Musculoskeletal injuries in elite pianists: Prevalence and associated risk factors

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Abstract
Pianists seem prone to Playing-Related Musculoskeletal Disorders (PRMDs), however little piano-specific epidemiological research into such disorders has been undertaken. This study aimed to establish the prevalence of PRMDs in a sample of elite (conservatory) pianists, identify associated risk factors and gather information regarding PRMD symptom distribution.

A survey of pianists enrolled at a large Australian university keyboard conservatory was undertaken. Survey items were developed from qualitative research that validated a PRMD definition for pianists and identified relevant perceived risk factors. Univariate and multivariate statistical techniques were used. Sixty-eight percent of pianists reported experiencing symptoms that interfered with their piano playing in the week prior to completing the survey. Statistically significant risk factors associated with PRMDs following were high levels of perceived stress and self-reported increased muscle tension when playing the piano. Survey participants reporting both high stress and increased muscle tension had an 84% chance of having a PRMD. Anatomical areas most frequently affected by PRMD symptoms were the posterior neck, shoulders and upper middle back. Knowledge of these risk factors, and the anatomical areas frequently affected by PRMDs, can aid piano teachers in the recognition and management of these disorders in consultation with appropriate health professionals.

Introduction

In recent years, there has been growing recognition that playing a musical instrument is analogous to athletic performance due to the intense level of demand and practice, emphasis on speed and accuracy and stress of competition.(Quarrier, 1993; Rozmaryn, 1993) Therefore, elite musicians are prone to Playing-Related Musculoskeletal Disorders (PRMDs), which are defined as:

> pain, weakness, lack of control, numbness, tingling, or other symptoms that interfere with your ability to play your instrument at the level you are accustomed to. (Zaza, Charles, & Muszynski, 1998)

PRMD prevalence amongst mixed instrumental cohorts is reported to range from 39 – 47% (Zaza, 1998). PRMD rates appear higher in pianists than in other instrumentalists such as woodwind players (Cayea & Manchester, 1998; Manchester, 1988; Manchester & Flieder, 1991). PRMDs have adverse physical and psychological effects on pianists and in extreme cases can be career-threatening (Bragge, Bialocerkowski, & McMeeken, 2006). However, piano-specific PRMD prevalence has not been established, primarily due to inadequate and inconsistent use of a PRMD definition (Bragge, Bialocerkowski, & McMeeken, 2006). Although many risk factors for PRMDs in pianists have been postulated, research evidence establishing these factors is similarly inconclusive (Bragge et al., 2006). Knowledge of such risk factors can inform preventative and educational strategies designed to optimise the physical health of pianists at all levels.

Therefore, the aim of this study was to establish the prevalence of PRMDs in a sample of elite (conservatory) pianists and identify associated risk factors. A secondary aim was to gather information on the distribution of PRMD symptoms.

Methods

Design

A cross-sectional, written survey design was used (Sackett, 1991).

Participants and recruitment

Eligible participants were pianists enrolled at a large Australian university keyboard conservatory in 2005. Recruitment was restricted to one university to minimise bias from institutional differences in courses. There were no exclusion criteria. Ethics approval was obtained from The University's Human Research Ethics Committee. Data collected were anonymous and confidential.

The survey was administered on 16 May 2005 during a two-hour Piano Class in which attendance by all enrolled pianists was expected. Absent students were invited to participate via mail to reduce non-response bias (Oppenheim, 1992).

Sample size
An *a priori* power calculation was impossible due to the lack of appropriate historical data on piano-specific PRMD prevalence and risk factors (Bragge et al., 2006). Thus, the results of statistical tests, such as confidence intervals, were used as a post-hoc measure of the strength of the inferences.

