.90	2.11	0.141	2.12	1.30	3.44	0.002
> usual and longer	1.30	0.76	2.22	0.343	1.43	0.76	2.69	0.27
> usual and more often	1.08	0.63	1.86	0.773	1.00	0.51	1.96	0.992
> usual and longer and more often	2.31	1.41	3.77	0.001	2.69	1.60	4.53	<0.001
Longest time practicing without a break								
< 30 minutes	1				1			
30 – 60 minutes	1.03	0.64	1.66	0.906	0.823	0.47	1.44	0.494
> 1 hour	1.37	0.82	2.230	0.226	0.863	0.48	1.55	0.621

Table 6.4 Multivariable Model for Music Practice and Intrinsic variables associated with PRMP (continued)

Final Model for PRMP	MPRMS				PRMD			
	Odds Ratio	95%	CI	p value	Odds Ratio	95%	CI	p value
How often usually take breaks when practice music in the last month								
Never-Almost never	1				1			
Sometimes	1.31	0.91	1.88	0.147	1.247	0.83	1.87	0.284
Most times-Always	1.32	0.85	2.05	0.216	1.529	0.95	2.47	0.082
Feeling of butterflies when play in concert/competition								
Never-almost never	1				1			
Sometimes	1.12	0.75	1.68	0.588	1.67	1.03	2.69	0.036
Most times	1.31	0.83	2.08	0.248	2.39	1.42	3.96	0.001
Always	1.90	1.18	3.06	0.009	2.51	1.51	4.18	<0.001

6.6 DISCUSSION

This study has identified that music experience, the pattern of music practice and performance anxiety are associated with PRMP in children after adjusting for age and gender and other music practice factors.

The number of years spent playing any instrument in our study was associated with a 7-10% increased risk for PRMP for each year the instrument was played in univariable analysis. Cumulative exposure to the instrument may explain these findings (Brandfonbrener 1991; Bejjani et al. 1996; Brandfonbrener 2000a). Once age was accounted for, the association was no longer significant. In contrast, the years spent playing the main instrument demonstrated a decrease risk for PRMP in multivariable analysis. This may be explained by the survivor effect or adaption. Children who have experienced problems may have stopped playing music and only those without problems, survivors, continue to learn. It could also be that the child-instrument interaction over years of playing may result in a training effect such that children become accustomed to the demands unique to their instrument and are protected from developing problems. Children often choose their main instrument which may result in a high locus of control, high self-esteem and enjoyment in playing (which was significantly associated with decrease in risk for problems in the current study). Such factors are associated with a decrease in risk for musculoskeletal disorders in workers (Christmansson et al. 1999) and may also explain the decrease in risk for PRMP. This inverse relationship between experience and problems has also been reported in studies amongst adult musicians (Zaza 1995).

Playing for 30 minutes or less on a daily basis was the music practice dose associated with least problems in univariable analysis. The relationship between music practice dose and problems followed the U shaped curve described in the occupational health and pain literature, where extreme exposure levels are associated with increased risk of musculoskeletal disorders (Winkel and Westgaard 1992; Campello et al. 1996). For music practice dose, the least (less than daily for 30 minutes or less) and most (daily for greater than one hour) practice dose was associated with increased risk of PRMP. Minimal practice dose may result in muscles not being adequately trained for their task and motor learning not optimized. Therefore, the execution of movement patterns remain deliberate, potentially requiring more force and increased load on muscles and added need for increased concentration. Practicing for long periods of time on a daily basis may load muscles potentially beyond their limits with little opportunity to recover and adapt to task demands which may result in tissue damage and pain as seen in office workers (Amell and Kumar 1999; Gerr et al. 2004). Whilst dose was no longer a significant risk in multivariable analysis, practice for less than 30 minutes on a daily basis can be recommended as a suitable dose of practice.

Practicing less or more than usual was associated with more risk of problems in multivariable analysis, replicating the same U shaped relationship seen with usual dose. Children playing less than usual may have experienced problems and be deliberately playing less (either because they reason playing less may relieve problems or are afraid that continued playing may exacerbate problems). Further, occupational studies suggest return to practice following a period of relative inactivity may place them at greater risk of problems due to deconditioning or unaccustomed use of muscles (Gerr et al. 1991). Playing more than usual, more often and for longer, represents increased exposure. So for muscles used to a certain level of activity, the demand of performing repetitive movements for longer and more often may load muscles beyond their capacity and result in tissue changes, potential tissue damage and subsequent soreness. Due to the study design, we cannot determine the direction of the relationship, that is, children with problems may have subsequently practiced less frequently and for less time or vice versa. Prior studies in adults (Fry 1986b; a; Newmark and Lederman 1987; Fishbein et al. 1988; Zaza and Farewell 1997; Burkholder and Brandfonbrener 2004), and children (Fry 1987; Fry et al. 1988; Lockwood 1988; Fry and Rowley 1989; Grieco et al. 1989; Shoup 1995; Britsch 2005) have not investigated the manner or pattern of how musicians might practice more than usual, but have generally noted that an increased time spent practicing prior to concerts/exams/recitals is associated with the reported experience of problems amongst musicians. Extra practice is predictable prior to concerts or exams and therefore strategies to ensure it is scheduled appropriately and is organized with variable practice frequency and practice duration should be considered to avoid potential development of problems.

Taking breaks during practice most times-always increased risk for PRMP compared to never taking breaks in univariable analysis. It may be that students with problems need to take breaks, rather than more breaks resulting in PRMP, however the cross sectional nature of the study design cannot determine this. Only one study in children reported on breaks during practice and found that asymptomatic musicians rarely rested during practice (Lockwood 1988). In our study, after adjusting for age and gender, taking breaks was no longer significantly associated for problems due to the confounding effect of gender. Specifically, more females reported the experience of PRMP and more females took breaks during practice, compared to males.

The majority of children in our study reported the experience of butterflies in the stomach, and this was significantly associated with PRMD after adjusting for age and gender. Muscle activation, changes in breathing and other physical changes associated with music performance anxiety may compromise technique and posture and subsequently contribute to the development of problems. In professional musicians, Zaza (1995) and Zaza and Farewell (1997) reported increased trait anxiety was associated with increased risk for PRMD and Fishbein et al (1988) reported the experience of stage fright was associated with problems. It is important that music educators, parents and health professionals recognise that children experience music performance anxiety and the potential negative impact of this on the child. Physical or behavioural signs and symptoms should be monitored and the child and family directed to appropriate health care for early management.

In our study warm up and cool down were not associated with PRMP. We did not specify physical warm up versus musical warm up (i.e. scales), and perhaps this could have made a difference as physical warm up was associated with a decreased risk for PRMD in adults (Zaza 1995). Ensuring muscles necessary for supporting and playing the instrument are adequately prepared for their task may be a good habit to encourage in child instrumentalists with developing musculoskeletal system but needs further research.

No association between difficulty of repertoire and PRMP was found. This may be due to children being proficient with their current repertoire as the data was collected in the lead up to end of year recitals and performances. Also, the study questionnaire may not have been sensitive enough to detect unique repertoire detail.

6.6.1 Limitations

The cross-sectional design of the study can only provide evidence of an association of potential risk factors to the development of PRMP and cannot infer causality. The interaction between child and the music instructor can influence the child's approach to the instrument and music learning and also his or her reaction to an injury or pain and therefore impact on performance (Havlik and Upton 1992; Brandfonbrener 2000a). Whilst considered an important factor for PRMP, this relationship remains the least explored and warrants investigation in future studies.

6.6.2 Acknowledgements

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6.7 CONCLUSION

Music practice habits are associated with the development of playing-related musculoskeletal problems in children. The findings from this study support the following recommendations in music education: children should practice for short periods of time on a daily basis; practice schedules should be planned to avoid extreme practice patterns during anticipated increased practice seasons, and breaks should be taken during practice sessions. Strategies to deal with the experience of music performance anxiety need to be identified and implemented from an early age to minimize the negative impact on the individual and music performance. These safe music practice habits will maximize adaptation of the developing musculoskeletal system to task demands, minimize the development of problems and promote enjoyable music experiences in children and help ensure continued participation in and commitment to music education.

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CHAPTER 8 DISCUSSION

This thesis investigated the prevalence and location of playing-related musculoskeletal problems (PRMP), both symptoms (PRMS) and disorders (PRMD), in children learning instrumental music, and examined the potential intrinsic (physical, psychosocial) and extrinsic (music and non-music related) factors associated with PRMP in young musicians.

This chapter will summarise the main findings of the thesis (as presented in Chapters 3 to 7), regarding the prevalence and location of PRMP and significant risk factors associated with PRMP. This chapter aims to link results from Chapters 3 to 7 according to the proposed risk factor model for PRMP in musicians outlined in Chapter 1 (Figure 1.1), and discusses the role of those risk factors found to be significantly associated with PRMP with reference to neurobiopsychosocial pain mechanisms. The discussion also considers the role of risk factors which were examined but not identified as statistically significant correlates of PRMP, and additionally, factors that were not investigated in this thesis for PRMP risk but have relevance to clinical practice. Due to the inability of cross sectional studies to provide causal evidence, it is important to reiterate, the best evidence from this thesis is only one of association with PRMP (Figure 8.1). Lastly, the limitations of the thesis will be outlined and recommendations for future research presented.

8.1 SUMMARY OF MAIN FINDINGS

The results of the thesis are listed below. Table 8.1 presents a summary of statistically significant risk factors associated with PRMP identified in the current study, with estimates (OR and 95%CI) and corresponding p-values before and after adjustment for gender and age.

1. PRMP are common in children and adolescents and most commonly reported in the upper extremities and the neck.

2. The intrinsic factors age and female gender were found to be significantly positively associated with PRMP and some PRMP locations.

3. The number of non-music related activity soreness experiences were significantly positively associated with PRMP, accounting for age and gender.

4. The intrinsic factor of experience of butterflies in the stomach (as a somatic measure of performance anxiety), was found to be significantly positively associated with PRMP, accounting for age and gender.

5. The nature of music exposure (specifically the type of instrument played and number of instruments played) was found to be significantly associated with PRMP, accounting for age and gender.

6. The amount of music exposure (specifically the years spent playing the main instrument, the total practice time, and the pattern of playing when playing more than usual) was found to be significantly positively associated with PRMP, accounting for age and gender.

7. The years spent playing any instrument, the playing dose (frequency x duration), the frequency of breaks and the longest time spent playing without a break were extrinsic music related factors found to be univariably significantly associated with PRMP, however after accounting for age and gender, they no longer remained significantly associated with PRMP.

8. The type of repertoire, the performance of warm up and cool down exercises and the reported enjoyment of playing music were extrinsic music related factors not found to be significantly associated with PRMP.

9. The exposure to extrinsic non-music related activity (frequency, duration and longest time spent in the activity) was not significantly associated with PRMP.

Table 8.1 Summary of Risk Factors and association with PRMP (continued)

Factor	Unadjusted Odds Ratio (95% CI), p value		Adjusted Odds Ratio (95% CI), p-value	
	PRMS	**PRMD**	**PRMS**	**PRMD**
Intrinsic Physical				
Gender	**1.56** (1.15-2.11) p=0.004	**1.46** (1.04-2.04) p=0.028	**1.67** (1.17-2.37) p=0.004	**1.62** (1.10-2.38) p=0.014
Age	**1.19** (1.11-1.29) p<0.001	**1.19** (1.08-1.29) p<0.001	**1.17** (1.06-1.28) p=0.002	**1.17** (1.06-1.30). p= 0.003
Intrinsic Physical - Non-music activity related soreness				
none	1	1	1	1
1	**2.43** (1.66-3.56) p<0.001	**2.4** (1.48-3.89) p<0.001	**2.22** (1.50-3.29) p<0.001	**2.31** (1.41-3.79) p<0.001
2	**5.19** (3.31-8.13) p<0.001	**4.71** (2.87-7.71) p<0.001	**4.58** (2.87-7.31) p<0.001	**4.38** (2.61-7.34) p<0.001
3	**7.16** (4.10-12.49) p<0.001	**6.53** (3.79-11.24) p<0.001	**6.59** (3.72-11.69) p<0.001	**6.69** (3.78-11.84) p<0.001
4	**10.18** (4.10-25.27) p<0.001	**14.44** (6.65-31.38) p<0.001	**9.10** (3.60-23.02) p<0.001	**13.73** (6.16-30.58) p<0.001
Intrinsic Psychosocial - Feelings of butterflies in stomach				
never - almost never	1	1	1	1
sometimes	1.24 (0.85-1.80) p=0.270	**1.71** (1.11-2.65) p=0.016	1.12 (0.75-1.68) p=0.588	**1.76** (1.03-2.69) p=0.036
most times	**1.71** (1.12-2.61) p=0.013	**2.46** (1.55-3.91) p<0.001	1.31 (0.83-2.08) p=0.248	**2.39** (1.42-3.96) p=0.001
always	**2.39** (1.53-3.73) p<0.001	**2.90** (1.83-4.60) p<0.001	**1.90** (1.18-3.06) p=0.009	**2.51** (1.51-4.18) p<0.001

Table 8.1 Summary of Risk Factors and association with PRMP (continued)

Factor	Unadjusted Odds Ratio (95% CI), p value		Adjusted Odds Ratio (95% CI), p-value	
	PRMS	**PRMD**	**PRMS**	**PRMD**
Extrinsic Music -Related - Instrument Related				
Instrument Group				
Piano	1	1	1	1
Upper Strings	1.61 (0.99-2.63) p=0.056	**1.97** (1.10-3.54) p=0.023	1.67 (0.99-2.83) p=0.053	**1.91** (1.04-3.50) p=0.038
Lower Strings	**2.68** (1.45-4.95) p=0.002	**2.71** (1.39-5.27) p=0.003	**2.93** (1.53-5.60) p=0.001	**2.74** (1.37-5.46) p=0.004
Woodwind	**2.16** (1.38-3.36) p=0.001	**2.29** (1.35-3.91) p=0.002	**1.78** (1.11-2.87) p=0.017	**1.85** (1.07-3.23) p=0.029
Brass	1.38 (0.82-2.32) p=0.219	**2.26** (1.23-4.15) p=0.009	1.37 (0.78-2.40) p=0.272	**2.27** (1.20-4.29) p=0.012
Guitar	1.60 (0.87-2.93) p=0.128	**2.16** (1.08-4.34) p=0.030	1.41 (0.74-2.69) p=0.292	1.78 (0.86-3.72) p=0.122
Percussion	1.85 (0.74-4.63) p=0.189	2.17 (0.80-5.92) p=0.130	1.61 (0.62-4.20) p=0.328	1.65 (0.57-4.79) p=0.361
Number of instruments				
1	1	1	1	1
2	1.16 (0.85-1.59) p=0.336	1.23 (0.88-1.71) p=0.227	1.01 (0.76-1.53) p=0.66	1.26 (0.87-1.81) p=0.222
3	0.68 (0.37-1.23) p=0.202	0.84 (0.42-1.66) p=0.607	**0.44** (0.22-0.89) p=0.022	0.68 (0.31-1.49) p=0.332
Extrinsic Music -Related - Music Practice				
Years playing any instrument	**1.1** (1.04-1.16) p=0.001	**1.07** (1.01-1.13) p=0.019	1.03 (0.94-1.09) p=0.449	0.99 (0.93-1.07) p=0.899
Years playing main instrument	**1.05** (1.00-1.11) p=0.012	0.99 (0.93-1.06) p=0.922	0.97 (0.90-1.04) p=0.340	**0.91** (0.84-0.98) p=0.014

Table 8.1 Summary of Risk Factors and association with PRMP (continued)

Factor	Unadjusted Odds Ratio (95% CI), p value		Adjusted Odds Ratio (95% CI), p-value	
	PRMS	**PRMD**	**PRMS**	**PRMD**
Total Practice Time (hrs/wk)	**1.07** (1.03-1.11) p=0.001	1.04 (0.99-1.08) p=0.070	**1.06** (1.1-1.11) p=0.025	1.01 (0.97-1.06) p=0.614
Practice Dose				
daily, <30min	1	1	1	1
<daily, <30 min	1.25 (0.79-1.99) p=0.343	1.42 (0.82-2.47) p=0.210	1.05 (0.63-1.76) p=0.846	1.04 (0.57-1.91) p=0.893
<daily, >30-60min	**1.64** (1.01-2.66) p=0.046	**1.95** (1.12-3.38) p=0.018	1.08 (0.63-1.85) p=0.784	1.33 (0.71-2.46) p=0.369
daily, >30-60min	**1.84** (1.23-2.75) p=0.003	**1.98** (1.23-3.17) p=0.005	1.12 (0.70-1.81) p=0.632	1.39 (0.80-2.43) p=0.243
Pattern of Practice				
about usual	1	1	1	1
< usual	**1.61** (1.09-2.38) p=0.018	**2.04** (1.3 -3.16) p=0.002	1.38 (0.90-2.12) p=0.141	**2.12** (1.303.44) p=0.002
> usual, longer	1.31 (0.79-2.17) p=0.285	1.35 (0.76-2.42) p=0.308	1.30 (0.756-2.22) p=0.343	1.43 (0.76-2.69) p=0.270
> usual, more often	1.17 (0.71-1.93) p=0.547	1.13 (0.62-2.07) p= 0.687	1.08 (0.63-1.86) p=0.773	1.00 (0.51-1.96) p=0.992
> usual, longer and more often	**3.12** (1.98-4.90) p<0.001	**3.04** (1.92-4.81) p<0.001	**2.31** (1.41-3.77) p=0.001	**2.69** (1.60-4.53) p<0.001

Table 8.1 Summary of Risk Factors and association with PRMP (continued)

Factor	Unadjusted Odds Ratio (95% CI), p value		Adjusted Odds Ratio (95% CI), p-value	
	PRMS	**PRMD**	**PRMS**	**PRMD**
Frequency of breaks				
never-almost never	1	1	1	1
sometimes	**1.40** (1.01-1.94) p=0.047	1.27 (0.89-1.83) p=0.192	1.31 (0.91-1.88) p=0.147	1.25 (0.83-1.87) p=0.284
most times-always	**1.50** (1.01-2.25 p=0.048	**1.62** (1.06-2.47) p=0.026	1.32 (0.85-2.05) p=0.216	1.53 (0.95-2.47) p=0.082
Longest time played without break				
<30 minutes	1	1	1	1
30-60 minutes	1.17 (0.76-1.79) p=0.473	0.99 (0.61-1.61) p=0.977	1.03 (0.64-1.66) p=0.906	0.82 (0.47-1.44) p=0.494
>1 hour	**1.83** (1.21-2.78) p=0.004	1.38 (0.87-2.19) p=0.166	1.37 (0.82-2.23) p=0.226	0.863 (0.48-1.55) p=0.621

8.2 PRMP PREVALENCE AND LOCATION

8.2.1 PRMP Prevalence and Impact

This thesis found children reported the experience of PRMP at high rates, similar to rates reported amongst adult musicians. Sixty seven percent reported the experience of symptoms at some point in the past, that is lifetime prevalence of PRMS, and 56% reported the experience of symptoms within the last month, that is monthly PRMS. Thirty percent reported the experience of symptoms that rendered them unable to play their instrument as usual, that is the experience of a PRMD in the last month.

