Sitting spinal posture in adolescents differs between genders, but is not clearly related to neck/shoulder pain: an observational study

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Question: Is neck/shoulder pain in adolescents related to their sitting spinal posture, taking account of gender? **Design**: Cross-sectional survey and direct observation. **Participants**: 1597 adolescents from the 'Raine' birth cohort study (781 females, 816 males) with a mean age of 14.1 years (SD 0.2). **Outcome measures**: Neck/shoulder pain prevalence and gender was measured by survey. Spinal posture (7 angles) during sitting was measured from photographs. **Results**: Life, month, and point prevalence for neck/shoulder pain among adolescents were 47%, 29%, and 5% respectively. Life prevalence was 10% higher in females than in males and month prevalence was 12% higher. When looking straight ahead, females sat with 2 degrees (95% CI 1 to 3) less neck flexion, 2 degrees (95% CI 0 to 3) less craniocervical angle, 7 degrees (95% CI 6 to 8) less cervicothoracic angle, 13 degrees (95% CI 12 to 14) less trunk angle, 10 degrees (95% CI 8 to 12) less lumbar angle, and 9 degrees (95% CI 7 to 11) more anterior pelvic tilt than males. Adolescents with neck/shoulder pain sat with 2 degrees (95% CI 1 to 3) less trunk angle, and 1 degree (95% CI 0 to 2) less cervicothoracic angle than those without pain. After controlling for gender, OR for neck/shoulder pain ever predicted by any angle ranged from 0.99 to 1.00 (range of 95% CI 0.98 to 1.01). **Conclusion**: Neck/shoulder pain is highly prevalent in Australian adolescents. Sitting spinal posture differs between males and females and differs slightly between those with and without neck/shoulder pain. However, posture was not predictive of neck/shoulder pain ever after controlling for gender. **[Straker LM, O'Sullivan PB, Smith AJ, Perry MC, Coleman J (2008) Sitting spinal posture in adolescents differs between genders, but is not clearly related to neck/shoulder pain: an observational study. *Australian Journal of Physiotherapy* 54: 127–133]**

Key words: Adolescent, Neck Pain, Shoulder Pain, Posture, Spine, Sex, Physiotherapy

Introduction

Neck/shoulder pain is common in adults (Croft et al 2001), with annual prevalence rates over 50% (Chiu and Leung 2006), and constitutes a significant personal and community health burden. The term neck/shoulder pain rather than neck pain is generally used, as neck pain often manifests in the trapezius muscle. Neck/shoulder pain was previously considered an adult complaint, but recent research has shown that many people experience their first episode before adulthood. There have been no studies of adolescent life or point prevalence, but year prevalence rates for 14 year olds of 20% have been reported (Niemi et al 1997), and month prevalence rates have ranged from 9% to 53% (Murphy et al 2004, Wedderkopp et al 2001). In the only study of Australian adolescents, week prevalence of neck pain was reported by 22% of girls and 11% of boys (Grimmer et al 2006). In general, adolescent prevalence rates approach those in adults (Palmer et al 2001). Adolescent neck/shoulder pain has been reported to be associated with a number of different factors, such as being female (Vikat et al 2000), negative psychosocial factors (Niemi et al 1997, Vikat et al 2000), or very high or low activity levels (Vikat et al 2000). However, no studies have adequately investigated sitting spinal posture as a risk factor for adolescent neck/shoulder pain.

Specific spinal postures have been associated with neck/shoulder pain in adults (eg Szeto et al 2005). The hypothesised relationship between spinal posture and neck/shoulder pain relates to influences of spinal posture on kinematics, motor control, and spinal loading. Altered craniocervical postures (especially head protraction) have been reported to alter cervical spine kinematics (Edmondston et al 2005). Altered cervical kinematics may then create altered strain on spinal structures, potentially leading to pain (Reitman et al 2004). This relationship is partially supported by cross-sectional associations between neck pain and altered cervical kinematics (Szeto et al 2005). Furthermore, sitting lumbo-pelvic posture can alter activation of the deep cervical flexors (Falla et al 2007), and thus possibly influence cervical spine posture and neck/shoulder pain (Falla et al 2007).

However, just two studies have investigated the link between specific spinal postures and adolescent neck/shoulder pain. Hertzberg (1985) observed that increased thoracic flexion and 'lateral pelvic tilt' (not defined) were not associated with adolescent neck/shoulder pain, but one or more 'postural deviations' (not defined) were associated with neck/shoulder pain. Murphy et al (2004) failed to detect associations between trunk or neck posture and neck/shoulder pain, but their method of postural measurement was categorical, with flexion categorised as > 20 degrees or > 45 degrees. Importantly, these two studies did not consider the effect of gender on the relationship between posture and neck/shoulder pain, despite evidence that gender influences adolescent sitting posture (Dunk and Callaghan 2005) and neck/shoulder pain (Vikat et al 2000).