Survey instrument
A custom-designed survey for this study was developed based on the results of a qualitative study (Barbour, 1999). We conducted one-on-one interviews with elite pianists with PRMD experience (n=18) and piano teachers (n=6) and health practitioners (n=6) of affected pianists (Bragge et al., 2006; Bragge, Bialocerkowski, & McMeeken, 2004). Participants defined a PRMD in their own words using trigger questions derived from a previous study (Zaza et al., 1998) and gave their perspectives on the importance of various physical and psychological risk factors identified from PRMD studies of mixed instrumental cohorts. Factors included technique (Hmelnitsky & Nettheim, 1987), joint laxity (Lockwood, 1989), posture (Zaza & Farewell, 1997), stress (Zaza & Farewell, 1997), and number of years playing (Bejjani, Kaye, & Benham, 1996). These and any additional risk factors reported were ranked based upon their perceived importance using a standardised protocol (Bragge et al., 2006; Bragge et al., 2004). Major findings of the qualitative study were that:

- the operational definition of PRMD previously derived by Zaza et al. (1998) was validated in pianists
- piano-specific risk factors associated with PRMDs were identified (Bragge et al., 2004).

The survey based upon these results was piloted prior to administration and minor changes were made based upon feedback. The final survey comprised three sections (Figure 1):

Section A: Demographic/background information and PRMD status*:*
One-week PRMD prevalence was ascertained using the validated PRMD definition (Zaza et al., 1998).

Section B: Nature of PRMD/PRMD-specific risk factors*:* Information on PRMD symptom distribution (Heming, 2004; Kuorinka et al., 1987; Lacey, Lewis, Jordan, Jinks, & Sim, 2005), PRMD symptom duration (Devereux, Vlachonikolis, & Buckle, 2002; Kuorinka et al., 1987) and two PRMD-specific risk factor items (schedule, overuse) was gathered. Two open-ended questions (perceived risk factors, perceived aggravating factors) were also included.

Section C: Non PRMD-specific risk factors*:* Information regarding nine risk factors from the qualitative study (Bragge et al., 2006; Bragge et al., 2004) was gathered. Perceived stress associated with five piano-playing scenarios described in the qualitative interviews was gathered using horizontal 100-millimetre Visual Analogue Scales (VAS) (Duggan et al., 2002; Freyd, 1923; Ghiadoni et al., 2000). Stress scores were summed to generate a *total stress score* (range 0 – 500) (Santamaria, 1994, 1995). Questions and response categories for other risk factor questions were informed by the qualitative study (Barbour, 1999; Oppenheim, 1992)

Data analysis
Data analysis was undertaken using SPSS for Macintosh (Version 11.0.3) and specialised software (Pezzullo, 2004) to calculate a 95% Binomial Confidence Interval for one-week PRMD prevalence. Following descriptive analysis of each variable (Gillham, 2000; Punch, 2003), analysis of relationships between risk factors and PRMD status was conducted using univariate and multivariate techniques. Demographic variables were included in these analyses to account for confounding (Portney & Watkins, 1993; Psaty et al., 1999). Thirteen independent (risk factor) variables were analysed:

1. Age
2. Gender
3. Year level
4. N (years learned piano)
5. Teacher
6. Warm-up
7. N (minutes practice in one session)
8. Breaks
9. Muscle tension
10. Seat height
11. Posture
12. Repertoire
13. Stress

Univariate analysis was undertaken using the chi-square and t-tests (Hosmer & Lemeshow, 2000; Portney & Watkins, 1993). Where the assumption of expected cell frequency was violated (Cochran, 1954), the offending categories were collapsed where possible (Siegel & Castellan Jr., 1988). When analysing 2 x 2 tables, *Fisher's exact* test was used (Cochran, 1954; Pallant, 2005; Siegel & Castellan Jr., 1988). For continuous data, the independent-samples t-test was used (Pallant, 2005; Portney & Watkins, 1993). The level of significance for all univariate statistical tests was 0.05.