A direct comparison of PRMP prevalence rates in this thesis to other child studies is not possible because other studies either did not use standard case definitions, were of special samples and/or used different assessment methods. This is the only child study to use a standard case definition of PRMS and PRMD.

Seven child studies (Fry 1986c; Dawson 1988; Fry et al. 1988; Lockwood 1988; Fry and Rowley 1989; Grieco et al. 1989; Shoup 1995) were conducted prior to establishment of a standard case definition of PRMP (Zaza 1995). These and some more recent studies (Roset-Llobet et al. 2000; Bruno et al. 2008) used the Fry pain severity scale (0-5) or a modified version. Attempts to align the severity categories reported in these studies to PRMS and PRMD equivalents were difficult as raw data were unavailable.

Reported prevalence rates on very mild symptoms, Fry’s Grade 1, pain in one site brought on by playing the instrument (Fry 1986c), were higher (Fry et al. 1988; Fry and Rowley 1989; Brown 1997; Bruno et al. 2008) than rates for lifetime and monthly PRMS in the current study (see Table 1.2). PRMS (mild aches and pains which are experienced during and following playing, that may or may not affect performance (Zaza et al. 1998)) may encompass Fry’s Grade 1 and Grade 2 (the experience of pain in two or more sites and impacts on playing) (Fry 1986c)) severity categories, and therefore the current study’s prevalence rates are lower than those studies reporting only on rates for Grade 1. However the disparity in rates between prior studies and the current study may also be due to the sample selection (e.g. clinic based compared to music class), low response rates in the other studies, method of data collection (physical examination compared to questionnaire), in addition to the heterogeneity of case definitions.

The few child studies with prevalence data for more severe problems reported lower prevalence rates than the current study (Fry 1986c; Shoup 1995). The different rates may be explained by the heterogeneity of case definitions and apparent inconsistencies in reported severity grade categories. For example, prevalence rates of 2% were reported for severe problems, Fry Grade 5, "pain at rest, pain at night or both…. career stops or seriously threatened" page 183, (Fry 1986c) in 425 junior and senior high school music students (Shoup 1995). However, in the same study, 20% of students reported missing rehearsals or being unable to play for one week, also representative of a PRMD, and with a rate comparable to the PRMD rate in this thesis. Similarly, these studies failed to report prevalence rates of other severity grades analogous to a PRMD, for example Grade 3, "pain persisting away from instrument….student underperforms" page 183 (Fry 1986c), and may thus have underestimated PRMD prevalence.

Other subsequent cross-sectional studies used discomfort scales (Britsch 2005) or pain and discomfort questions (Betuel and Clairet 1999). These questionnaire based studies reported similar high rates of symptoms to the monthly PRMS rates in this thesis, but did not report on more severe problems (Table 1.2). Physical examination may more accurately determine prevalence and location of PRMP than a questionnaire survey (see Chapter 1) and may explain the more modest PRMP prevalence rates amongst music students and adult musicians who were physically examined (Table 1.2 and Table 1.3).Very few studies used both a questionnaire survey and physical examination to determine PRMP prevalence, with rates varying from 9.3% (Fry 1987) to 84.4% (Burkholder and Brandfonbrener 2004) according to the sample studied. No music study has reported agreement between PRMP prevalence determined by questionnaire versus physical examination. However the pain and occupational medicine research suggests high rates of agreement between questionnaire and clinical examination (Andersson et al. 1993; Schierhout and Myers 1996; Ciccarelli 2008). For the purpose of this thesis, physical examination was not feasible.

Some other studies have been of specialist samples, for example three child studies (Dawson 1988; Dawson 2002; Burkholder and Brandfonbrener 2004) were clinic based where a higher prevalence rate would be expected as only patients with some health problems were sampled (Altman 1991). A specialised performing arts medical centre reported a prevalence rate of 100% as all musicians presenting to the clinic were injured (Burkholder and Brandfonbrener 2004) (Table 1.2). However, lower PRMP prevalence rates were reported in a university affiliated medical clinic. Students presenting with upper limb musculoskeletal soreness were physically examined and diagnosed with music related (overuse), trauma, arthritis or ‘other’ problems (Dawson 1988; Dawson 2002). Music related problems were diagnosed in 20% and 12% fewer students than the current study’s rates for PRMS or PRMD respectively.

The case definitions used in the current study were consistently used in more recent adult studies. Prevalence rates of PRMP in young musicians in the current study were not far behind those of university music students and professional musicians. The monthly prevalence rate of PRMS amongst 90 university music students was 67% (Roach et al. 1994) and 58% in 1400 adult orchestral musicians (Middlestadt and Fishbein 1989). The rates are similar to the 56% monthly PRMS rate in the current study, with the slightly higher rates in the university student group potentially due to the lower response rate. Monthly PRMD rates of 39% and 38% were reported amongst groups of professional and university musicians (Zaza 1995; Bruno et al. 2008). The 30% monthly PRMD rate amongst children in this study is disconcertingly similar to these adult rates.

The pain literature suggests disorders of adults may begin in childhood (Croft et al. 1993; Smedbraten et al. 1998; Perry et al. 2008). This may well be relevant to PRMP in musicians. The study’s high monthly and lifetime PRMS rates and modest monthly PRMD rate suggest PRMP are a very important issue for young instrumentalists. Firstly, PRMP are common in child instrumentalists. Secondly, PRMP may be serious enough to prevent a child playing their instrument as usual or at all. Consequently, factors contributing to increased risk for PRMP in children need to be understood to ensure prevention initiatives are promoted and implemented to reduce PRMP risk and prevent the development of more disabling disorders in adulthood.

PRMP are not trivial for children. In our study 4.6% (19/409) of those with problems reported taking medication, and 4.2% (17/407) reported visits to health professionals (Figure 1.8). For those students who reported the experience of a PRMD, this represented 8.3% (18/216) who took medication and 6.9% (15/217) who visited health professionals. It may also be that the experience of a PRMP may impact on children in other facets of life. They may not be able to participate in social activities or organised sports. This may have psychosocial implications and affect mood and general well-being, which in turn may further compound the PRMP experience. It is paramount that children's mild symptoms be acknowledged by educators, parents and health professionals, as simple advice or re-education may prevent symptom progression.

An implication drawn from the current study is that in order to establish precise PRMP prevalence rates in children, studies should use clear, consistent case definitions of PRMS and PRMD. More accurate comparisons across child studies and adult studies will then be possible. The current study used established case definitions and found PRMP are prevalent in young instrumentalists and that these problems are not trivial.

8.2.2 Prevalence of PRMP in Different Locations

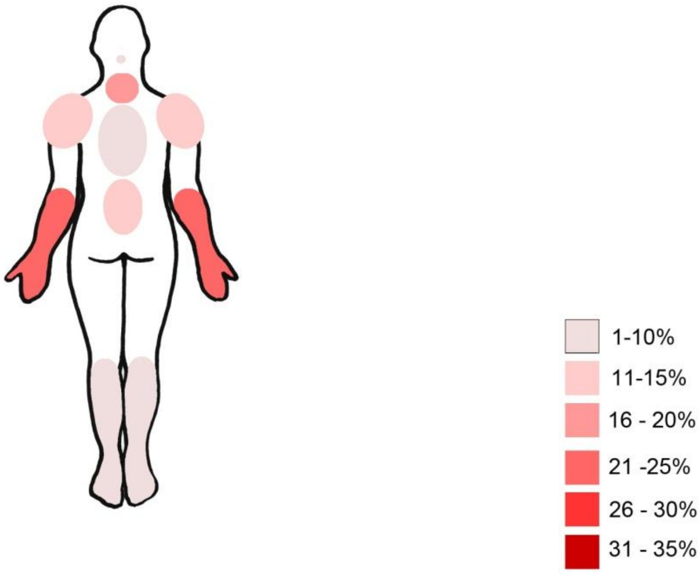
This was the first child study to document the prevalence of PRMP in different locations, both for symptoms and disorders (Chapter 5). The upper extremities, particularly the right and left hand/elbow, the neck and right shoulder, were the most commonly reported locations for PRMP (see Figure 8.1 and Table 5.6). Site specific prevalence rates were similar to some others that have been reported in child studies (Dawson 2002 ; Burkholder and Brandfonbrener 2004; Britsch 2005; Bruno et al. 2008) and some adult studies (Larsson et al. 1993b; Zaza 1995; Yeung et al. 1999; Dawson 2002).

Similar common locations to the those in the current study were reported in studies physically examining PRMP in children (Dawson 2002; Burkholder and Brandfonbrener 2004; Bruno et al. 2008), even though PRMS and PRMD case definitions were not specified in those studies. In contrast, other child studies which used questionnaires and did not specify a method for determining PRMP location, i.e. use of body diagram or specific questions/anatomical categories, found the spine to be more commonly affected followed by the upper extremities (Grieco et al. 1989; Betuel and Clairet 1999; Roset-Llobet et al. 2000). It is likely that the body map derived PRMP location prevalences in the current study and the physical examination based PRMP prevalences more accurately reflect true prevalence for PRMP locations.

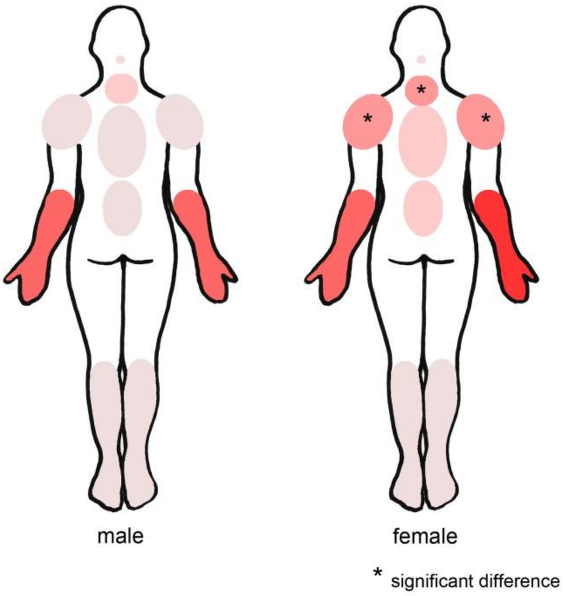
The patterns of PRMP location may reflect the unique physical demands of the type of instrument played (see Figure 8.3 and Figures 5.8-5.10). This study surveyed a range of 23 instruments representative of instruments used by children in an orchestral score, and reported PRMP prevalence at locations according to the type of instrument/instrument group. Only 2 child studies previously reported PRMP locations across a representative range of instruments (Dawson 2002; Burkholder and Brandfonbrener 2004).The higher PRMP rates at specific locations in this study compared to previous studies may be due to previous studies being of special, clinic based, samples (Dawson 2002; Burkholder and Brandfonbrener 2004). In contrast, the current study had a large sample size with a high response rate and the reported prevalence rates can be seen to be representative of PRMP experienced by children learning instrumental music in Australia.

The experience of musculoskeletal soreness is common during childhood and adolescence (see section. 1.2.3.1.1.5). In the literature, the lumbar spine is the most commonly reported location of musculoskeletal pain in children, followed by the thoracic and cervical spine (Salminen 1984; Balague et al. 1988; Troussier et al. 1994; Balague et al. 1995; Mikkelsson et al. 1997; Mikkelsson et al. 1998). The neck, low back and mid back were the most commonly reported locations, followed by right elbow/hand and lower limb, for school and home computer related musculoskeletal soreness in a cross sectional questionnaire survey of 1351 students aged between 6 to 16 years (Harris 2010). These patterns of musculoskeletal soreness location most likely reflect different physical demands of the different tasks.

Clearly the pattern of PRMP location in this study differs to the pattern of musculoskeletal soreness from activities such as computer use. However, children learning instrumental music may also concurrently participate in activities such as watching TV and computer use and subsequently may experience soreness from participation in these non-music activities. This other activity soreness experience may have implications for the reported PRMP locations. This other musculoskeletal soreness experience and the relationship with PRMP is discussed in a following section (8.3.3).



Prevalence PRMP for whole sample



Prevalence PRMP for male and female

Figure 8.1 Prevalence of PRMP at different locations across the whole sample, and each gender (colour density refers to percentage of reported PRMP) (* highlights where there was a significant difference in prevalence rates between genders)

The reported PRMP locations in this study are similar to the patterns reported in adult musician studies. The distal extremity and neck/cervical spine were consistently reported in adult studies collecting information on specific PRMP locations (Larsson et al. 1993b; Zaza 1995; Yeung et al. 1999; Dawson 2002). Other adult studies reported the spine (neck, low back, thoracic spine) to be the more common PRMP location followed by the shoulder, arm and distal extremity (Fishbein et al. 1988; Fjellman-Wiklund and Sundelin 1998; Semmler 1998; Chesky et al. 2002; Kaneko et al. 2005; Abreu-Ramos and Micheo 2007). Data collection methods were not consistently detailed in these studies and as mentioned previously, the comparison of prevalence rates for different PRMP locations in this study to those in adult studies is difficult due to different and often limited range of instruments.

Evidence suggests the experience of soreness in childhood predicts the experience of soreness in adulthood (Perry et al. 2008). This study showed the pattern of PRMP locations in young musicians is similar to the pattern of PRMP location in adult musicians. This emphasises the need to understand the potential risks associated with these PRMP patterns in children to prevent recurring patterns in adulthood. An enhanced understanding will inform prevention initiatives in music education and music medicine.

8.3 RISK FACTORS AND PRMP

Figure 8.2 illustrates the intrinsic (gender, age, other soreness experience (specifically non-music related activity soreness experience) and extrinsic (type of instrument, number of instruments played, years played main instrument, total playing time and pattern playing more than usual) risk factors identified by this study to be significantly associated with PRMP after adjusting for age and gender. It also shows the risk factors significantly associated only univariably with PRMP (years any instrument played, playing dose i.e. frequency x duration, taking breaks and longest time spent playing without a break), the risk factors identified by this study as not significantly associated with PRMP (enjoyment, repertoire, warm up/cool down and non-music related activity exposure) and, risk factors not examined in this study (hypermobility, anthropometry, general health, psychosocial factors and habitual and playing posture). Relevant chapters will be referred to with respect to specific study results.

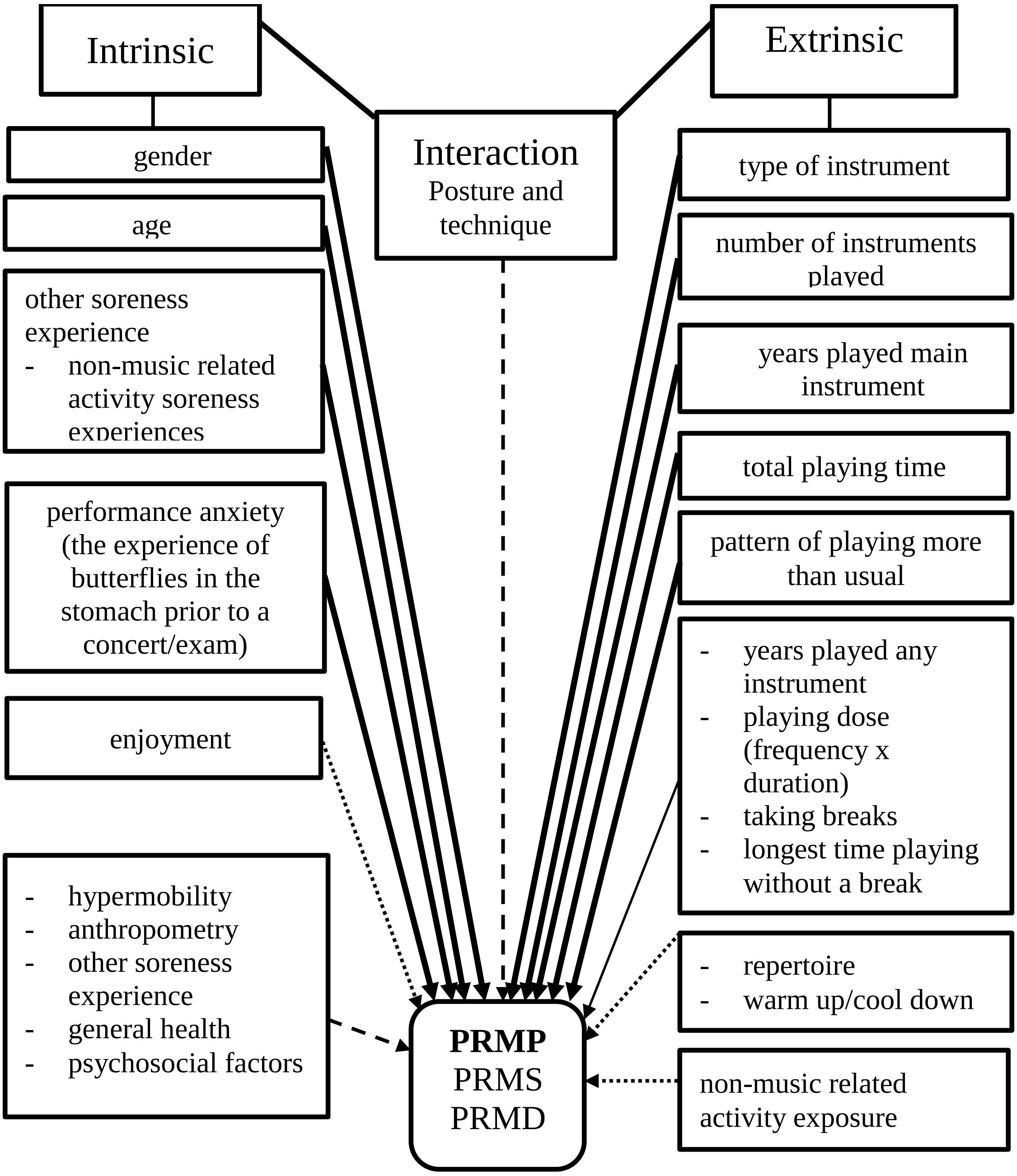


Figure 8.2 Model of potential factors associated with PRMP in children and adolescents

→ Factors independently associated with PRMP in this thesis

→ Factors univariably associated with PRMP in this thesis

→ Factors with no significant association in this thesis

→ Factors whose association with PRMP was not investigated in this thesis and remain unknown

8.3.1 Intrinsic Risk Factors and PRMP

The following section discusses the intrinsic risk factors significantly associated with PRMP in children, specifically gender, age, number of reported PRMP locations and other musculoskeletal soreness experiences, and performance anxiety.