The research questions addressed in this study were therefore:

1. What is the prevalence of neck/shoulder pain in Australian male and female adolescents?
2. What is the sitting spinal posture of male and female adolescents?
3. Is the sitting spinal posture of adolescents with neck/shoulder pain different to the posture of those without neck/shoulder pain?
4. What is the relationship between adolescent neck/shoulder pain and sitting spinal posture, taking account of gender?

Method

Design

A cross-sectional epidemiological survey was conducted as part of the longitudinal 'Raine' child health study (http://www.rainestudy.org.au/). This study is investigating a range of child health and development issues and started as a pregnancy cohort of women attending King Edward Memorial Hospital for Women, Perth, between 1989 and 1991. The children have been followed at birth, 1, 2, 3, 5, 8, 10, and now 14 years of age. For the current study, eligible families were contacted and invited to participate at around the time of the adolescent's 14th birthday. Families agreeing to participate were sent consent forms and questionnaires for completion by primary and secondary carers, and appointments were arranged for physical assessments of the adolescents and both carers.

Participants

At the 14 year follow-up, of the 2868 children included at birth, 651 were no longer eligible for the study: 32 (1%) had died, 207 (7%) had been lost to follow-up, and 412 (14%) had withdrawn. Of the remainder, 357 (12%) agreed to participate but did not complete any assessment, with 1860 (65%) providing some data. Neck/shoulder pain data were available for 1597 adolescents (72% of those eligible, 781 females, 816 males) with spinal posture and spinal pain data available for 1470 adolescents (66% of those eligible, 757 females, 713 males). There were no exclusion criteria. Participants had a mean age of 14.1 years (SD 0.2), height of 1.64 m (SD 0.08), and weight of 57.7 kg (SD 13.2).

Outcome measures

Adolescents completed a series of questionnaires on a laptop at the assessment centre with the help of a research assistant. The questionnaires contained 130 multiple choice questions concerning a broad range of physical, medical, nutritional, psychosocial, and developmental issues and took about one hour to complete. Participants answered 'Yes' or 'No' to questions relevant to the prevalence of neck/shoulder pain: Have you ever had neck and shoulder pain? (life prevalence) Has your neck/shoulder been painful in the last month? (month prevalence) Is your neck/shoulder painful today? (point prevalence). The life prevalence question is very similar to that used by Chiu and Leung (2006), which was shown to be reliable.

Spinal posture (seven angles) during sitting was then measured from photographs. Retro-reflective markers were placed on the right outer canthus, right tragus, C7 and T12 spinous processes, anterior superior iliac spine, and greater trochanter. Participants were instructed to 'Sit with your hands half way up your thighs with the palms up, sit like normal and relax, look straight ahead.' Lateral photographs were taken with each participant sitting on a stool (adjusted to their popliteal height) during three different postures: a) looking straight ahead, b) looking down at their lap, and c) in a slumped position (Figure 1). The first two postures were chosen to represent common seated postures, with the last position included to allow calculation of difference between