Stepwise logistic regression was used to investigate multivariate relationships between risk factors and PRMD status (Hosmer & Lemeshow, 2000; Tabachnick & Fidell, 2001). To optimise the ratio of cases to variables:

- risk factor variables with more than three missing values in the data (hours played: last 7 days, hours played: typical week, hours played: last week of vacation) were eliminated as they were not significantly associated with PRMD status in univariate analysis (Tabachnick & Fidell, 2001)

- categorical variables with more than two levels (year level, seat height, repertoire) were collapsed into two levels.

Both forward and backward techniques were employed to generate the best prognostic model (Bekkering, Hendriks, van Tulder, Knol, Simmonds et al., 2005). The p-values for entry into and removal from the model were 0.05 and 0.10 respectively (Bekkering, Hendriks, van Tulder, Knol, Simmonds et al., 2005), with 0.05 the level of significance for inclusion of risk factors in the final model. Each model was re-run with eligible continuous variables categorised around their median value (Nyland & Grimmer, 2003). Logistic regression equations calculated PRMD probability for each combination of significant predictor variables in the dataset.

Open-ended questions were analysed using qualitative content analysis (Altheide, 1987; Sandelowski, 2000). A standardised protocol (Bragge et al., 2004) was used for analysis of perceived PRMD risk factors in Section B of the survey.

Results

Response rate

Eighty-seven of 132 eligible participants (66%) completed the survey; 78 during group administration and nine via mail.

Demographic / background information

The mean age of the participants was 20.2 years (sd 2.3, range 18 - 31). Participants had learned piano for a mean of 13.2 years (sd 3.0, range 4 - 19) and 59% were in the first or second year of conservatory study. Females outnumbered males 57:30.

PRMD prevalence

Fifty-nine participants reported a PRMD in the week preceding the survey, giving a one-week PRMD prevalence rate of 68% [95% Binomial CI 56.9, 77.4].

PRMD symptom distribution and duration

The most frequently reported anatomical areas affected by PRMDs were the posterior neck (n = 35), the posterior right (n = 32) and left (n = 31) shoulders and the upper middle back (n = 30). Other frequently affected areas were the wrists and hands (Figure 2). Twenty-five of the 59 participants with a PRMD (42%) had experienced their symptoms for over 30 days, 16 (27%) for 8 – 30 days and 18 (31%) for 1 – 7 days.

Perceived risk factors associated with PRMDs and PRMD-specific risk factors
The top five perceived risk factors associated with PRMDs were 'Muscle tension', 'Technique', 'Posture', 'Practice time' and 'Stress'. Twenty-one of the 59 participants with a PRMD (36%) perceived that their PRMD was related to a change in practice routine. Most participants (79%) reported that they continued to play piano after the onset or worsening of their PRMD symptoms.

Univariate analysis
Statistically significant risk factors were muscle tension ($p = 0.033$), posture ($p = 0.045$) and total stress score ($p = 0.048$) (Tables 1 and 2). There was a non-significant trend towards higher mean values for practice time in participants with a PRMD (Table 2).

Multivariate analysis
The variables stress and muscle tension were identified as significant predictors of PRMD status regardless of the model used and the type of data. Given the similar predictive ability of each model, the final prognostic model chosen (forward stepwise) was that with the lowest number of predictors (Bekkering, Hendriks, van Tulder, Knol, Hoeijenbos et al., 2005). Results are presented for the categorical version of this model for ease of odds ratio interpretation (Portney & Watkins, 2000). The logistic regression model explained 11% - 15% of the variation in PRMD status.

According to the adjusted odds ratios:

- Participants who experienced high levels of perceived stress (above the median value of total stress score) were 3.3 times more likely to experience a PRMD than participants who experienced low perceived stress levels [95% CI 1.2, 9.3]
- Participants who reported increased muscle tension when playing the piano were 4.6 times more likely to experience a PRMD than participants who did not [95% CI 1.1, 19.8] (Table 3).

Stress and muscle tension had a cumulative influence on the probability of experiencing a PRMD (Table 4).