In this study, more females than males reported the experience of PRMP across childhood, and PRMP increased with age for both genders, with no significant interaction effect between gender and age (see Chapter 3). This is the first study to establish that gender and age are significantly associated with increased risk for development of PRMP in young instrumentalists.

Clearly, gender and age are factors that may also influence the relationship between other potential risk factors and PRMP. Thus subsequent analyses investigating the independent associations of other potential intrinsic and extrinsic risk factors with PRMP adjusted for the potential confounders of gender and age.

8.3.1.1 Gender

In this study, females were 1.5 times more at risk of developing PRMP than males, accounting for age. The gender findings are consistent with adult music studies (Fishbein et al. 1988; Manchester and Lustik 1989; Zaza 1992; 1995; Zaza and Farewell 1997; Cayea and Manchester 1998; Zetterberg et al. 1998; Pak and Chesky 2001; Spahn et al. 2002; Kaneko et al. 2005; Abreu-Ramos and Micheo 2007), as well as pain (Unruh 1996; Fillingim 2003) and occupational medicine (Strazdins and Bammer 2004) research.

Only one prior child study (Lockwood 1988) found significantly more females reported problems than males in 113 music students aged 13 to 18, however limited statistical analysis (chi square) did not quantify the association of gender with PRMP and did not adjust for age (Table 1.4). Only one adult study accounted for age and found females were at twice the risk of PRMD compared with males (Zaza 1995) (Table 1.4).

In this study, females also reported PRMP more frequently at all locations than males, although the pattern of locations was similar (Figure 8.1). No prior child study investigating the location of PRMP reported differences between genders in the number of locations. However four adult studies found females reported more PRMP locations than males (Zaza 1995; Cayea and Manchester 1998; Kaneko et al. 2005; Abreu-Ramos and Micheo 2007).

Pain research has investigated gender differences in experimentally induced pain and clinical pain to better understand the mechanisms that may be responsible for the differences (Unruh 1996; Fillingim 2003). Experimentally, females are more sensitive to various modes and methods of noxious stimulation than males. Differences were reported in subjective responses and objective neurophysiological measures such as neuroimaging, which showed greater activation in some brain regions during painful stimulation among females than males (Berman et al. 2000). In the clinical setting, females report more frequent pain, more severe pain, and pain of longer duration than males (Fillingim 2003).

Various mechanisms have been proposed to explain the gender differences associated with perception of pain and response to pain (Unruh 1996; Fillingim 2003). These are biological mechanisms, which include genetic and hormonal factors, neurophysiological mechanisms such as brain anatomy and function and psychosocial mechanisms such as depression, anxiety, psychological distress, catastrophising, self-efficacy, and family history, For example, hormonal influences explained the variation of pain perception across the menstrual cycle in healthy women (Fillingim and Ness 2000) and explained the lower pain thresholds in postmenopausal women undergoing hormone replacement therapy compared to their non-hormone replacement controls (Fillingim and Edwards 2001). Hormonal factors may also explain the peak prevalence of PRMP in females at 13 years of age in this study, compared to males reaching peak prevalence at 15 to 17 years (see Chapter 3).

Psychosocial factors, such as depression, anxiety and psychological distress are significantly associated with reported increased pain and physical symptoms (Carroll et al. 2004; Gatchel et al. 2007). Females report greater depression, anxiety and psychological distress than males from adolescence (Unruh 1996; Fillingim 2003) and therefore, being female may be a proxy for other risks.

Social roles are thought to influence gender differences in reporting of pain (Unruh 1996; Fillingim 2003). Typically, there is a level of expectation and acceptance that females report the experience of pain, whereas males tend to take on the stoic “macho” role and do not readily report the experience of pain (Otto and

Dougher 1985). This factor may well explain the gender difference in PRMP reporting in this study, with males possibly underreporting PRMP compared to females (see Chapter 3).

Neurophysiologically, the sex differences in brain anatomy and function may contribute to the differences in pain perception and response to pain between females and males (Fillingim 2003).

This study found female gender was significantly positively associated with PRMP. Biological mechanisms for pain perception and pain response may be modifiable, as are the various psychosocial factors potentially contributing to gender differences in pain experiences and pain responses. Music educators, health professionals and parents need to monitor female instrumentalists for the experience of PRMP, particularly earlier PRMS experience, and should be mindful of the potentially stoic young adolescent male.

8.3.1.2 Age

This study found that PRMP were experienced at all school ages, including in the very young. Prevalence increased across childhood and monthly prevalence peaked earlier in females (12-13 years) compared to males (15-17 years). This study was the first child study to establish that increasing age is a potential risk associated with PRMP and found a 20% increase in odds for PRMP with each increasing year of age from 7 to 17 years, after accounting for gender (see Chapter 3).

A prior study of 195 university music students aged 11 to 26 year old found older students were at 2.2 times the risk of PRMP compared with younger students (95% CI: 1.02-5.69, p=0.04 (Bruno et al. 2008). However the ‘younger’ students were categorised as 18 years or less. In adult musicians, an inverse association has been reported between age and PRMP prevalence (p=0.003) (Pak and Chesky 2001), however the association was not quantified. The influence of age in adult musicians is unclear. It may be musicians experiencing PRMP leave the orchestra whilst healthy musicians continue, potentially decreasing the prevalence rates across older age groups. The many years of music practice may result in appropriate adaptive changes of the musculoskeletal system (to the musician’s instrument demands) and subsequently lower prevalence rates among older musicians. Conversely, the many years of practice may represent cumulative load on the aging musculoskeletal system and may increase prevalence rates among older musicians. However, in pain research, evidence suggests the development of spinal musculoskeletal disorders commonly begins in adolescence (Perry et al. 2008) and pain in childhood predicts the experience of pain in adulthood (Jones et al. 2007).

The current study found that high prevalence rates for upper limb problems appeared early in childhood and remained high across childhood (Chapter 5). The shoulder and right hand/elbow PRMP prevalence peaked in mid adolescence, whereas the left hand/elbow PRMP prevalence continued to increase across childhood. Spinal pain was also found to increase across childhood. No other study was found which investigated prevalence of PRMP in different locations across childhood.

Pain research suggests most musculoskeletal pains increase in prevalence with age across childhood, reaching adult levels by late adolescence (Jeffries et al. 2007; Jones et al. 2007; Jones 2011). This means that for most people, their first episode of pain has occurred by late adolescence. Episodes of adolescent neck and back pain are associated with an increased risk for the experience of neck and back pain in adulthood (Hertzberg 1985; Harreby et al. 1995; Siivola et al. 2004), suggesting the experience of PRMP by child instrumentalists may increase their risk of experiencing PRMD in adult life.

Mechanisms that may explain the increase in prevalence with age across childhood may be associated with the developing musculoskeletal (e.g. growth spurts, ligamentous laxity) (Beunen and Malina 1988), and neurophysiological systems (changes/reorganisation brain activation networks) (Woolf 2011) and changes in psychosocial factors (school peers, teachers, parents, self-identity/personality traits, competing interests, coping mechanisms) (Malleson et al. 1992; Balague et al. 1995) during childhood.

A rapid growth spurt in adolescents has been associated with musculoskeletal pain, particularly low back pain (Kujala et al. 1992; Feldman et al. 2001). Pubertal growth spurt, characterised by a rapid increase in bone length with a lag in associated muscle length increase, may cause “growing pains” due to this discordance (Beunen and Malina 1988). The potential loss of muscle flexibility or increase in muscle tension as opposite ends of the muscle are stretched may elicit pain (Nissinen 1995).

Neuromuscular coordination is challenged during this time, and more attention may be necessary for planning of skilled motor tasks. This increased demand of brain activation, at a time of known cortical reorganisation, may impact on motor planning and sensorimotor integration and may predispose the individual to increased risk for the experience of pain or injury itself (Beunen and Malina 1988).

The complex and highly repetitive movements involved in playing instrumental music requires specialised sensorimotor skills. Sensorimotor integration allows for the control and feedback of muscle and tendon tension along with joint positions which allow continuous monitoring of finger, hand or lip position according to the instrument (Altenmuller 2008). Clearly, the specialised demands of instrumental music on the developing systems during childhood may further increase the risk of PRMP.

The potential pressures associated with an individual's personal/emotional and social development during childhood and adolescence may negatively influence their self-esteem, self-worth and sense of achievement. Psychosocial factors, specifically depressed mood and stress, have been linked to low back pain (Balague et al. 1994; Balague et al. 1995) and neck and upper limb pain in children and adolescents (Mikkelsson et al. 1997; Stahl et al. 2008). It may be children have not learnt adequate coping or resilience strategies to manage potentially psychosocially tumultuous times during their childhood and may be more at risk for soreness experience through biological and activity related biomechanical mechanisms (see 1.3.4). It is therefore important to consider the potential influence of cognitive and social changes on the individual's perception and response to PRMP.

Changes associated with puberty may explain the finding in this study where PRMP prevalence rose rapidly at 12 – 13 years of age for females and 15 to 17 years for males (see Chapter 3). As mentioned previously, females reach puberty earlier than males and the associated hormonal changes during puberty may contribute to this reported PRMP pattern.

This study found that PRMP prevalence increased across childhood, after accounting for gender. This has potential implications for preventing the experience of PRMP in adulthood. Clinically, music educators, health professionals and parents *need to monitor children for PRMP experience as they progress with music tuition, particularly during potentially vulnerable stages such as puberty.*

Gender and age may influence exposure to other activities (participation and exposure levels) and be relevant for the reported experience of general health problems, general musculoskeletal complaints and PRMP. Therefore the influence of gender and age on potential risk factors should be considered when examining their association with PRMP.

8.3.1.3 PRMP Comorbidities - other soreness experience

Other soreness experience investigated in this thesis included the experience of *PRMP* in multiple locations and the experience of non-music related activity soreness. The suggested explanations for the co-occurrence of pain: the individual's general pain vulnerability, the shared psychosocial factors and the shared physical factors (Chapter 1.2) are discussed below.

8.3.1.3.1 Experience of PRMP in multiple locations

Sixteen percent (184) of children reported PRMP at three or more locations, 15% (110) at two locations and 25% (184) at only one location. In this thesis, children who reported the experience of a PRMD reported more PRMP locations than those who reported monthly PRMS. The final regression models for PRMP in specific locations demonstrated that the number of other locations of reported PRMP experience was significantly and independently associated with problems in specific locations.

No known child study has investigated the association between the number of reported PRMP locations and PRMP. However the current findings are consistent with adult studies. In a study of professional musicians, the reported experience of pain at 3 or more anatomic sites was significantly associated with problems ($p<0.001$) (Kaneko et al. 2005) and musicians with PRMP reported more problems elsewhere ($p<0.01$) compared to musicians without PRMP (Miller et al. 2002).

The initial experience of a problem, may interrupt the intricate balance and coordinated movement required for music performance (Tubiana et al. 1989; Brandfonbrener 1990; Tubiana 2001) and subsequent postural changes to alleviate the (initial) discomfort may transfer loads to adjacent joints (more distal or proximal) and muscles. These structures may be unaccustomed to the forces and thus may undergo tissue changes resulting in the experience of symptoms (Armstrong et al. 1993).

The individual's pain vulnerability, mediated by peripheral and central sensitisation (Woolf 2011), may influence the number of reported PRMP locations. Peripheral sensitisation explains the experience of pain from a previously non-noxious stimulus and the exaggerated or prolonged pain response to a previously noxious stimulus. For example, a clarinettist may have always experienced pain in the right thumb while supporting the instrument, however now, the thumb pain continues even when not supporting the instrument. Central sensitisation may explain the experience of pain independent to an initial nociceptive stimulus (Woolf 2011). The pain is no longer associated with the intensity or duration of a stimulus in the periphery, and the body responds to low threshold stimuli and the pain tends to be widespread (Woolf 2011). In the clarinettist, the pain, originally felt in the thumb, may now contribute to the pain experience in the wrist, forearm and possibly the shoulder/shoulder girdle.

The current study’s results concur with child pain research reports that the co-occurrence of musculoskeletal pains at different anatomical locations are common in children (El-Metwally A 2004) and adolescents (Mikkelsson et al. 1997; Auvinen et al. 2009). The reported experience of ‘other’ musculoskeletal pains was a risk factor for the occurrence and persistence of neck pain in children (Stahl et al. 2008). In adults, pain at other musculoskeletal sites was associated with the subsequent occurrence of low back pain (LBP) (Papageorgiou et al. 1996).

The shared psychosocial risk factors for pain may also explain reported PRMP in multiple locations (Chapter 1.2). High level psychological distress was associated with reported musculoskeletal pain across four anatomic sites in a prospective study of 829 workers from diverse occupational groups (Larsson and Sund 2007). A study of music teachers found high work demand and low level of control was associated with PRMP, though no detail was provided with respect to how many locations were reported (Fjellman-Wiklund et al. 2003). Mechanisms to explain how psychosocial factors of stress may potentially contribute to physical musculoskeletal symptoms include associated changes in muscle tension and activity, and are discussed in the section to follow (8.4).

This study did not examine formal psychosocial risk factors however it did find that the experience of butterflies in the stomach before a concert or exam, as a crude somatic measure of performance anxiety, was significantly positively associated with PRMP, accounting for gender and age. This study did not investigate the association of this potential psychosocial risk factor with the number of reported PRMP locations. Future research could examine this potential relationship and explore the role of psychological factors in PRMP development.

An implication of the findings of the current study is that music educators and health professionals need to monitor children for the initial PRMP experience and consider personal individual features that may contribute to the potential experience of PRMP elsewhere. This may prevent the development of PRMP in multiple locations and potentially prevent the development of more disabling disorders.

8.3.1.3.2 Experience of non-music related activity soreness

The experience of non-music activity soreness may be related to PRMP due to the shared neurobiophysical mechanisms for pain, as discussed in the previous paragraphs. However, it may be related to the shared physical factors the non-music activities have in common with playing music. No prior child music study has reported investigating the relationship between non-music related activity or non-music related activity soreness and PRMP.

This study investigated non-music related activities (exposure and soreness experience) which may have shared physical risk factors (similar postures and task demands to playing instrumental music). Exposure (frequency and duration), which potentially is a measure of physical load, was not significantly associated with PRMP, however soreness experience was significantly associated with PRMP. This study found non-music related activity soreness experience was significantly positively associated with PRMP, both PRMS and PRMD, and further, the number of soreness experiences was significantly associated with increased risk for PRMP after adjusting for gender and age (Chapter 7).

Whilst not identified as significantly associated with PRMP in this study, exposure to participation in concurrent activities of childhood may contribute to the experience of PRMP in multiple locations because children may participate in one or more activities that involve sustained postures over the course of a day or the week

(Croft et al. 1993; Kroner-Herwig et al. 2011). Watching TV (Balague et al. 1999; Kristjansdottir and Rhee 2002; Sjolie 2004; Auvinen et al. 2007) and computer use (Jacobs and Baker 2002; Hakala et al. 2006) are known risk factors for spinal pain. Similarly, hand intensive activities such as writing and handicraft with sustained hand grip are associated with neck and upper limb pain (Niemi et al. 1996). The majority of children in this study participated in several non-music related activities such as watching TV, writing/drawing, computer use, moderate vigorous physical activity, electronic game use and hand intensive activities and many reported the experience of non-music activity related soreness (Chapter 7). For the child instrumentalist, playing, often in awkward postures for prolonged periods and adopting other sustained postures for any length of time, may represent cumulative exposure. The corresponding increased demands on the developing musculoskeletal system and tissue damage potential may elicit soreness experience (Armstrong et al. 1993), thus compounding the risk for musculoskeletal pain. Again, the individual's vulnerability to pain will influence their pain experience and response.

Due to the cross sectional design of this study, it is not possible to establish the temporal relationship of non-music related activity soreness with PRMP, that is, it is unknown whether children with non-music activity related soreness experience go on to develop PRMP or whether children with PRMP subsequently report non-music activity related soreness, or if both develop simultaneously (see limitations 8.5). As discussed above, the evidence suggests the experience of other musculoskeletal soreness influences the experience of soreness at other sites (Stahl et al. 2008).

This study did not identify the location of non-music related activity soreness and so it is difficult to determine whether common or different locations occurred across music and non-music related soreness. This information may elucidate potential mechanisms for the patterns observed and should be addressed in future research (discussed further in section 8.6). However, research has shown the lumbar spine was the most commonly reported location of musculoskeletal pain, followed by the thoracic and cervical spine, in children participating in sedentary activities such as watching TV (Salminen 1984; Balague et al. 1988; Troussier et al. 1994; Balague et al. 1995; Mikkelsson et al. 1997; Mikkelsson et al. 1998) and the neck, low back, mid back were the most commonly reported location followed by right elbow/hand

and lower limb, for school and home computer related musculoskeletal soreness in a cross sectional questionnaire survey of 1351 students aged between 6 to 16 years (Harris 2010). This study's findings of PRMP prevalence at predominantly the distal extremities and neck are different to the patterns of soreness location associated with the aforementioned non-music related activities. Therefore the PRMP locations in this study may reflect music related physical stresses and associated soreness.