Discussion
Strengths and limitations of the study
This is the first known piano-specific survey of PRMDs in which survey items were informed by a qualitative study. Qualitative validation of a PRMD definition added credibility to our findings (Bragge et al., 2004). The statistically significant risk factors were also ranked in the top five perceived risk factors according to our previous qualitative study, strengthening our risk factor findings (Slevin & Sines, 1999).

Although the response rate (66%) exceeded that of most studies in our systematic review (Bragge et al., 2006) and was consistent with recommendations in the literature (Baruch, 1999), it is possible that the prevalence estimate of 68% is subject to non-response bias. However, a prevalence figure based upon the worst possible hypothetical case of non-response bias (where none of the survey non-respondents had a PRMD) remains high (45%). Because cross-sectional surveys establish associations between variables (Bongers, Kremer, & ter Laak, 2002) rather than causality, this study cannot make conclusions regarding the relationships between risk factors and PRMD status (Norell, 1992). The ratio of events to variables (approximately 4:1) in the logistic regression model was below recommended levels (van Belle, 2002) although comparable to other PRMD studies (Zaza, 1992; Zaza & Farewell, 1997). The low explanatory power of the logistic regression model indicates that there are additional risk factors associated with PRMDs in pianists that were not measured with sufficient sensitivity (Yee, Harburn, & Kramer, 2002) or not measured at all (Bekkering, Hendriks, van Tulder, Knol, Simmonds et al., 2005). Therefore, future research priorities include use of prospective study designs to establish aetiological relationships, validation of the survey findings in a larger sample and consideration of which risk factor variables are included and how they are measured.

Prevalence
The one-week prevalence of 68% in this survey indicates that PRMDs are a substantial problem amongst elite pianists. This is reinforced by the finding that 42% of participants had experienced PRMD symptoms for more than 30 days, representing chronic musculoskeletal symptoms (Thibeault, Merrill, Roy, Gray, & Smith, 2004). Table 5 summarises the current prevalence findings compared with other known studies of musicians using the same PRMD definition (Furuya,

Nakahara, Aoki, & Kinoshita, 2006; Yeung et al., 1999; Zaza & Farewell, 1997) Of these, only one study (Furuya et al., 2006) was confined to pianists. The higher prevalence rate of 77% obtained in this all-female study may be the result of the effect of gender (Heming, 2004; Zaza & Farewell, 1997); however in our study, gender was not found to be significantly associated with PRMDs. Table 5 also illustrates that compared to other instrumentalists, pianists are especially prone to PRMDs (Cayea & Manchester, 1998; Manchester, 1988; Manchester & Flieder, 1991).

Risk factors

Stress and muscle tension were associated with PRMDs in this survey in both univariate and multivariate analysis. The findings regarding stress are consistent with a previous study of female pianists (Yee et al., 2002). Another piano-specific survey (Shields & Dockrell, 2000) found four out of 41 respondents (9.8%) identified stress as a possible cause of injury, however there was no further analysis of the relationship between stress and PRMDs. Studies of mixed instrumental cohorts have also reported associations between stress and PRMDs (Middlestadt & Fishbein, 1988; Salmon, Shook, Lombart, & Berenson, 1995). Furthermore, systematic reviews of occupational medicine studies outside of the performing arts support an association between stress and musculoskeletal disorders (Bongers et al., 2002; Linton, 2000). The finding of an association between stress and PRMDs in the present study is important because it demonstrates that a risk factor that has been identified in many different occupational settings may also be of importance to elite pianists. This may mean that strategies already developed for managing stress in other populations may be of use to elite pianists.