Clinically, an implication of the current study is that it is important to establish the current (and past) non-music activity related soreness experience of patients and the soreness location to assess the potential impact in the child playing specific instrument/s. This will guide appropriate intervention programs to prevent soreness at further locations.

8.3.1.4 Psychosocial risk factors

Psychosocial factors, such as depression, poorer mental health, and anxiety have been associated with musculoskeletal pain in adult workers (Bongers et al. 1993) (Bongers et al. 1993) and in children and adolescents (Malleson et al. 1992; Balague et al. 1995).

As mentioned previously, this study did not examine formal psychosocial risk factors. The experience of butterflies in the stomach before a concert or exam was used as a known somatic measure of performance anxiety (Salmon 1990) and was significantly positively associated with PRMP after accounting for gender and age. However music enjoyment was not significantly associated with PRMP in this study. No prior child studies were found that investigated psychosocial factors with PRMP.

Psychosocial factors such as high work demand and low decision making, were associated with increased prevalence of PRMD amongst adult musicians (Moulton and Spence 1992; Fjellman-Wiklund and Sundelin 1998). This is consistent with reported psychosocial factors of high perceived job stress and high job demands associated with work-related upper limb musculoskeletal problems (Bongers et al. 2002).

The potential physiological processes postulated to explain the association include the increased muscle tension and decreased micro-pauses in the activity of muscles due to perceived high mental load and job demand, with subsequent muscle fatigue (Westgaard 1999). Adjacent muscles and structures may need to take on the demands of the task and the potential changes in work posture/s may contribute to the development of new symptoms, exacerbation or maintenance of symptoms (Bongers et al. 2002).

In some individuals, the process of peripheral and central sensitisation may further compound their response, so that they may perceive pain away from the initial site of injury (Woolf 2011) and subsequently report the experience of pain at the initial anatomical site of injury and elsewhere, either adjacent to or far removed from the initial site.

8.3.1.4.1 Performance Anxiety

There was no established tool to assess music performance anxiety at the time of the data collection for this thesis and investigating the range of psychosocial factors known to be associated with musculoskeletal problems was beyond the scope of this thesis. The reported experience of feeling of butterflies in the stomach is a common somatic symptom of music performance anxiety (Kenny et al. 2004). This thesis therefore used this description and found the reported experience of feeling butterflies ‘most times’ to ‘always’ was significantly associated with increased risk for PRMP compared to ‘never’ or ‘almost never’ experiencing butterflies (See Chapter 6). More females than males reported the experience of butterflies in the stomach ($p<0.001$) and older children reported the experience of butterflies in the stomach more than younger children ($p<0.001$). This crude measure of anxiety remained significantly associated with PRMP even after adjusting for gender and age.

Child studies have reported the experience of music performance anxiety negatively impacts on performance, with older children experiencing music performance anxiety more than young children (Ryan 1998; 2005). No studies were found that investigated the association of music performance anxiety with PRMP in children. Music performance anxiety has also been associated with negative effects on music performance in adults (Fishbein et al. 1988; van Kemenade et al. 1995). Attempts by the musician to improve performance, may mean more practice of the particular repertoire and more effort to cope with the physical symptoms of anxiety such as sweaty hands. This may subsequently increase both muscular and mental tension and result in muscle fatigue and soreness due to the continuous firing of low threshold motor units (Westgaard 1999).

The child learning instrumental music may have the same somatic experience prior to or during assessment in other academic areas. Implementing strategies to cope with impending music assessments or recitals may help decrease associated somatic and potential physical symptoms in young instrumentalists as well as assisting them in other non-music assessments.

8.3.1.4.2 Enjoyment of Music

This thesis found the majority of students (60%) enjoyed playing music 'very much'/'loved' playing music (see Chapter 6), with no significant association between the reported enjoyment of music and risk for PRMP (Table 6.2). No studies in children were found that investigated the association between music enjoyment and PRMP. In elite adult pianists, internal, self-generated pressures, such as music pleasure and enjoyment were found to motivate performance and subsequently were perceived to contribute to the development of PRMP (Bragge et al. 2006c). The current study's measure of enjoyment may not have been sufficiently sensitive to establish an association with PRMP or the relationship may be weaker in children.

In music education and psychology research, enjoyment of music and other psychosocial factors such as parent involvement, are associated with the interest and motivation in learning an instrument and contributed to the commitment to continue to learn and achieve in music (McPherson 2000). If children experience PRMP, they may stop playing, or begin to lose interest in playing music. Depending on the individual's pain vulnerability, the PRMP may potentially curtail other activities and the potential declining social interaction with peers may impact on their self-esteem and general physical and mental well-being.

This study did not thoroughly examine the psychosocial domain and its potential association with PRMP. Given the links of psychosocial factors with musculoskeletal pain in children and adolescents, psychosocial factors in young instrumentalists may further compound the PRMP experience. Clearly this is an area warranting further research to explore relationships between various psychosocial factors and PRMP experience. This will enable an holistic approach to preventing and managing PRMP in young instrumentalists.

8.3.1.5 *Other intrinsic factors*

The evidence for the association of other intrinsic factors such as joint hypermobility, anthropometric measures of hand span and BMI, previous PRMP experience, and general health with PRMP is weak in adult studies and lacking in child studies (see Chapter 1 and Table 1.4). This study did not aim to examine the association of these factors with PRMP and this is discussed in the limitations section. However, preliminary analyses have shown that BMI is a potential risk factor associated with PRMP. An increase in 1kg/m^2 (that is, one BMI unit) was associated with a 12% ($p<0.001$) and 10% ($p<0.001$) increase in the odds for lifetime PRMS and monthly PRMS respectively, and an 8% ($p=0.003$) increase in the odds for monthly PRMD (see Appendix VI). After adjusting for age and gender, the association between BMI remained significant for lifetime PRMS (8%, $p=0.009$) and monthly PRMS (7%, $p=0.015$), however BMI was no longer significantly associated with monthly PRMD (5%, $p=0.06$) (see Appendix VI).

Hand span was significantly associated with lifetime PRMS only. An increase in one cm in the left hand span was associated with a 11% ($p=0.13$) increase in the odds for lifetime PRMS and an increase in one cm in the right hand span was associated with a 9% ($p=0.046$) increase in the odds for lifetime PRMS. Once age and gender were accounted for, left or right hand span was no longer significantly associated with lifetime PRMS.

Summary of intrinsic factors

Individual physical (gender, age, other soreness experience) and psychosocial factors (performance anxiety) are associated with the experience and location of PRMP in young instrumentalists. This may also help explain why, for seemingly similar individuals playing the same instrument, one individual may go onto experience a PRMP while the other remains pain free. This study has identified intrinsic factors associated with PRMP taking into account gender and age and will help inform music educators and health professionals of children instrumentalists potentially at increased risk for PRMP.

8.3.2 Extrinsic Factors

Chapters 4 and 5 investigated the association of extrinsic music related factors of instrument exposure (that is, the type of instrument and number of instruments, and time spent playing) with PRMP accounting for gender and age. Chapter 6 investigated the association of music practice characteristics with PRMP accounting for gender and age and Chapter 7 investigated the association of extrinsic non-music related activities with PRMP. The following section will discuss extrinsic music related and non-music related factors significantly associated with PRMP.

8.3.2.1 Extrinsic Factors - Music Related

It was expected that music-related extrinsic factors specifically connected to the instrument, i.e. the type of instrument, number of instruments and time spent playing instruments, would be associated with PRMP. It was also expected that music practice characteristics, particularly those representing increased exposure, would be positively associated with PRMP. Some extrinsic factors, particularly practice characteristics, are potentially influenced by some intrinsic factors, such as age and performance anxiety, and therefore these should be accounted for when examining the independent association of extrinsic factors with PRMP.

8.3.2.1.1 Type of Instrument and PRMP Prevalence and Location

In this study, instruments were categorised in into 7 groups: upper strings, lower strings, woodwind, brass, percussion, plucked strings and piano. This categorisation was previously used in adult music studies and some child studies. However this was the first study to comprehensively establish risk associations between instrument/instrument category and PRMP in child instrumentalists (Chapter 4).

The prevalence and pattern of PRMP location have been described in detail in Chapter 4, and Figure 8.3 illustrates PRMP prevalence rates by body region and instrument group. It was expected the prevalence and location of PRMP would vary according to the type of instrument/instrument group and reflect the specific physical tasks demands on the developing musculoskeletal system. Therefore, the findings in this study were expected to be similar to the prevalence and location of PRMP for different instrument groups reported in other child and adult studies.

In this study the piano group was associated with the least problems (PRMP 52%) and was the only instrument group where patterns of location differed to adult studies. The lower string (76%) (both cello (72%) and bass (89%)) and woodwind (76%) (saxophone (86%) and flute (71%)) categories were associated with increased risk for PRMP compared to the piano group (adjusted for gender and age) (see Table 4. 3). This is in contrast to prior adult music studies which found more PRMP were reported among keyboard (Hartsell and Tata 1990; Manchester and Flieder 1991; Cayea and Manchester 1998) and strings instrumentalists (Fishbein et al. 1988; Zaza and Farewell 1997; Davies and Mangion 2002; Fjellman-Wiklund et al. 2003). In child music studies, upper strings were associated with more problems than all other instruments (Burkholder and Brandfonbrener 2004) and more problems were common with large strings than small strings in 113 secondary school-aged students (Lockwood 1988). The differences in PRMP prevalences for these instrument groups in prior studies, compared to this study, may be attributed to differences in the instrument groups included. Studies that did not examine keyboards found string instrumentalists, particularly upper strings reported more PRMP than other instrumental groups of woodwind, brass and percussion (Fishbein et al. 1988; Middlestadt and Fishbein 1989). This study found upper strings reported more PRMP than piano and percussion. It may be the suitably sized instruments supplied by SIM minimises the child-instrument mismatch and therefore minimised the PRMP reported for string players in this study.

In studies of professional and tertiary pianists, it may be the difficulty/type of the piano repertoire played and the cumulative repetitions and prolonged postures of more extensive adult playing times which may explain why adults in prior studies reported more PRMP with piano/keyboards than children in our study

The left hand was affected marginally more than the right hand in piano players in this study (25.7% vs. 21.3% respectively, see Figure 8.3). In adult pianists, more problems were reported in right hand compared to the left hand. Repetitive techniques required for complex repertoires and the force applied to the keys are thought to be contributing factors for PRMP associated with piano playing (Brandfonbrener 1990; 2000a). It may well be that children have learned how to abduct the thumb and little finger of the right hand, reaching keys with relative ease. However, attention to left hand technique and necessary adaptation (because the left hand was less frequently used) may result in the experience of symptoms. As mentioned, children in this study may not be playing the complex repertoire and technique that adult pianists perform and therefore may be less likely to have associated problems in the right hand.

As mentioned previously, the hands, neck and shoulder were the most commonly reported PMRP locations in this study (Figure 8.1). Typically, upper string instruments were associated with PRMP at the neck, left hand/elbow and left shoulder; lower string at the right shoulder, right hand/elbow; plucked string at the left hand/elbow, right hand/elbow; woodwind, the right hand/elbow, neck, left hand/elbow and mouth; brass at the mouth and left hand/elbow; percussion at both shoulders and the piano at both hand/elbows (see Figure 8.3). As mentioned in the preceding section 8.2.2, this study's findings are similar to the pattern of location in other child and adult studies, though rates at these locations may have differed due to methods of data collection for location differed (i.e. body map versus physical examination).

Given episodes of musculoskeletal soreness in adolescence predicts episodes in adulthood and that the location of PRMP appears to link with physical stresses associated with each instrument, it may be that the pattern of PRMP location in adults was established in their childhood. Only longitudinal studies following a musician's career could establish this association and further elucidate associated risk factors and potential mechanisms. It may be feasible to conduct a longitudinal study in children throughout their music tuition at school (see Future Directions 8.6).

Mechanisms that may explain the relationship between the location of problem and instrument type are directly related to the specific task and motor demands on the musculoskeletal system dictated by the particular instrument, as described in detail in Chapter 6. Sustained awkward postures, often at end range, and repetitive and forceful movements are required to play instrumental music, with some instruments requiring end of range postures more than others. For example the left hand in upper strings and in guitarists, remains in extreme wrist flexion, while performing repetitive finger movements, loading the extrinsic wrist and finger flexors, while the right wrist in upper strings remains in mid-range and in the guitarist in a more flexed position, explaining why more problems are experienced in left hand/elbow than the right in upper strings, and why both left and right hand/elbow experience equally high problems in guitarists.

In the occupational medicine research, task repetition, and force applied to tools or materials during repeated or sustained gripping are predictors of risk for WRMD, The requisite postures and movements may present challenges for the developing neuromusculoskeletal systems, especially during periods of growth. For example the combination of static postures distally and dynamic postures proximally in the one upper extremity (for example the bowing arm with the violin and viola), and the combination of static postures proximally and highly repetitive movements distally in the contralateral limb (for example the fingering/holding arm with the violin or viola), may place the child at risk for PRMP.

Regardless of the potential for children to adapt to their instrument, there is clear evidence that instrument type is an important risk factor for the development and location of PRMP in children. Therefore music educators should be aware of these risks and monitor children for the specific PRMP locations associated with the specific instrument.

Number of Instruments

In this study 38% of students played two and 7% played three or more instruments, and playing three or more instruments was significantly associated with a decrease in risk for monthly PRMS compared to playing one instrument.

No other prior child or adult music study had investigated the association between the number of instruments played and PRMP. Playing three instruments was expected to be positively associated with PRMP as it was thought to represent a potential increase in load on the musculoskeletal system. However, playing three instruments may also be a marker for some other factors such as high motivation of the individual. High motivation has been linked with PRMP in adult pianists (Bragge, 2006) potentially due to associated biopsychological mechanisms (Bongers, 2002) and is therefore unlikely to be the cause of the protective relationship observed in the current study. In this study, the students who played more than one instrument played different instruments (i.e. from a different instrument category), which potentially represents physical task variety. In the occupational medicine literature, variation in task exposure is associated with decreased risk for WRMSD (Fernstrom and Aborg 1999; Christensen et al. 2000; Mathiassen et al. 2003; Mathiassen 2006).

Students playing similar instrument types should be monitored for PRMP. Learning a different 2nd or 3rd instrument may be suggested to potentially prevent PRMP.

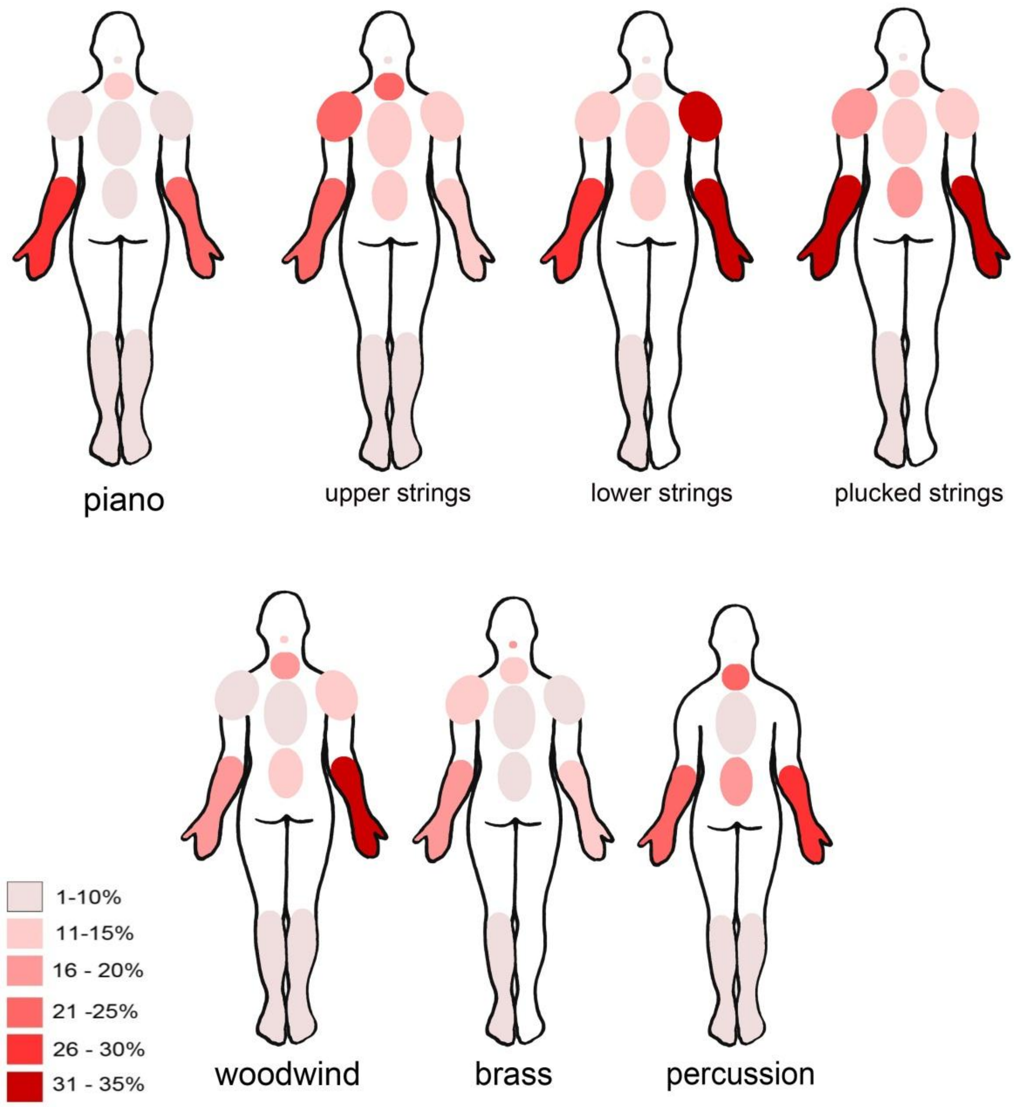


Figure 8.3 PRMP location across instrument (colour density refers to percentage of reported PRMP)

8.3.2.1.2 Time Spent Playing

In this study, the time a student spent playing per week ranged from 17 minutes to 41 hours (average 5.3hours). An increase in playing time of an hour per week was associated with 6% increase in the odds for PRMS. No prior child music study was found which investigated the relationship between time spent playing and PRMP. In adult studies, an increase in playing time of an hour was associated with a 14% increase in the odds for PRMP (Roset-Llobet et al. 2000) (Table 1.4).