Our muscle tension findings are also consistent with both piano-specific and general occupational medicine literature. A survey of 203 pianists (Furuya et al., 2006) found a significant association between self-reported excessive muscle tension when playing chords forcefully and PRMDs at the hand/finger ($p = 0.01$), wrist ($p = 0.001$), forearm ($p = 0.004$) and elbow ($p = 0.025$). Furthermore, respondents who reported being warned often about excessive levels of key compression force by their teachers had higher PRMD rates at the finger/hand ($p = 0.041$) and forearm ($p = 0.015$). Two other piano-specific studies (Grieco et al., 1989; Revak, 1989) did not statistically evaluate associations between muscle tension and PRMDs. Studies of other instrumental groups (Berque & Gray, 2002; Philipson, Sorbe, Larsson, & Kaladjev, 1990), dancers (Ramel & Moritz, 1998), and computer workers (Peper et al., 2003) have also reported associations between elevated muscular tension and PRMDs or comparable musculoskeletal conditions.

Therefore, although few piano-specific studies have definitively linked excessive muscle tension to PRMDs, research in related areas indicates that muscle tension may play a role in PRMD development. However, as the level of muscle tension was not measured directly in this study, objective measurement of muscle tension (for example electromyography) in pianists with and without a PRMD could more definitively establish this association. Similarly, objective measurement of posture, for example using photographic analysis (Chansirinukor, Wilson, Grimmer, & Dansie, 2001), is required to further explore the relationship between posture and PRMDs, given the significant association of posture with PRMD status in univariate (but not multivariate) analysis.

PRMD symptom distribution

The most frequent anatomical areas affected by PRMDs were the central posterior neck/shoulder/upper back areas and the wrists and hands, which are most active during piano playing (Grieco et al., 1989). These locations may suggest problems in the cervical (neck) and glenohumeral (shoulder) areas, with secondary referral of symptoms further down the arm, as postulated in a study of musculoskeletal disorders amongst computer users, musicians and other workers that incorporated physical assessment (Pascarelli & Hsu, 2001). However in our survey, primary and secondary symptoms were not identified and no physical examination was undertaken. Therefore, no conclusions regarding the pathophysiology of PRMD symptoms in the surveyed pianists can be drawn. Although our results were in agreement with the location of symptoms reported by a number of previous studies (Furuya et al., 2006; Grieco et al., 1989; Linton, 2000), there were some differences in the relative distribution of PRMD symptoms. For example, we found a greater prevalence of neck and shoulder symptoms compared with the wrist and hand. This is in contrast to Furuya et al. (Furuya et al., 2006), who found that the most frequently reported symptomatic areas were the hand/finger.

Conclusions
Our results suggest that PRMDs are a substantial problem in elite pianists (one-week prevalence = 68%). Increased levels of stress and muscle tension were significantly associated with PRMDs. Slumped posture may also play a role in PRMD development. These risk factors have been identified in other occupational groups, but this is the first known study to use a validated PRMD definition to identify these risk factors in elite pianists. These findings can inform strategies for teachers and health practitioners to reduce PRMD risk. Based on the present survey, such strategies should aim to:

1. Reduce psychological stress associated with piano-playing: Authors have recognised the need for both preventative and management strategies when addressing stress in musicians (Davies & Mangion, 2002; Middlestadt & Fishbein, 1988). Preventative strategies include increasing awareness of stress and the importance of life balance (Sternbach, 2002), whilst deep breathing and visualisation are two examples of stress management techniques (Gratto, 1998)
2. Reduce excessive muscle tension: Relaxation and stretching exercises for pianists have been proposed (Grieco et al., 1989). Self-monitoring of muscle activity, as recommended in viola and violin players (Berque & Gray, 2002) is also likely to benefit pianists.
3. Address seating and ergonomics: Seating modifications such as use of semi-rigid, shaped seating or a back-rest (Grieco et al., 1989) the potential role of posture in PRMD development (Shields & Dockrell, 2000) and the value of postural education have been described in piano-specific risk factor literature (Blackie, Stone, & Tiernan, 1999). This reflects occupational medicine literature regarding posture and ergonomics in work-related musculoskeletal disorders (Buckle, 1997; Hagberg, 1996; Ketola, 2004a; Yassi, 2000).