It was difficult to compare the findings from this study with other child and adult studies due to varying measures of categorisation of time spent playing. The usual average and maximum amount of practice was reported in most studies, with some reporting a positive (unquantified) association with PRMP (Lockwood 1988; Grieco et al. 1989; Revak 1989; Manchester and Park 1996; Roset-Llobet et al. 2000; Britsch 2005; Furuya et al. 2006) and others reporting no association with PRMP (Zaza 1992; Roach et al. 1994; Zetterberg et al. 1998; Yeung et al. 1999).

In the occupational medicine literature, an increase in hours spent computing (greater than 20 hours per week) was significantly associated with increased risk for upper limb problems amongst 630 university students (Katz 2000; Blatter and Bongers 2002). The increased time spent playing represents an increase in exposure to sustained postures, which may increase static loads on passive structures and increase muscle activity. The potential for muscle fatigue and subsequent undue tension on supporting muscles may predispose the individual to injury (Westgaard 1999).

As expected, older children in this study practiced for longer, and subsequently age-adjusted estimates of time spent playing were lower and no longer significantly associated with lifetime PRMS and PRMD. In contrast, the estimates for the risk of increased age with PRMP were largely unchanged after accounting for playing time, indicating the presence of other age-related correlates of PRMP. The importance of age-related physical, social, emotional, cognitive developmental changes and their potential influence on activity exposure, such as time spent practicing, needs to be considered. For example during puberty, establishing self-identity involves changes socially and the relationships with peers becomes more important. Some students may rebel and not practice and place themselves at risk for

PRMP. For students who choose to focus on music or who have decided to pursue music as a career, their beliefs, such as the “no pain, no gain” motto and excessive practice behaviours, may potentially place them at risk for PRMP. In younger students, inadequate coping skills during challenging situations, may result in behaviours ranging from intense practice to avoidance of playing, placing the student at risk for PRMP. Concurrent vulnerability of the changing musculoskeletal system to external demands, such as long playing sessions or other contemporaneous activities (e.g. computer and information technology use) may stress or load growing weak structures and cause discomfort or potential injury. It may be that during periods of rapid growth, practice times should be monitored more closely and shorter practice sessions recommended to help prevent potential stress and load on vulnerable structures. Therefore playing time needs to be carefully managed for child instrumentalists of all ages, during all stages of development, particularly with respect to strategies to accommodate increasing playing time, to minimize their risk of PRMP.

8.3.2.2 Extrinsic Music Related – Music Practice Characteristics

Chapter 6 investigated the association of extrinsic music related factors of music practice characteristics, such as music experience, the years playing any and main instrument, practice dose, change in pattern of music practice, taking breaks, longest time playing without breaks, repertoire, warm up and cool down, with PRMP accounting for gender and age. Age was significantly related to various music practice characteristics. Subsequently, many statistically significant age-unadjusted odds ratios for practice characteristics were lower and no longer significant after adjusting for age. Regardless, music educators and health professionals need to consider these practice characteristics, which vary with age, in the prevention and management of PRMP in young developing musicians. Psychosocial factors may also influence practice characteristics, potentially compounding the risk for PRMP.

8.3.2.2.1 Prior Music Experience

There was a significant positive relationship between age and the number of years any instrument ($r=0.626$, $p=<0.001$) and the main instrument was played ($r=0.515$, $p<0.001$). The years of music experience represents cumulative exposure to the instrument (Brandfonbrener 1991; Bejjani et al. 1996; Brandfonbrener 2000a) and was univariably significantly associated with PRMP in this study. However, even after adjusting for age, the number of years the main instrument had been played remained significantly associated with PRMP and demonstrated a decrease risk for PRMD (OR 0.88 (0.81-0.96), p=0.003) (see Table 8.1).

Whilst no prior child studies have examined the association of years of instrument playing and PRMP, adult studies also reported a similar inverse relationship. Musicians who had played their instrument for many years reported fewer problems compared to those who had played for fewer years (Zaza and Farewell 1997), OR 0.95 (0.91-0.98, p=0.010); (Yeung et al. 1999), OR 0.75 (0.6-1.0, p=0.018) (see Table 1.4). The inverse association in these adult studies and the current child study may be explained by the survivor effect. In the occupational medicine literature the "healthy worker survivor effect" describes the continuing selection process where those workers who remain employed tend to be healthier than those who leave employment (Arrighi and Hertz-Picciotto 1994)(pg. 189). In this study, children who have experienced problems may have stopped playing music and only those without problems, survivors, continue to learn. It could also be that the child-instrument interaction over years of playing may result in a training effect such that children become accustomed to the demands unique to their instrument and are protected from developing problems. Children often choose their main instrument which may result in a high locus of control, high self-esteem and enjoyment in playing (which was univariably significantly associated with a decrease in risk for problems in the current study). In the occupational medicine literature, such factors are associated with a decrease in risk for musculoskeletal disorders in workers (Christmansson et al. 1999) and these factors may explain the decrease in risk for PRMP found in this study.

Neural plasticity may also help to understand this inverse relationship. The functional and structural reorganisation in the sensorimotor and auditory systems are thought to be instrument specific and correlate with training history (Altenmuller 2008). Cortical reorganisation in turn may facilitate the coordination and sequencing of complex requisite movements, promoting fluent movements with potentially low level muscle activity.

8.3.2.2.2 Current Music Practice Dose (frequency x duration)

In this study there was no association between playing frequency or playing duration (usual) within the last month and PRMP. However the “dose” variable, frequency x duration, demonstrated a U shape relationship, with extremes of exposure increasing risk of PRMP. Students who practice infrequently (and potentially for less time in each session) may not be adequately training requisite muscles for the necessary tasks and potentially place themselves at risk for PRMP. This association relies on self-report data and assumes children did not report the experience of a PRMP to get out of practicing. No previous child study had investigated the frequency or duration of playing and PRMP.

In adult music studies, musicians playing greater than four hours at one time reported more problems than musicians playing less than four hours (Furuya et al. 2006). In the occupational medicine literature task frequency and duration contribute to musculoskeletal disorder risk (Viikari-Juntura 2003). Currently there is no clear dose-response relationship for frequency and duration with work-related musculoskeletal problems due to the varied measures of exposure. However, task duration was the more commonly reported measure of exposure associated with musculoskeletal problems in computer use amongst adults (Blatter and Bongers 2002) and in children (Harris and Straker 2000; Jacobs and Baker 2002).

In this study, the exposure measures of frequency and duration of playing within the last month were combined to establish a pattern of intensity exposure (dose), which was significantly associated with PRMP. A U shaped relationship was observed, with playing less than 30 minutes daily the dose associated with least PRMP, and categories reflecting lower and higher dose having higher PRMP prevalence rates. Fry and Rowley (1989) reported that ‘intensity’, frequency x duration, was associated with PRMP in their school aged population, but provided no statistical quantification of the association. No other music study has investigated dose or intensity of exposure and PRMP. No prior adult study has examined the relationship between dose of exposure and PRMP.

In this study, the relationship between music practice dose and PRMP followed the U shaped curve described in the occupational health and pain literature, where extreme exposure levels are associated with increased risk of musculoskeletal disorders (Winkel and Westgaard 1992; Campello et al. 1996) (see Chapter 6). Minimal practice dose may result in muscles not being adequately trained for their task and motor learning not being optimized. Therefore, the execution of movement patterns remains deliberate and requires concentration, potentially requiring more force and increased load on muscles. Practicing for long periods of time on a daily basis may load muscles beyond their limits, and leave little opportunity to recover and adapt to task demands. This may result in tissue damage and pain as seen in office workers (Amell and Kumar 1999; Gerr et al. 2004). In occupational medicine research, intensity of computer exposure compared to other measures of exposure is the most consistently reported measure associated with musculoskeletal problems (Gerr et al. 2004).

As expected, age was significantly positively correlated with playing dose and consequently playing more than 30 minutes daily compared to less than 30 minutes daily was no longer significantly positively associated with PRMP after adjusting for age. Time and frequency spent practicing may also be influenced by the type of instrument, the student's music experience (with the instrument i.e. having played for a number of years versus having commenced recently), the type of repertoire and the student's familiarity with the repertoire. For example, if a student is unfamiliar with the repertoire (new or challenging), it may be they practice for longer each time in an effort to learn or perfect the repertoire. Given the lack of other specific evidence on which to base recommendations for optional playing frequency and duration, the practice dose associated with least problems in the current study, playing less than 30 minutes on a daily basis, may therefore be used as a tentative recommendation. As mentioned previously, the U-shaped association of playing dose with PRMP means playing too little (i.e. less frequently than less than 30 minutes daily) and playing too much (i.e. more than 30 minutes daily) may potentially lead to the experience of PRMP. Future research should be longitudinal or a randomised controlled trial to provide better evidence regarding optimal practice time.

8.3.2.2.3 Change in Pattern of Music Practice within last month

In this study, preparation for concerts, learning new repertoire and exams were commonly reported as reasons for a change in pattern of music practice. A change in pattern of practice within the last month was compared to practice as usual. Practicing less than usual and practicing more than usual, for longer and more often, significantly increased the risk for PRMP adjusting for age and gender. This U shaped exposure pattern and its significant association with PRMP is similar to that described in the previous section.

Children playing less than usual may have experienced problems and be deliberately playing less (either because they reason playing less may relieve problems or are afraid that continued playing may exacerbate problems). Alternatively, as outlined in the previous section, playing less may not adequately condition muscles for the requisite demands of playing their instrument and may predispose the child to PRMP. Playing more than usual, more often and for longer, represents increased exposure. So for muscles accustomed to a certain level of activity, the demand of performing repetitive movements for longer and more often may load muscles beyond their capacity and result in tissue changes, potential tissue damage and subsequent soreness. This practice characteristic may be influenced by individual psychosocial factors such as performance anxiety. Children anxious with respect to impending exams may practice more often and for longer and subsequently be exposed to cumulative risk for PRMP.

An increase in the amount of practice, e.g. prior to a concert, has been associated with PRMP in adult musicians (Knishkowy and Lederman 1986; Newmark and Hochberg 1987; Newmark and Lederman 1987; Dawson 1988; Amadio and Russotti 1990) and student musicians (Fry et al. 1988; Lockwood 1988; Fry and Rowley 1989; Grieco et al. 1989), mirroring increased musculoskeletal problems in athletes following changes in training (Sward et al. 1990; Kujala et al. 1992; Grimmer et al. 2000; Emery 2005). Similarly, in tertiary students, Manchester and colleagues (Manchester 1988; Manchester and Flieder 1991; Manchester and Park 1996) reported PRMP peaked at times of the year that coincided with increased exposure related to practice for recitals/exams. Interestingly, Manchester and Flieder (1991) also found PRMP peaked early in the school year suggesting unaccustomed exposure may be important also. An increased dose of practice may be advantageous creating adaptive changes in the musculoskeletal system, or alternatively it may result in irreversible structural change with deleterious long term effects (Bejjani and Nilsson 1984; Bejjani and Halpern 1986).

Previous studies in adults and children have not investigated how musicians might practice more than usual - whether this is more often, for longer or a combination of the two. Given extra practice is predictable prior to concerts or exams, strategies should ensure practice is scheduled appropriately, and is organized with variable practice frequency and practice duration, to avoid potential development of problems. Similarly, students should be educated with respect to such strategies and pacing for impending concerts or exams.

8.3.2.2.4 Taking breaks and longest time playing without break

In this study, 20% of students reported taking breaks 'most times' to 'always' when practicing, and significantly more females reported taking breaks than males with no differences across age groups. Taking breaks 'most times' to 'always' compared to 'never' taking breaks, was no longer significantly associated with increased risk for PRMP after adjusting for female gender. In this study, students with problems may have needed to take breaks, rather than the practice of taking more breaks resulting in PRMP. However the cross sectional nature of the study cannot determine the direction of cause.

Only one prior study in children reported on breaks during practice and it found that asymptomatic musicians rarely rested during practice (Lockwood 1988). Amongst adult musicians (Zaza 1995) taking breaks was associated with increased risk for problems, which is consistent with pain stimulating breaks. In tertiary piano players, playing for lengthy periods (greater than 60 minutes) without breaks was associated with problems (Bruno et al. 2008), which is consistent with lack of breaks contributing to pain.

In this study playing longer than one hour without a break was significantly associated with increased risk for PRMP compared to playing less than 30 minutes without a break, and remained significantly associated with monthly PRMS after adjusting for gender and age.

In other child studies, uninterrupted practice was associated with PRMP (Lockwood, 1988) and playing for greater than 60 minutes without a break was associated with PRMP (Bruno et al. 2008). These studies did not quantify the association with PRMP. As mentioned previously (8.4.1.3), playing continuously in a sustained posture may load structures beyond their capacity and result in tissue changes, potentially causing tissue damage and subsequent soreness experience.

In the occupational medicine literature, pause breaks have been associated with decreased risk of musculoskeletal disorders (Sundelin and Hagberg 1989). It may be that the opportunity for muscles to rest and recover from periods of activity, particularly low load over long periods of time, may serve to protect the worker from soreness experience. This has implications for music education and rehabilitation of injured musicians. While taking breaks was no longer significantly associated with PRMP in the multivariable analysis, the evidence from occupational research suggests promoting safe music practices that include taking breaks during practice may reduce PRMP. Performing a task or activity that requires a change in position and involves movement other than those used for playing during the break may then allow muscles the opportunity to rest and recover. Other practice strategies, such as mental practice, known to activate similar cortical networks activated in physical practice, can be incorporated into the practice routine to minimise tissue stresses.

8.3.2.2.5 Repertoire

There was no association between repertoire difficulty and PRMP in this study. This may be due to the fact 50% of students reported that the repertoire played was no more difficult than usual and that the children may have been proficient with their current repertoire because data collection was later in the school year. Also, the study questionnaire may not have been sensitive enough to detect sufficient detail of repertoire variation. There were no prior studies in children that documented an association between change in repertoire and PRMP. In an adult study a change in repertoire was associated with a decreased risk for PRMP (OR 0.37 (0.15-0.91) $p=0.030$) (Zaza and Farewell 1997). Whether the change in repertoire represented easier or more difficult pieces was unclear. Other studies found musicians reported problems following a change in repertoire (Fry 1987; Fry et al. 1988; Brandfonbrener 2000a) or teacher (Fry 1987; Brandfonbrener 1991; Manchester and Flieder 1991), however no associations were quantified.

A change in repertoire to a more challenging, technically difficult piece represents an increase in task demand (due to increased repetition and increased playing time), which in occupational literature is associated with musculoskeletal disorders (Moore et al. 1991; Stock 1991). This has implications for music education to ensure a graded and varied introduction to more difficult repertoire. Music educators may employ various learning strategies such as mental imagery, by ear and by improvisation (McPherson 1995; McPherson and McCormick 2006) and pace the tempo.

8.3.2.2.6 Warm up/cool down

In the current study warm up and cool down were not associated with PRMP. We did not specify physical warm up (e.g. stretching) versus musical warm up (i.e. scales), and perhaps this distinction is important given physical warm up was associated with a decreased risk for PRMD in adults (Zaza 1995). No prior study in children could be found which investigated the association between warm up/cool down practices and PRMP.

Muscle exercise and stretching is widely used to prevent injury and prepare for sporting task performance (Shellock and Prentice 1985; Safran et al. 1988). Stretching alone does not prevent injuries (Herbert and Gabriel 2002; Shrier 2004). A systematic review of randomized controlled trials on the effects of warm up, found that warm up including aerobic activity in addition to stretching significantly reduced risk of injury compared to warm up with stretching only (Fradkin et al. 2006).

Ensuring muscles necessary for supporting and playing the instrument are adequately prepared for their task may be a good habit to encourage in young instrumentalists with developing neuromusculoskeletal systems, but needs further research.

8.3.3 Extrinsic Factors – Non Music Related

8.3.3.1.1 Non music activity related exposure

Health outcomes associated with non-music related activity participation are influenced by levels of exposure. For example regular moderate to vigorous physical activity provides cardiovascular and musculoskeletal benefits, promotes weight control and self-esteem (Rowland and Freedson 1994; Aaron and LaPorte 1997) and may prevent the development of some chronic diseases later in life (Faigenbaum et al. 2009). However, intensive physical training in young students has been associated with musculoskeletal soreness and injury (Kujala et al. 1999; Auvinen et al. 2007).

In the current study, the majority of students participated in non- music related activities of childhood, at moderate levels of exposure. We expected non-music activity exposure would be associated with PRMP given some of the non-music related activities have similar potential risk factors to instrumental music (8.2.1.3). However, whilst there was an association between non-music activity soreness and PRMP, there was no association between any non–music related activity exposure and PRMP in this study. It may be that the exposure measures (for non-music related activities) in the questionnaire were not sensitive enough to capture detailed information (e.g. large time categories versus smaller time categories) to establish an association (See limitations 8.5). Alternatively, the physical exposures may have been sufficiently varied as to not result in tissue fatigue. As mentioned earlier, individual factors may contribute to levels of physical exposure participation and influence the experience of, and response to, any non-music related soreness experience.

No prior child instrumental study had investigated concurrent exposure to non-music related activity and its association with PRMP.

8.3.4 Potential Risk Factors Not Examined in the Current Study

Factors which reflect an interaction between intrinsic and extrinsic factors, such as playing posture, were not investigated in the current study. Playing posture is influenced by the task demands (musical instrument and furniture) and the individual's habitual posture. Experts have published recommendations on suitable playing posture based on observations of the musician's performance and their knowledge of the body's normal anatomy, biomechanics and pathophysiology (Tubiana et al. 1989; Amadio and Russotti 1990; Cailliet 1990; Brockman et al. 1992; Tubiana and Chamagne 1993; Chamagne 1999; Tubiana 1999; 2000; 2002).