The above strategies are optimised by collaboration between the teachers and health practitioners who work with pianists. For example, a health practitioner may seek input from a pianist's teacher regarding specifics of piano-playing technique to better understand the physical demands of piano playing. Conversely, a piano teacher may liaise with a pianist's health practitioner regarding stretching exercises appropriate for a pianist with a PRMD or a history of other physical problems. This dialogue should be reflected in the wider inter-professional context, for example via the development of PRMD awareness and educational initiatives in conservatory / senior secondary school settings. At least one Australian Conservatorium has made progress towards this goal (Grant, 2008).

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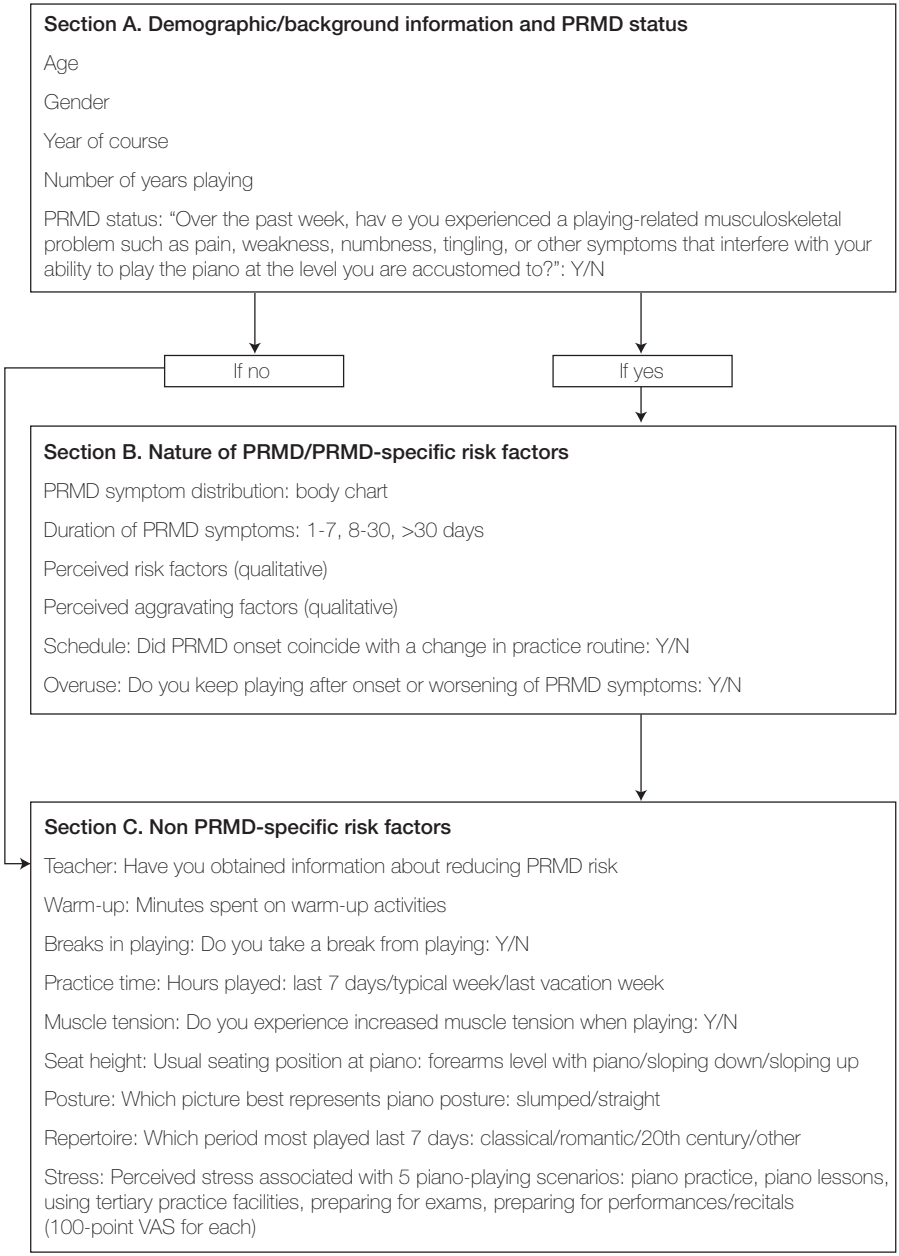
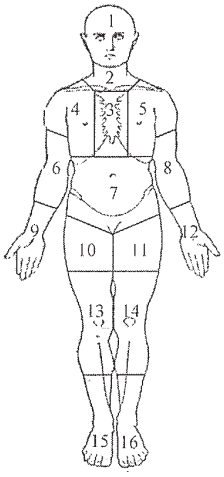