The impact of task demands on posture in adult musicians has been assessed using kinematic and muscle activity analyses. For example, Turner-Stokes (1999) used 3D movement analysis to compare postures on different string instruments of asymptomatic adult musicians. The results demonstrated shoulder elevation was greater on the cello compared to the violin and elbow flexion range was greater on the violin. A number of studies have found muscle activity varied between specific instruments for adults (Clapp 1982; Grieco et al. 1989; Philipson et al. 1990;

Moulton and Spence 1992). No detailed study of the influence of instrument on the posture of children instrumentalists has been reported.

Several authors have investigated whether there are differences in the playing postures of musicians who develop PRMSs and those who do not (Clapp 1982; Grieco et al. 1989; Philipson et al. 1990; Moulton and Spence 1992). Greater muscle activity (upper trapezius and shoulder muscles) was identified in musicians with pain compared to those without pain suggesting a difference in motor control either contributing to symptoms or resulting from symptoms. These findings contrasted with results from a study of ten violinists which found no increase in trapezius muscle activity in musicians with pain compared to musicians with no pain. The authors attributed this finding to the role of synergistic muscles (Berque and Gray 2002), however a small sample size may have contributed to the non-significant results. No study has investigated the habitual postures of children instrumentalists with and without PRMP.

Analysis of playing posture and posture at rest in future research may quantify load on musculoskeletal structures and elucidate potential mechanism for PRMP. This will provide recommendations for music educators and health professionals with strategies to decrease load and potentially prevent PRMP.

As mentioned earlier, interaction between the child and the music instructor may influence the child’s attitude to learning instrumental music, the child's response to pain or an injury, and may impact on performance (Havlik and Upton 1992; Brandfonbrener 2000a). The potential association of the child-teacher relationship with PRMP is unknown and is a factor for investigation in future studies.

8.3.5 Summary of Risk Factors

The risk factor model introduced in Chapter 1 illustrated the potential intrinsic, extrinsic and interaction risk factors associated with PRMP. Figure 8.2 presents a refined model for risk factors associated with PRMP in children. This model highlights those risk factors found to be significantly associated with PRMP and those risk factors not found to be significantly associated with PRMP in this study, and the potential risk factors yet to be investigated with PRMP (Figure 8.1).

8.4 LIMITATIONS AND STRENGTHS

8.4.1 Limitations

There were several limitations to this study related to the study design and questionnaire design and these limitations will guide the direction of future research.

Limitations include:

1. Cross sectional study design

A cross-sectional study design was used in this thesis to establish prevalence rates and location of PRMP in children learning instrumental music and also collect information regarding the characteristics of the children, music playing characteristics and non-music related activity participation and soreness experience. According to the NHMRC hierarchy of evidence (National Health and Medical Research Council 2008), this study is graded Level IV. Statistical analyses investigated the relationship of these characteristics with PRMP. The information regarding PRMP and these characteristics, i.e. the potential risk factors, were collected at the same time, therefore the sequence in timing of the PRMP experience and risk factors is unknown. A clear inference of cause and effect cannot be determined and the best evidence this type of study design affords is that of an association of potential risk factors with PRMP (Altman 1991).

Future studies should be prospective in nature to establish incidence rates for PRMP, and better establish the causal direction of association of potential risk factors with PRMP (see 8.6).

2. The use self-report for outcome measures

The use of self-report measures to collect data on outcome measures, that is PRMS and PRMD, has inherent limitations. Prevalence rates may be inflated or underestimated due to the potential biases associated with self-report. Recall bias, the respondents' reliability in recalling past events or experiences or behaviour, and reporting bias, respondents failing to faithfully reveal the information requested, require results to be interpreted with caution (Bowling 1997).

As mentioned previously, outcome prevalence rates may be inflated or underestimated using self-report. The use of physical examination may also inflate prevalence rates depending on the sample being examined. Samples from clinics may present with high rates of cases compared to samples from the general population (Altman 1991). However, studies from pain and occupational health research have shown high rates of agreement between pain prevalence estimates from self-report and physical examination (Andersson et al. 1993; Franzblau et al. 1997).

3. The use of self-report for exposure measures

The use of self-report measures to collect data on risk factor exposure has similar inherent limitations to those for data collection of outcome measures. Recall bias may bias exposure responses upwards or downwards and associations between PRMP and outcomes may not be detected when they actually exist (Bowling 1997).

The response categories for some questions in the YAQ(m) may not have been sufficiently sensitive to accurately determine exposure levels. For example categories used to identify duration and frequency were large, e.g. < 30 minutes, 30-60 minutes, 1x week and 1x month, respectively, and consequently the decreased variance in the data may be such that estimates of the degree of exposure will be inaccurate and any association with PRMP may remain undetected. Smaller increments may better detect differences between groups (i.e. PRMP and no PRMP) and establish clear associations with PRMP.

The occupational medicine literature has showed acceptable test-retest reliability of self-reported exposure to ergonomics exposures at work over 1 year in a cohort of automobile manufacturing employees interviewed at baseline at one year later (d'Errico et al. 2007). In children, data collected from the YAQ has previously been compared to data from timed diaries and observation, and analysis showed evidence for the validity of data collected based on self-reported exposure (Ciccarelli 2008).

4. Limited examination of physical measures

It was beyond the scope of this thesis to examine all physical factors potentially associated with PRMP. This is an impetus for future research in young instrumentalists, particularly children playing instruments associated with a greater risk of PRMP.

The experience of musculoskeletal soreness is associated with the experience of other musculoskeletal soreness at other locations. In this study, the experience of non-music related activity soreness was significantly associated with PRMP. Due to the cross-sectional study design we cannot determine a clear inference of causality. Future longitudinal studies are needed to gain an understanding of the patterns of development of PRMP and musculoskeletal soreness from other activities, and the relationship between these patterns.

Hypermobility was not examined in this study. There is some evidence to support the association of hypermobility with musculoskeletal soreness (Grahame 1971) and given many children are hypermobile (Murray and Woo 2001), the young hypermobile musician may be at increased risk of PRMP, particularly during periods of physical growth, where muscle - bone length discordance may further compound stability issues at hypermobile joints. Therefore prospective longitudinal research to assess hypermobility of children at the commencement of musical tuition and at potentially vulnerable stages of childhood and adolescence is necessary to establish evidence for the association of hypermobility with PRMP.

Adiposity was not formally examined in this study. Given unhealthy weight ranges are linked to musculoskeletal soreness (Webb et al. 2004; Adamson et al. 2006; Jinks et al. 2006) and the potential this may have on the musician-instrument interface, it may be appropriate to consider examining this factor in future research and establish any association with PRMP especially as 25% of Australian children are overweight or obese (Magarey et al. 2001).

The posture of the instrumentalist without and with the instrument was not investigated in this study. Recommendations of good posture whilst children use a computer are supported by laboratory and field studies (Straker et al. 2009). Recommendations for good posture while playing instrumental music are not evidence based. This study identified instrument groups more at risk of PRMP. Future postural research could include laboratory based posture studies conducted in specific instrument groups. Subsequent data analysis may elucidate potential biomechanical mechanisms for PRMP which can be used to develop evidence based recommendations for optimum postures with instrumental playing.

5. Limited examination of psychosocial measures

Psychosocial factors are clearly important factors contributing to musculoskeletal soreness in adults (Bongers et al. 1993) and children (Malleson et al. 1992; Balague et al. 1995). It was beyond the scope of this thesis to examine this domain adequately. Future research in musicians warrants a comprehensive assessment of psychosocial factors, including standardised measures of depression, stress and somatisation, and could include the recently validated Music Performance Anxiety Inventory for Adolescents (MPAI-A) (Osborne et al. 2005) to establish the association with PRMP.

8.4.2 Strengths

The strengths of this study included:

- a large, representative sample of children learning instrumental music across a range of ages, a range of instruments, and range of socioeconomic areas.
- the first child study to use clear case definitions of PRMS and PRMD and establish the lifetime and monthly prevalence rates for PRMS and monthly prevalence rates for PRMD.
- the first child study to demonstrate the independent association of age and gender with PRMP and,
- important evidence of the multifactorial nature of risk factors for PRMP in children, specifically,
- intrinsic factors of gender, age, the experience and number of non-music related activity musculoskeletal soreness, and the experience of butterflies in the stomach before a concert or exam, and
- extrinsic music-related factors of instrument type, playing time and pattern of playing more than usual.

8.5 FUTURE RESEARCH

Limitations highlighted in the previous section identify directions for future research in child musicians. These directions relate to the use of appropriate research design and valid and reliable data collection methods, to provide robust evidence for the association of risk factors with PRMP and evidence upon which to base guidelines for music educators and health professionals.

8.5.1 Research Design

Prospective longitudinal studies in young instrumentalists are needed to identify emerging PRMP patterns, identify changes in individual characteristics, music-related characteristics, non-music related activity participation and soreness experience, to better understand the relationship between these factors and PRMP.

Adult studies have identified difficulties associated with this type of study design in professional musicians due to issues such as performance scheduling, touring and simply a lack of time for musician participation. However, in younger musicians, a prospective study coinciding with the school year may be feasible and possibly over a number of years. Data collection could be conducted at the beginning and end of the year and potentially at several points during the year. Practically, a questionnaire survey combined with a study of some physical measures is achievable, as demonstrated in this thesis. The laboratory testing of physical factors in specific instrument groups may present more challenges practically with respect to study location, however incentive schemes may help overcome this hurdle.

8.5.2 Risk Factor Data Collection

Question design or frame limitations in the survey tool identified response categories may not have been sufficiently sensitive for adequate data collection of specific exposure measures. Future research should therefore examine improved methods for capturing exposure.

8.5.2.1 Other musculoskeletal soreness experience

This study was unable to determine whether the location of other musculoskeletal soreness experience differed to PRMP location because questions pertaining to other musculoskeletal soreness did not explicitly exclude soreness due to playing. A body diagram to record other musculoskeletal soreness location should be included in future studies so that the location of other musculoskeletal soreness locations can be recorded and comparisons made to PRMP locations, which will help identify music specific musculoskeletal soreness location. Questions regarding soreness onset and its duration may further differentiate other musculoskeletal soreness from PRMP. Future longitudinal studies comparing other musculoskeletal soreness experience in musicians who develop PRMP to those who remain pain free, will better establish the influence of other musculoskeletal soreness on PRMP.

8.5.2.2 Music exposure variables

Music exposure measures used in this study were based on those outlined in the literature, though no measure had reported evidence for reliability and validity. Music exposure variables in this study that were not significantly associated with PRMP included, repertoire difficulty, warm up and cool down exercises, and as with other exposure measures, the response categories may not have been sufficiently sensitive or specific to establish differences in musicians with PRMP and those without. For example warm up questions may need to differentiate between physical warm up, for example stretches, and musical warm, for example scales.

Several international studies conducting research into musicians have recently chosen to use the YAQ (m) as their survey tool. The results from these studies may assist in establishing validity of this tool. Similarly, data collected from the child's parent, teacher and health professional can be triangulated for validity. With advancing technology, small recording mechanisms, such as a pendant camera, may objectively record subjective reports of time spent practising, places and postures of practice and agreement between the self-report and objective measures evaluated.

8.5.2.3 Physical Examination and Laboratory Studies

The physical risk factors of hypermobility, anthropometric measures, muscle activity and posture, are best quantified by physical examination. A case-control study using clinical and laboratory measures could examine these factors in children with PRMP and those without PRMP. Elements of normal posture or playing posture are difficult to assess in two dimensions, therefore a 3D kinematic laboratory study of young instrumentalists in pre and post pubescent age groups, matched for gender and instrument, could elucidate potential mechanisms for PRMP. This could be conducted with a survey questionnaire covering biopsychosocial domains (Szeto 2003).

8.5.2.4 Psychosocial variables

Psychosocial factors are clearly important factors contributing to musculoskeletal soreness in adults and children. A comprehensive assessment of psychosocial factors to establish the association with PRMP is recommended and would necessitate a study in its entirety and run in parallel to a physical measures study. Important factors to investigate would include family music history, the experience of headaches and stomach aches and other somatic symptoms, and relevant psychological scales, specifically the validated Music Performance Anxiety Inventory for Adolescents (MPAI-A) (Osborne et al. 2005), depressed mood using the Beck Depression Inventory for Youth (BDI-Y; Beck et al, 2001), self-efficacy using the modified version of the Perceived Self-Efficacy Scale (PSE; Cowen et al., 1991) and the socioeconomic status (SES) using the Index of Advantage/Disadvantage (IAD) from the Socio-Economic Indexes for Areas (SEIFA; Australian Bureau of Statistics, 2001).

8.5.2.5 Music Education

This study showed music practice characteristics, such as total playing time, and practicing more than usual for longer and more often, were significantly associated with PRMP. Given music educators may influence aspects of music practice, it seems relevant that research in music education be explored. University music curricula have recently introduced music health education including basic anatomy and pathology, biomechanical and nutritional modules. The aim of this curricula is that university music students will be better informed with respect to preventing PRMP and disseminating music health education to young music students. However, the music health knowledge of current music educators is unclear and has implications for the tomorrow’s musicians. Studies should investigate the present music health knowledge of our current music educators and identify continuing professional education requirements to ensure health music education of today’s young instrumentalists, tomorrow’s musicians.

In summary music education and music medicine would benefit from continued research to better establish the evidence for, and understand the *contribution of, multifactorial factors to the development of PRMP. Specifically physical factors of hypermobility, anthropometric and adiposity measures, psychosocial factors, particularly music performance anxiety, non-music related activity exposure and posture, particularly playing posture.*

CHAPTER 9 CONCLUSION

Instrumental music is a popular activity of childhood with 20% of Australian children learning music outside of school hours. Music education promotes emotional, physical, social and cognitive growth of students and benefits the community at large.

The literature suggests playing-related musculoskeletal problems (PRMP), common in adult musicians, are experienced in young musicians. Risk factors associated with PRMP have been investigated in adult studies, however it was unclear if these risk factors were relevant in the young instrumentalist.

The main aims of this thesis were to investigate the prevalence and location of playing-related musculoskeletal problems (PRMP) in children using established operational definitions of playing-related musculoskeletal symptoms (PRMS) and playing-related musculoskeletal disorders (PRMD) (Zaza 1995), and identify potential risk factors associated with PRMP accounting for gender and age.

731 students (460 girls and 271 boys) from six primary and five high schools in the Western Australian School of Instrumental Music program, participated in the study. The sample was representative of a range of socioeconomic areas, range of ages and a range of instruments. The cross-sectional study involved completion of a questionnaire (YAQ-m) containing items related to the participant's music playing and participation in other non-music related activities. Physical measures of height and weight were also collected at the time of questionnaire completion.

The thesis results included that PRMP are common across childhood with 67% reporting the experience of PRMS at some point and 56% reporting the experience of PRMS within the past month. PRMP are not trivial with 30% of children unable to play the instrument as usual, that is, the experience of a PRMD, and of these students 4.6% reported taking medication and 4.2% reported health professional visits. The hands and the neck were the most commonly reported PRMP locations. The PRMP prevalence rates and location are disconcertingly similar to PRMP rates and location in adults.

In this thesis, the piano (42%), the violin (19%), clarinet (16%) guitar (15%) and flute (12%) were the most commonly played instruments. The piano, violin and clarinet were most frequently played as the main instrument, with the piano most commonly played as a second and third instrument.

The intrinsic physical factors of female gender and increasing age were found to be significantly associated with increased PRMP risk. The independent associations of other potential intrinsic factors and extrinsic music-related and non-music related factors with PRMP were examined accounting for gender and age. The final model showed the intrinsic factors of non-music activity related soreness experiences and performance anxiety (as measured by the experience of butterflies in the stomach) were significantly associated with increased risk of PRMP. The extrinsic music-related factors of type and number of instruments played, number of years the main instrument was played, total playing time and the pattern of practice when practicing more than usual, were significantly associated with PRMP risk.

Limitations of the study were related to the cross-sectional study design, limited valid and reliable psychosocial exposure measures and incomplete investigation of association other potential risk factors (such as anthropometric measures and hypermobility). The strengths of the study included a large representative sample of children across a range of ages, a range of socioeconomic areas and across a range of instrument groups to establish prevalence rates of PRMP in young instrumentalists and develop a working model of potential risk factors associated with PRMP.

These findings will help the young instrumentalist and their family, music educators from teachers/instructors to administrators in curricula development and health professionals understand the potential risk factors associated with PRMP. The findings will help direct intervention initiatives in young instrumentalists, maximizing the benefits of and minimising the potential risks associated with learning instrumental music and thus promote the longevity and enjoyment of music for the individual and indeed for all.

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Every reasonable effort has been made to acknowledge the owners of copyright material. I would be pleased to hear from any copyright owner who has been omitted or incorrectly acknowledged

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APPENDICES

Appendix I a Copyright permission International Journal of Music Education

Appendix I b Copyright permission Medical Problems of Performing Artists

Appendix II a Statement of Contribution by Others

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Appendix III Ethics Approval

Appendix IV Letter to Principal

Appendix Va Study Description – Newsletter

Appendix Vb Letter to Parents/Information Sheet

Appendix Vc Request Exclusion from study form

Appendix Vd Written Consent Form

Appendix VI BMI, Hand Span and PRMP

Appendix VII The Young people's Questionnaire – music (YAQm)

APPENDIX Ia Copyright Permission – International Journal of Music Education

From: Engstrand, Helena
To: Sonia Ranelli
Cc: s.ranelli@curtin.edu.au
Subject: RE: from Sonia Ranelli re copyright permission
Date: Friday, 18 November 2011 6:32:21 PM

Hi Sonia,

Sorry for my late reply! I have checked with our Rights department and have been advised as follows: Republishing in a thesis is ok – so long as it is stated in the thesis that the work is published in the journal – and with a correct citation if possible.

Hope this helps.

All the best,

Helena

Helena Engstrand
Production Editor, Journals
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London EC1Y 1SP
Tel.: +44 (0)20 7324 8721
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From: Sonia Ranelli [mailto:s_ranelli@iprimus.com.au]
Sent: 25 October 2011 15:24
To: Engstrand, Helena
Cc: s.ranelli@curtin.edu.au
Subject: FW: from Sonia Ranelli re copyright permission

Hi Helena

I have just received Amy's email informing me of a contact for matters relating to IJME. Could you read the email I sent Amy initially and let me know if you can help me or direct me to the appropriate personnel who can please.

Many thanks in anticipation

Sonia Ranelli

From: Sonia Ranelli [mailto:s_ranelli@iprimus.com.au]
Sent: Tuesday, 25 October 2011 3:02 PM

To: Goggins, Amy (amy.goggins@sagepub.co.uk)
Cc: s.ranelli@curtin.edu.au
Subject: from Sonia Ranelli re copyright permission

Hi Amy,

I don't know if you are the person to approach with respect to asking for copyright permission, however, given I have had contact with you at the time I needed to check proofs for a manuscript accepted for publication in IJME, I thought I would try you. I have contacted the Editor of the IJME, Chris Johnson but to date, have had no reply.

I am in the final stages of collating my doctoral thesis which involves the inclusion of the manuscripts I have had published in the IJME, 2011, volume 29, number 1, page28-43 and the most recent manuscript #MS405 which I submitted in May 2011 and is currently in review .The University's submission regulations require that I request copyright permission from the journal to reproduce the paper/s in my doctoral dissertation/thesis. I would like to request the Journal's permission to reproduce both aforementioned manuscripts in my doctoral thesis. I am happy to forward the University's requirements if you so wish.

Many thanks in anticipation.

Sonia

APPENDIX Ib Copyright Permission – Medical Problems of Performing Artists

From: M Bokulich [mailto:bokulich@sciandmed.com]
Sent: Wed 12/10/2011 9:21 AM
To: Sonia Ranelli
Subject: Re: copyright permission for MPPA published manuscripts

Date: October 11, 2011

Dear Ms. Ranelli:

Material:

Playing-related Musculoskeletal Problems in Children Learning Instrumental Music: The Association Between Problem Location and Gender, Age, and Music Exposure Factors.

Sonia Ranelli, Leon Straker, Anne Smith

Medical Problems of Performing Artists Sept 2011; 26(3):123-139.

Prevalence of Playing-related Musculoskeletal Symptoms and Disorders in Children Learning Instrumental Music.

Sonia Ranelli, Leon Straker, Anne Smith

Medical Problems of Performing Artists: Dec 2008; 23(4):178-185.

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APPENDIX IIa Statement of Contribution by Others

To Whom It May Concern,

I, Leon Straker, contributed to the research questions, the research design, study supervision and revision of drafts to the papers/publications entitled:

1. Ranelli, S., Straker, L. and Smith, A. (2007). Prevalence of playing-related musculoskeletal problems in children learning instrumental music. Proceedings of the Human Factors and Ergonomics Society of Australia's (HFESA) National Conference, Perth, November 2007.

2. Ranelli, S., Straker, L. and Smith, A. (2008). Prevalence of playing-related musculoskeletal symptoms and disorders in children learning instrumental music. Medical Problems of Performing Artists 23(4):178–185

3. Ranelli, S, Smith, A and Straker, L. (2011). Playing-related musculoskeletal problems in child instrumentalists: the influence of gender, age and instrument exposure. International Journal of Music Education. 29(1): 28-44

4. Ranelli S, Straker L and Smith A. (2011). Playing-related musculoskeletal problems in children learning instrumental music: the association of problem location, and gender, age and music exposure factors. Medical Problems of Performing Artists 26(3):123-139

5. Ranelli, S, Smith, A and Straker, L. The influence of music practice on playing-related musculoskeletal problems (PRMP) in children learning instrumental music. International Journal of Music Education - in review.

6. Ranelli S, Straker, L and Smith, A. The experience of non-music activity related soreness influences playing-related musculoskeletal problems in child and adolescent instrumentalists submitted to the Australian Journal of Physiotherapy 2012

Professor Leon Straker
Supervisor

APPENDIX IIb Statement of Contribution by Others

To Whom It May Concern,

I, Anne Smith, contributed to the research questions, the data analysis and interpretation and revision of drafts to the papers/publications entitled:

1. Ranelli, S., Straker, L. and Smith, A. (2007). Prevalence of playing-related musculoskeletal problems in children learning instrumental music. Proceedings of the Human Factors and Ergonomics Society of Australia's (HFESA) National Conference, Perth, November 2007.

2. Ranelli, S., Straker, L. and Smith, A. (2008). Prevalence of playing-related musculoskeletal symptoms and disorders in children learning instrumental music. Medical Problems of Performing Artists 23(4):178–185

3. Ranelli, S, Smith, A and Straker, L. (2011). Playing-related musculoskeletal problems in child instrumentalists: the influence of gender, age and instrument exposure. International Journal of Music Education. 29(1): 28-44

4. Ranelli S, Straker L and Smith A. (2011). Playing-related musculoskeletal problems in children learning instrumental music: the association of problem location, and gender, age and music exposure factors. Medical Problems of Performing Artists 26(3):123-139

5. Ranelli, S, Smith, A and Straker, L. The influence of music practice on Playing-Related Musculoskeletal Problems (PRMP) in children learning instrumental music. International Journal of Music Education - in review.

6. Ranelli S, Straker, L and Smith, A. The experience of non-music activity related soreness influences playing-related musculoskeletal problems in child and adolescent instrumentalists submitted to the Australian Journal of Physiotherapy 2012

Dr Anne Smith

Co-Supervisor

APPENDIX III Ethics Approval

MINUTE

Curtin
UNIVERSITY OF TECHNOLOGY

To	Sonia Ranelli, Physiotherapy
From	Max Page, Executive Officer, Human Research Ethics Committee
Subject	Protocol Approval **HR 234/2002**
Date	11 December 2002
Copy	Associate Professor Leon Straker, Physiotherapy Graduate Studies Officer, Division of Health Sciences

Office of Research and Development

Human Research Ethics Committee

TELEPHONE 9266 2784
FACSIMILE 9266 3793
EMAIL t.lerch@curtin.edu.au

On behalf of the Human Research Ethics Committee I am authorised to inform you that the project *"ASSESSMENT OF RISK FACTORS ASSOCIATED WITH THE DEVELOPMENT OF UPPER LIMB MUSCULOSKELETAL PROBLEMS ASSOCIATED WITH CHILDREN LEARNING INSTRUMENTAL MUSIC"* is granted **provisional approval**, subject to further information/clarification of the points raised below. Please forward your response to the Secretary, HREC, C/- Office of Research & Development as soon as possible.

1. There are some inconsistencies within and between the written proposal and the participant information sheet regarding the age of the children to be included. Children aged 1 to 9 years appear to have been ignored in the information statement. Moreover, the proposal states that only children for whom written informed consent has been obtained will be included, wheras the participant information staterment suggests only children who return a completed withdrawal form will be excluded from the study. These inconsistencies should be corrected or better explained to remove any ambiguity.

2. There are errors in the proposal in the classificaiton of independent and dependent variables and the single sentence on the logistic regression analysis suggests the researcher does not have an adequate understanding of these aspects of the study design. Perhaps the researcher should consult someone with experience in analysis of this nature.

3. Questionnaire layout has been shown to influence the accuracy and completeness of the data collected. The questionnaire proposed for this study is quite dense with many questions and various questions having different formats. Younger participants who self-complete may have difficulty with this and a pilot study with only three children may not be sufficient to identify all of the potential limitations. It may be worth seeking some expert advice regarding the design and layout of the questionnaire.

Final approval will be subject to a satisfactory response to the items above. Provisional approval of this project is for a period of twelve months **9/12/2002** to **8/12/2003**.

When the project has finished or if at any time during the twelve months changes/amendments occur, or if a serious or unexpected adverse event occurs, the attached FORM B is to be completed and returned to Ms Tania Lerch, (Secretary, HREC) C/- Office of Research & Development as soon as possible. The approval number for your project is **HR 234/2002**. *Please quote this number in any future correspondence.*

Please find attached your protocol details together with the application form/cover sheet.

Tania Lerch

MP Maxwell Page
Executive Officer
Human Research Ethics Committee

J:\OR\HREC\REG99\HR 234/2002

Please Note: The following standard statement must be included in the information sheet to participants. *"This study has been approved by the Curtin University Human Research Ethics Committee. If needed, verification of approval can be obtained either by writing to the Curtin University Human Research Ethics Committee, c/- Office of Research and Development, Curtin University of Technology, GPO Box U1987, Perth, 6845 or by telephoning 9266 2784."*

APPENDIX IV Letter to Principal

Principal

Dear,

Re: Study on Activity Related Musculoskeletal Problems in Children

Thank you for your time over the telephone with respect to this study. Essentially the study involves a questionnaire that takes approximately 30 minutes to complete. Enclosed is a letter to you, as principal of Rossmoyne Senior High School, explaining the rationale for the study and interest in surveying your school, a copy of the participant information sheet, request to exclude sheet that will be sent to parents and a copy of information that may be included in the school newsletter.

With regards to specific points raised by you, I have addressed these in point form below.

Benefits

- **School**
  The school will be involved in a unique study which aims to establish evidence based guidelines for the identification of risk factors in children learning instrumental music in an effort to prevent musculoskeletal problems in these children.
- **The staff**
  The risk factors identified from the study may then be adopted as a screening process by staff for children at various stages of the school year or children's instrumental career and assist in identifying or "flagging" those children at risk of developing musculoskeletal problems. Appropriate management of the child may then be implemented.
  Staff may also gain knowledge with respect to physiological factors influencing problems and subsequent modification of teaching practices.
- **The students**
  The students and their parents will be informed of factors that may contribute to problems. This will serve as an educational tool with respect to identification of poor habits and most importantly, prevention of potentially harmful habits.
- **To the researcher**
  This study is part of my PhD. Clinically my aim is to prevent problems occurring in instrumentalists at such early ages. In the event not all problems can be prevented then the aim is to identify problems as soon as possible in order to manage them effectively and return the instrumentalist to learning and playing music. Academically it will assist me in consolidating my research experience and enable me to confidently supervise under graduate and post graduate physiotherapy students with their research project.

Resources

In order to minimise the imposition on the school, the staff and the students the following method has been adopted with the study at another school.

School requirements

- School Registrar/staff:
  - Collation of list of students enrolled in the music program to obtain addresses of students - request that the addresses be printed on self-adhesive stickers (these will be placed onto the envelopes by myself at the school)
  - Mailing of envelopes – the cost of postage will be reimbursed by the School of Physiotherapy on receiving an invoice from your school.
- Informing necessary staff of issuing students with the questionnaire and ensuring "roll call" of completed forms to maximise response rate. I will be happy to meet with staff collectively or individually to explain the procedure or talk to them via phone or email. I have offered Mrs Parker to present to music staff. **Please note the questionnaires can be completed in the students own time and not involve school time if the school prefers**.
- Surveying of several non-instrumentalists (controls) in years 8 or 9, and 10 or 11. Numbers would be comparable to the numbers of instrumentalists

Researcher Requirements

- Collates Participant Information sheet, Request to exclude sheet, self-addressed envelope into envelopes in preparation for mailing out to parents.
- Places stickers with parent's address onto envelopes on school premises and seals envelopes. Returns to school registrar who arranges mail out.
- Liaises with staff teaching instrumental music and staff of selected non-instrumentalists with respect to delivering and collecting questionnaires.
- Inform relevant staff of study and answer questions at any time via any forum.

I would be happy to discuss any issues or concerns you may have in person or over the phone and thank you again for considering this request.

Yours sincerely,

Sonia Ranelli
Physiotherapist
Doctoral candidate
School of Physiotherapy
Curtin University Of Technology

APPENDIX Va Study Description – Newsletter

Newsletter article

Our school has been specially selected to participate in a research project. The project will investigate how many children report muscle, bone and joint (musculoskeletal) problems and how the activities which modern children undertake may increase their risk of these problems.

The project will be focusing on the activities of learning instrumental music and using computers. Parents of children in selected classes will receive a letter informing them of the details of the study and offering the chance to withdraw their child.

If parents and child are happy to participate, children will complete a questionnaire in class and have their height, weight and hand size measured. The questionnaire will ask about soreness experienced and how much music, computer, TV, sport etc. children perform.

The research is being conducted by a research team from the School of Physiotherapy Curtin University of Technology and Princess Margaret Hospital and has the support of the Department of Education and Training School of Instrumental Music. The team is happy to present the research to a P&C meeting if there is sufficient interest.

APPENDIX Vb Letter to Parents/Information Sheet

Research Participant Information Sheet

Playing-Related Musculoskeletal Problems In Children Learning Instrumental Music

A study conducted by the School of Physiotherapy, Curtin University of Technology in association with the School of Instrumental Music.

YOUR school has been selected by the Department of Education and Training School of Instrumental Music to participate in a study to help reduce the risk of children developing problems in the muscles, bones or joints (musculoskeletal problems).

WHY are we conducting the study?

Some adult musicians experience musculoskeletal problems. There is concern that children learning instrumental music may also experience discomfort as a result of their music playing. Children learning instrumental music also participate in a range of other activities at school and home. Many of these activities involve the use of new technology such as desktop or laptop computers, video games and electronic hand held games. We also know that children experience discomfort as a result of using new technology. What we don't know is whether children learning instrumental music have more discomfort than children who don't learn music. We also don't know how to advise children, parents and teachers to prevent discomfort developing.

This study will tell us how music playing and other activities may contribute to children experiencing discomfort. This information will be used to provide guidelines which music teachers and parents can use to help children to play instrumental music in a safe, efficient and productive manner.

HOW? What do I have to do?

Participation is voluntary. Your child will be included in the study and will be given a questionnaire to complete during school time with their teacher and the chief researcher present.

There will be no cost to you. The cost to your child will be their time to complete the questionnaire, which we anticipate will be 30 minutes. There are no risks associated with participation in this research. Your child will be expected to answer some personal questions related to their date of birth, suburb they live in, class teacher's name, school they attend, and any history of health problems with their muscles, bones or joints. Questions regarding the musical instrument/s they play and on the type of activities they participate in (e.g. writing, reading, drawing, using computers or playing electronic games, watching television, exercise) will also be asked.

The benefit of participating in this study is that you and your child will help us to understand why some children experience musculoskeletal problems related to instrument playing. Information about the findings of this study and recommendations will be made available to you via the school.

What if I do not want my child to take part?

If after reading this information sheet you decide you do not want your child to participate in the study, all you need to do is to fill in the attached form titled "Request to Exclude" and return it in the replied paid envelope by September 2003. Your child will participate in his/her routine class activity and he/she will not be prejudiced in any way.

Will my child's information be kept confidential?

We are not collecting your child's name, so all information collected will be anonymous.

What about the results of the study?

Detailed reports on the study will be published in international scientific journals. We will also make a report available at our web site and let you know about this with a short notice for the school newsletter when we have finished the study.

Has this study been approved?

This study has been approved by your Principal, and Mary-Jane Whitehead, Manager of Instrumental Music Services, Education Department of Western Australia. The study has also been approved by the Human Research Ethics Committee of Curtin University of Technology (HR 234/2002). Office of Research and Development, Curtin University of Technology, GPO Box U1987, PERTH 6845. Phone: (08) 9266 2784.

Questions? If you have any questions, queries or problems please contact Sonia Ranelli: School Of Physiotherapy, Curtin University of Technology, GPO Box U1987, PERTH 6845

Phone: (08) 9266 3668, Email: s.ranelli@curtin.edu.au

Thankyou

Sonia Ranelli
Physiotherapist
Doctoral candidate
School of Physiotherapy
Curtin University Of Technology

Associate Professor Leon Straker
Physiotherapist/Ergonomist
School of Physiotherapy
Curtin University Of Technology

Dr Kevin Murray
Paediatric Rheumatologist
Princess Margaret Hospital

APPENDIX Vc Request Exclusion from Study Form

Request to Exclude

Playing-Related Musculoskeletal Problems In

Children Learning Instrumental Music

A study conducted by the School of Physiotherapy, Curtin University of Technology in association with the School of Instrumental Music.

We request that our child

____

(Name)

in ____

(Class)

at ____

(School)

be <u>excluded</u> from this study.

We understand that our child will not be prejudiced in any way for not participating.

Name: ____
(parent / guardian / custodian)

Signature: ____

Date: ____

APPENDIX Vd Written Consent Form

Participant Consent Form

Playing-Related Musculoskeletal Problems In

Children Learning Instrumental Music

A study conducted by the School of Physiotherapy, Curtin University of Technology in association with the School of Instrumental Music.

Parent consent

You are voluntarily making a decision to allow your child to participate in this research project. Your signature certifies that you have decided to allow your child to participate, having read and understood the information presented. Your signature also certifies that you have had the opportunity to ask questions and further clarify any information.

I/We give my/our permission for any results of this study to be used in any report or research paper, on the understanding that my child's confidentiality will be preserved. I understand that I/we may withdraw my/our child from the study at any time without prejudice. If I/we do withdraw consent, I/we will contact the investigator at the earliest opportunity.

We allow our child

____
(Name)

in ______________________________________
(Class)

at ______________________________________
(School)
To be included in this study

Date: __________________________________

Student Consent

I agree to participate in this research project. I give permission for the results of this study to be used in research reports or papers. I am aware that my confidentiality in participating in this study will be preserved. I understand that I can choose to withdraw from this study at any time without prejudice. If I choose to withdraw from the study I will notify the chief researcher.