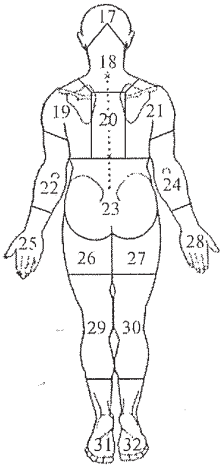
PRMD: Playing-Related Musculoskeletal Disorder
Y: Yes
N: No
VAS: Visual Analogue Scale

Figure 2: Anatomical area of PRMD symptoms (n = 59)



Key[a]		
Anterior (front)	**n (%) pianists with PRMD symptoms**	**% of sample: area-specific prevalence**
2. Neck	7 (12%)	8%
3. Sternum	1 (2%)	1%
4. Right shoulder	8 (14%)	9%
5. Left shoulder	8 (14%)	9%
6. Right elbow	15 (25%)	17%
7. Abdomen	1 (2%)	1%
8. Left elbow	13 (22%)	15%
9. Right wrist/hand	24 (41%)	28%
12. Left wrist/hand	21 (36%)	24%
15. Right ankle/foot	1 (2%)	1%

Key[a]		
Anterior (front)	**n (%) pianists with PRMD symptoms**	**% of sample: area-specific prevalence**
18. Neck	35 (59%)	40%
19. Left Shoulder	31 (53%)	36%
20. Upper middle back	30 (51%)	35%
21. Right shoulder	32 (54%)	37%
22. Left elbow	12 (20%)	14%
23. Lower back	19 (32%)	22%
24. Right elbow	12 (20%)	14%
25. Left wrist/hand	22 (37%)	25%
28. Right wrist/hand	24 (41%)	28%



a: The numbered body chart was only used for analysis purposes: survey participants shaded affected areas on a blank body chart

Table 1 - Observed frequencies and chi-square tests investigating the association between categorical variables and PRMD status

Variable	Categories	n (PRMD)	n (No PRMD)	Test	Value	Degrees freedom (df)	Level of sig.'
Gender	Male	20	10	Fisher's	n/a§	n/a§	1.000
	Female	39	18				
Year level	1st yr	25	9	Pearson x^2	1.839	3	0.607
	2nd yr	19	8				
	3rd yr	10	7				
	4th/5th yr†	5	4				
Teacher‡	Yes	20	8	Fisher's	n/a§	n/a§	0.806
	No	39	20				
Warm-up	Yes	43	19	Fisher's	n/a§	n/a§	0.608
	No	14	8				
Breaks	Yes	40	19	Fisher's	n/a§	n/a§	1.000
	No	17	9				
Muscle tension	Yes	55	21	Fisher's	n/a§	n/a§	0.033*
	No	4	7				
Seat height	Forearms level	44	20	Fisher's	n/a§	n/a§	0.793
	Forearms not level†	14	8				
Posture	Straight	41	26	Fisher's	n/a§	n/a§	0.045*
	Slumped	16	2				
Repertoire	Baroque	11	5	Pearson x^2	1.474	4	0.831
	Classical	16	7				
	Romantic	15	5				
	20th century	6	5				
	Multi/other†	11	6				

§ The output of Fisher's exact test does not include a value or df, only a level of significance

† Collapsing of categories was required in order to avoid violating the assumptions of chi-square regarding minimum expected cell frequency (Siegel & Castellan Jr., 1988)

‡ The categories for the variable 'teacher' were defined according to the answer to the question: 'Have you obtained information about reducing PRMD risk?'

* Statistically significant ($p < 0.05$)

Table 2 - Mean values and independent-samples t-tests investigating the association between continuous independent variables and PRMD status

Variable	Mean (sd): PRMD	Mean (sd): No PRMD	t-value (df)	Level of sig.
Age	20.3 (2.6)	20.0 (1.5)	- 0.714 (85)	0.477
Number of years learned piano	13.3 (3.0)	12.9 (3.1)	- 0.592 (85)	0.555
Number of minutes practice in one session	98.4 (64.4)	85.2 (34.1)	- 1.015 (83)	0.313
Hours played: last 7 days	14.9 (9.2)	11.9 (10.2)	- 1.346 (79)	0.182
Hours played: typical week	16.7 (8.1)	14.5 (10.9)	- 1.060 (79)	0.292
Hours played: last week of vacation	12.2 (10.1)	10.8 (9.4)	- 0.598 (77)	0.552
Stress (VAS): practising	46.4 (23.0)	37.5 (24.7)	- 1.654 (85)	0.102
Stress (VAS): having lessons	55.9 (25.9)	48.5 (27.6)	- 1.218 (85)	0.227
Stress (VAS): using practice rooms	38.8 (26.0)	30.8 (27.9)	-1.291 (84)	0.200
Stress (VAS): preparing for exams	74.2 (20.8)	65.3 (24.3)	-1.749 (84)	0.084
Stress (VAS): preparing for performances/recitals	81.6 (19.9)	69.9 (28.0)	- 1.969 (38.5)†	0.056†
Total stress score (VAS): (sum of stress scores)	296.9 (84.7)	254.9 (100.9)	- 2.009 (84)	**0.048***

* Statistically significant ($p < 0.05$)

† Equal variances not assumed

Table 3 - Variables in the equation: categorical forward stepwise logistic regression model

Variable	B†	S.E.	Wald§	df	Level of Sig.§	OR	95% CI
Stress	1.202	0.527	5.204	1	0.023	3.3	1.2, 9.3
Muscle tension	1.531	0.741	4.264	1	0.039	4.6	1.1, 19.8
Constant	- 1.168	0.759	2.368	1	0.124	0.3	n/a

† B-values indicate the direction of influence of the variable on PRMD status, where positive indicates that increases in the value of the variable

§ The Wald test and level of significance determine the contribution of each variable to PRMD status

Table 4 - PRMD probability based upon combinations of significant predictors using categorical forward stepwise logistic regression

	Low stress†	High stress†
No increased muscle tension	24%	51%
Increased muscle tension	62%	84%

† Relative to the median total stress score for the sample

Table 5 - Comparison of prevalence findings of present study with studies based on the same operational definition of PRMD

Author	Population rate	Response	Prevalence estimate
Bragge et al. [current study]	87 conservatory pianists (57 female, 30 male)	66%	68% one week PRMD prevalence
Furuya et al. (Furuya et al., 2006)	203 female high school (63), conservatory (83), professional (20) pianists and piano teachers (37)	78%	77% prevalence of PRMDs that lasted 'for more than a few days' (p. 113)
Zaza and Farewell (Zaza and Farewell, Farewell,	281 professional and conservatory musicians (155 female, 126 male)	67%	39% point PRMD prevalence
Yeung et al. (Yeung et al., 1999)	39 professional orchestral musicians (9 female, 30 male)	23%	64% 12-month PRMD prevalence