____
(Name)

in ____
(Class)

at ____
(School)

Date: ____________________________________

APPENDIX VI Unadjusted and adjusted logistic regression odds ratio estimates (95% CI) for BMI and hand span for the three outcome measures of PRMP

COVARIATE	Lifetime Playing-Related Musculoskeletal Symptoms			Monthly Playing-Related Musculoskeletal Symptoms			Playing-Related Musculoskeletal Disorders		
	Odds Ratio	95% CI	P value	Odds Ratio	95% CI	P value	Odds Ratio	95% CI	P value
unadjusted OR									
Gender (female)	1.38	1.01-1.89	0.046	1.56	1.15-2.11	0.004	1.46	1.04-2.04	0.028
Age (years)	1.23	1.14-1.33	<0.001	1.19	1.11-1.29	<0.001	1.19	1.08-1.29	<0.001
BMI	1.12	1.06-1.19	<0.001	1.10	1.04-1.16	<0.001	1.08	1.03-1.13	0.003
Hand Span									
Left	1.11	1.02-1.21	0.013	1.05	0.97-1.14	0.212	1.05	0.96-1.14	0.273
Right	1.09	1.00-1.19	0.046	1.03	0.95-1.11	0.488	1.04	0.95-1.13	0.424
BMI adjusted OR									
BMI	1.08	1.02-1.15	0.009	1.07	1.01-1.13	0.015	1.05	0.99-1.12	0.061
Gender (female)	1.45	1.03-2.04	0.032	1.66	1.20-2.29	0.002	1.59	1.12-2.27	0.010
Age (years)	1.17	1.07-1.28	0.001	1.15	1.05-1.25	0.002	1.16	1.05-1.27	0.003
Hand Span adjusted OR									
Left	1.01	0.91-1.13	0.803						
Right	0.99	0.89-1.10	0.988						
Gender (female)	1.46	1.03-2.05	0.033	-	-	-	-	-	-
Age (years)	1.22	1.11-1.35	p<0.001	-	-	-	-	-	-

APPENDIX VII The Young people's Questionnaire – Music (The YAQ-M)

Curtin University of Technology

Young people's Activity Questionnaire - Music

YAQ-m

Dear Student,

Many of the activities you do regularly at home and school are new to your generation. We are trying to understand the impact of these activities on your physical, mental and social development. Our aim is to provide guidelines for wise participation in these activities - so you can enjoy the benefits without experiencing any problems.

We appreciate the time and effort you put in to completing the questionnaire.

Regards,
Young People's Activity research team.

☐☐☐☐☐☐☐☐☐☐☐☐☐☐

Q1. First some questions about you and your school.

1a	Which school do you go to?	☐
1b	When were you born? (Date of birth) (eg 27th June 1990 ⇒ 27/06/90)	☐ day ☐ month ☐ year
1c	Write the 1st, 3rd and 4th letter of your name (For example M A R T I N)	☐ ☐ ☐ M R T
1d	What year are you in at school?	☐ year/grade
1e	Who is your home class teacher?	☐
1f	What suburb do you live in?	☐
1g	What are your initials?	☐
1h	Are you a boy or girl?	☐ boy ☐ girl
1i	Do you wear glasses or contact lenses?	☐ yes ☐ no
1j	Which hand do you usually write with?	☐ left ☐ right ☐ either
1k	How tall are you?	☐ cms
1l	How much do you weigh?	☐ kgs

1m In the **last month**, how often did you have any headaches?
☐ didn't ☐ 1 x month ☐ 1 x week ☐ 2-3 x week ☐ every day
▶ **If '*didn't*' go to question 1p**

1n In the **last month**, did you ever have to stop doing an activity because of the headaches?
☐ yes ☐ no

1o In the **last month**, did you take any medicine for the headaches?
☐ yes ☐ no

1p In the **last month**, how often did you have any stomach aches?
☐ didn't ☐ 1 x month ☐ 1 x week ☐ 2-3 x week ☐ every day
▶ **If '*didn't*' go to question 2**

1q In the **last month**, did you ever have to stop doing an activity because of the stomach aches?
☐ yes ☐ no

1r In the **last month**, did you take any medicine for the stomach aches?
☐ yes ☐ no

2. Now some questions about your muscles, bones and joints.

2a Can you do 'tricks' with your joints? (eg your thumb can touch your forearm)
☐ yes ☐ no ☐ don't know

2b Do your joints often feel like they need to click?
☐ yes ☐ no ☐ don't know

2c Have you ever had a problem with your muscles, bones or joints?
☐ yes ☐ no
▶ **If '*didn't*' go to question 3**

2d Please describe the problem with your muscles, bones or joints.

2di What was the problem (for example, broken bone, scoliosis, arthritis)

2dii Where was the problem
☐ neck ☐ mid back ☐ low back shoulder/arm ☐left ☐right elbow/ hand ☐left ☐right leg ☐left ☐right ☐other

2diii How long ago you had it

2div How it affects you now

2dv Why do you think you had it

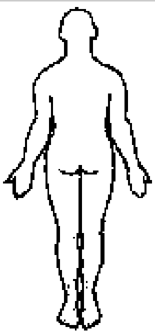
2e In the **last month**, how often did you feel any soreness, pain or discomfort in your muscles, bones or joints?
☐ didn't ☐ 1 x month ☐ 1 x week ☐ 2-3 x week ☐ every day
▶ **If '*didn't*' go to question 3, page 3**

2f In the **last month**, did you ever have to stop doing an activity because of the soreness?
☐ yes ☐ no

2g In the **last month**, did you take any medicine to reduce the soreness?
☐ yes ☐ no

2h In the **last month**, did you see a doctor/physiotherapist/etc. because of the soreness?
☐ yes ☐ no

2i
Circle each body part on the picture where you felt soreness in the last month.



2j
For each area you circled, put a number in the box for that area to rate how much soreness you had on a scale from
0 (no soreness) to 10 (extreme soreness).

0 no soreness — 10 extreme soreness

☐	a neck
☐	b mid back
☐	c low back
☐	d left shoulder/arm
☐	e left elbow/hand
☐	f right shoulder/arm
☐	g right elbow/hand
☐	h left leg
☐	i right leg
☐	j other

2k What do you think caused this soreness?

3. *Now some questions about…*

…playing a musical instrument.

3a In the **last month**, how often did you play a musical instrument?
☐ didn't ☐ 1 x month ☐ 1 x week ☐ 2-3 x week ☐ every day
▶ If '*didn't*' go to question 4, page 6

3b About what age were you when you started playing a musical instrument?
☐ years old

3c Have you ever felt any soreness anywhere when you played a musical instrument?
☐ yes ☐ no

3d List the musical instruments you play regularly.

3e In the **last month**, for how long did you usually play a musical instrument each time?
☐ < 30 minutes ☐ 30-60 minutes ☐ 1-2 hours ☐ 2-5 hours ☐ >5 hours

3f In the last month, what was the longest time you played a musical instrument without a break?
☐ < 30 minutes ☐ 30-60 minutes ☐ 1-2 hours ☐ 2-5 hours ☐ >5 hours

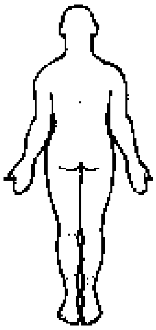
3g In the last month, how often did you feel any soreness anywhere when you played a musical instrument?
☐ didn't ☐ 1 x month ☐ 1 x week ☐ 2-3 x week ☐ every day
▶ If '*didn't*' go to question 3B, on page 4

3h In the last month, did you feel any instrument playing related soreness, tingling or weakness which stopped you from playing your instrument as well as you usually play?
☐ yes ☐ no

3i In the last month, did you take any medicine to reduce the soreness you felt when playing a musical instrument?
☐ yes ☐ no

3j In the last month, did you see a doctor/physiotherapist/etc. because of the soreness you felt when playing a musical instrument?
☐ yes ☐ no

3k
Circle each body part on the picture where you felt soreness in the last month related to playing a musical instrument.



3l
For each area you circled, put a number in the box for that area to rate how much soreness you had on a scale from 0 (no soreness) to 10 (extreme soreness).

0 no soreness — 10 extreme soreness

☐	a neck
☐	b mid back
☐	c low back
☐	d left shoulder/arm
☐	e left elbow/hand
☐	f right shoulder/arm
☐	g right elbow/hand
☐	h left leg
☐	i right leg
☐	j other

3m What do you think caused this soreness?

3B. Now some extra questions about your musical instrument playing

3Ba Which instrument do you play the most?.

3Bb About what age were you when you started playing your **main** musical instrument?
years old

3Bc How often do you usually do warm up exercises before music practice/performing?
1☐ never 2☐ almost never 3☐ sometimes 4☐ most times 5☐ always

If you did warm up exercises, why?

3Bd How often do you usually take breaks when you practice music?
1☐ never 2☐ almost never 3☐ sometimes 4☐ most times 5☐ always
If you did take breaks, why?

3Be How often do you usually do cool down exercises after music practice/performing?
1☐ never 2☐ almost never 3☐ sometimes 4☐ most times 5☐ always

If you did cool down exercises, why?

3Bf Have you been playing more or less than usual in the last month?
1☐ much less 2☐ a little less 3☐ about usual 4☐ a little more 5☐ a lot more

3Bg If you were playing more, why? (tick as many boxes as you need)
1☐ exams 2☐ new piece of music 3☐ concerts 4☐ competition 5☐ school performance 6☐ no reason

3Bh How did you practice more than usual? (tick only one box)
1☐ don't 2☐ play for longer 3☐ play more often 4☐ play longer and more often

3Bi Was the piece of music you were playing in the last month more or less difficult than usual?
1☐ much easier 2☐ a little easier 3☐ about usual 4☐ a little difficult 5☐ a lot more difficult

3Bj In the last month, why did you play a musical instrument? (tick as many boxes as you need)
1☐ mostly for school 2☐ mostly own fun 3☐ mostly for private lessons 4☐ other reasons

3Bk How often do you usually get the feeling of butterflies in your stomach when you play music in a competition/concert? (tick only one box)

1☐ never 2☐ almost never 3☐ sometimes 4☐ most times 5☐ always 6☐ have not played in a concert

► If '*never*' go to question 3Bm

3Bl Do you usually take any medicines (eg Beta blockers) for the feeling of butterflies in your stomach
1☐ never 2☐ almost never 3☐ sometimes 4☐ most times 5☐ always

3Bm How much do you usually enjoy playing music?
1☐ don't enjoy it 2☐ enjoy it a little 3☐ enjoy it 4☐ enjoy it very much 5☐ love it

3C. Now, when and where do you practice music.

Please describe your usual weekly playing schedule (use your diary to help you remember).

Please fill in when and where you practice and for how long (eg. In my bedroom for 35 minutes)

Day of the week	Before School/ Early Morning		At School/middle of the day		After school/evening	
	Where	How long	Where	How long	Where	How long
Example	*Bedroom*	*35 min*	*Class*	*55 min*	*Band practice*	*45 min*
Monday Main Instrument						
Instrument No 2						
Instrument No 3						
Tuesday Main Instrument						
Instrument No 2						
Instrument No 3						
Wednesday Main Instrument						
Instrument No 2						
Instrument No 3						
Thursday Main Instrument						
Instrument No 2						
Instrument No 3						
Friday Main Instrument						
Instrument No 2						
Instrument No 3						
Saturday Main Instrument						
Instrument No 2						
Instrument No 3						
Sunday Main Instrument						
Instrument No 2						
Instrument No 3						

4. Now some questions about…

…watching TV or videos.

4a In the last month, how often did you watch TV/videos?
☐ didn't ☐ 1 x month ☐ 1 x week ☐ 2-3 x week ☐ every day
If *'didn't'* go to question 5

4b In the last month, for how long did you usually watch TV/videos each time?
☐ < 30 minutes ☐ 30-60 minutes ☐ 1-2 hours ☐ 2-5 hours ☐ >5 hours

4c In the last month, how often did you feel any soreness anywhere when you watched TV/videos?
☐ didn't ☐ 1 x month ☐ 1 x week ☐ 2-3 x week ☐ every day

5. Now some questions about…

… drawing or writing.

5a In the last month, how often did you write or draw on paper?
☐ didn't ☐ 1 x month ☐ 1 x week ☐ 2-3 x week ☐ every day
If *'didn't'* go to question 6

5b In the last month, for how long did you usually write or draw each time?
☐ < 30 minutes ☐ 30-60 minutes ☐ 1-2 hours ☐ 2-5 hours ☐ >5 hours

5c In the last month, how often did you feel any soreness anywhere when you wrote or drew?
☐ didn't ☐ 1 x month ☐ 1 x week ☐ 2-3 x week ☐ every day

6. Now some questions about…

…playing electronic games.

6a In the last month, how often did you play electronic games (hand held games like Game Boy and TV/console based games like Play Station)?
☐ didn't ☐ 1 x month ☐ 1 x week ☐ 2-3 x week ☐ every day
If *'didn't'* go to question 7, next page

6b List the electronic game equipment you use regularly.

6c In the last month, for how long did you usually play electronic games each time?
☐ < 30 minutes ☐ 30-60 minutes ☐ 1-2 hours ☐ 2-5 hours ☐ >5 hours

6d In the last month, how often did you feel any soreness anywhere when you played electronic games?
☐ didn't ☐ 1 x month ☐ 1 x week ☐ 2-3 x week ☐ every day

7. Now some questions about…

…using a desktop or laptop computer

7a In the last month, how often did you use a computer?
☐ didn't ☐ 1 x month ☐ 1 x week ☐ 2-3 x week ☐ every day
▶ If *'didn't'* go to question 8

7b About what age were you when you started using a computer?
☐ years old

7c In the last month, for how long did you usually use a computer each time?
☐ < 30 minutes ☐ 30-60 minutes ☐ 1-2 hours ☐ 2-5 hours ☐ >5 hours

7d In the last month, what was the longest time you used a computer without a break?
☐ < 30 minutes ☐ 30-60 minutes ☐ 1-2 hours ☐ 2-5 hours ☐ >5 hours

7e In the last month, how often did you feel any soreness anywhere when you used a computer?
☐ didn't ☐ 1 x month ☐ 1 x week ☐ 2-3 x week ☐ every day

8. Now some questions about…

…other hand intensive activities.

8a In the last month, how often did you do other activities where you use your hands a lot (eg sewing, yoyo, woodwork/metalwork, making models, making jewelry, playing cards)?
☐ didn't ☐ 1 x month ☐ 1 x week ☐ 2-3 x week ☐ every day
▶ If *'didn't'* go to question 9

8b List the activities you do regularly where you use your hands a lot (crafts, playing cards, etc.)

8c In the last month, for how long did you usually do these activities each time?
☐ < 30 minutes ☐ 30-60 minutes ☐ 1-2 hours ☐ 2-5 hours ☐ >5 hours

8d In the last month, how often did you feel any soreness anywhere when you did these activities?
☐ didn't ☐ 1 x month ☐ 1 x week ☐ 2-3 x week ☐ every day

9. Now some questions about…

…vigorous physical activities.

9a In the last month, how often did you do vigorous physical activity (activities that make you puff or your heart beat faster like running, football, netball, hockey, vigorous dancing, bike riding)?
☐ didn't ☐ 1 x month ☐ 1 x week ☐ 2-3 x week ☐ every day
▶ If *'didn't'* go to question 10, next page

9b List the vigorous physical activities you do regularly.

9c In the last month, for how long did you usually do these activities each time?
☐ < 30 minutes ☐ 30-60 minutes ☐ 1-2 hours ☐ 2-5 hours ☐ >5 hours

9d In the last month, how often did you feel any soreness anywhere when you did these activities?
☐ didn't ☐ 1 x month ☐ 1 x week ☐ 2-3 x week ☐ every day

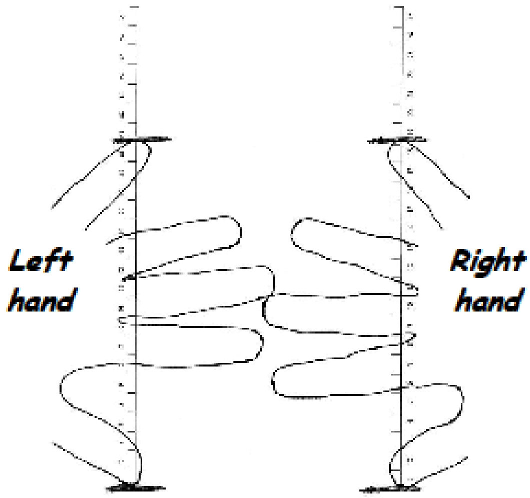
10. Finally,

10a Were your activities over the last week different to usual?

☐ yes ☐ no

If 'yes' please describe how your activities were different

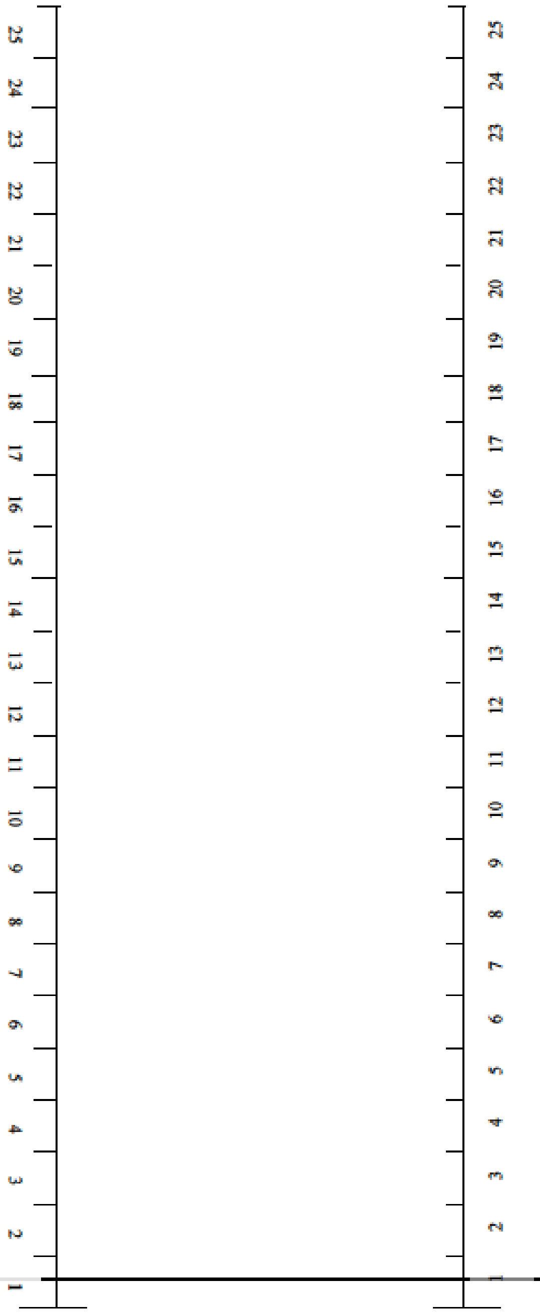
10b. Trace your left and right hand along <u>the ruler on the next page</u> and mark your thumb tip and finger tip, just like the picture below.



10b Hand Span

Place your hand along the ruler, spread fingers as far as possible and mark your thumb tip and little finger.

LEFT HAND



RIGHT HAND