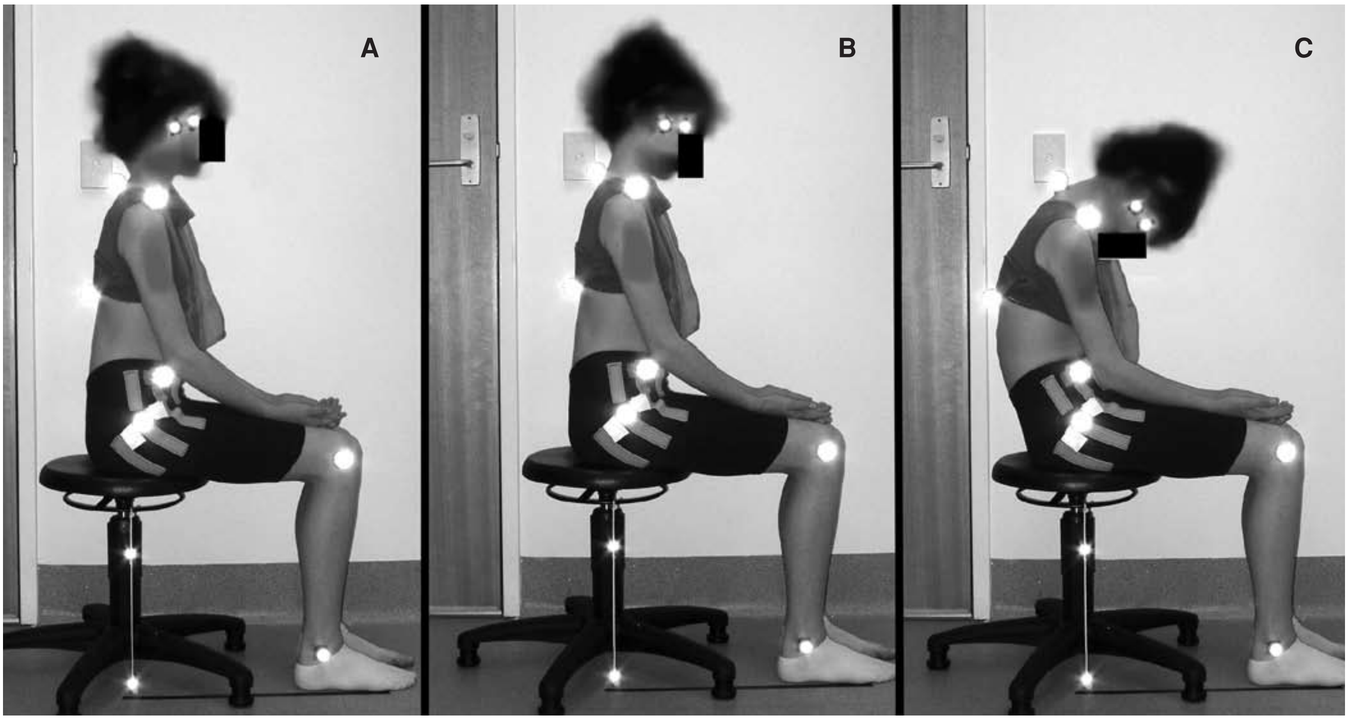

Figure 1. A participant in the three sitting postures: a) looking straight ahead, b) looking down, and c) slump sitting with retro-reflective markers on the right outer canthus, right tragus, C7 and T12 spinous processes, anterior superior iliac spine, and greater trochanter. The markers on the knee and ankle were not used in this study. The markers under the chair indicate vertical.

Table 1. Prevalence of neck/shoulder pain in participants.

Participants	Life			Month			Point		
	n with pain	n of participants	%	n with pain	n of participants	%	n with pain	n of participants	%
Female	406	781	52	271	780	35	37	780	5
Male	342	816	42	187	815	23	45	813	6
Total	748	1597	47	458	1955	29	82	1593	5

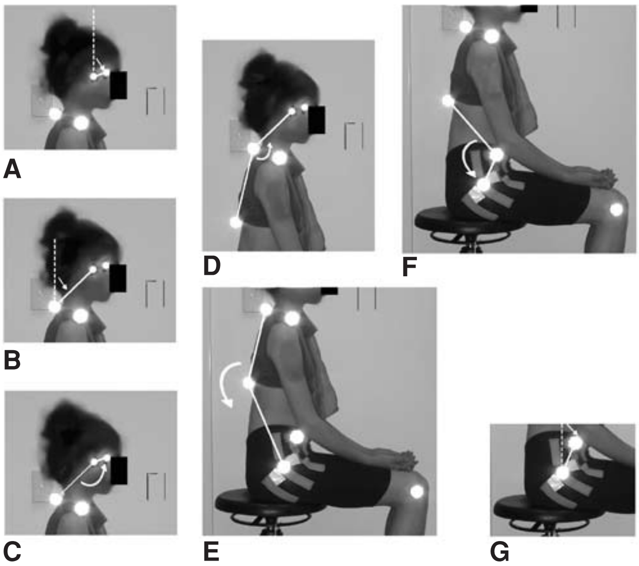

Figure 2. Illustration of the calculation of the angles defining spinal posture during sitting for: a) head flexion, b) neck flexion, c) craniocervical angle, d) cervicothoracic angle, e) trunk angle, f) lumbar angle, and g) pelvic tilt.

upright sitting and slump sitting. Marker points were digitised using the PEAK motion analysis system[a] and head flexion, neck flexion, craniocervical, craniothoracic, trunk, lumbar, and anterior pelvic tilt angles were calculated, as shown in Figure 2. This method has demonstrated reliability (Perry et al in press).

Data analysis

For all analyses, point and month prevalence rates were calculated as a percentage of the whole cohort. Descriptive statistics are presented for the life, month, and point prevalence of neck/shoulder pain. Chi-squared analysis was used to assess the difference between genders for prevalence. The effect of individual angles on neck/shoulder pain after controlling for gender differences was assessed using logistic regression models (entry method). Alpha probability level was set at $p < 0.05$ for all comparisons.

Results

Prevalence of neck/shoulder pain and gender

Life, month, and point prevalence rates for adolescent neck/shoulder pain were 47%, 29%, and 5% respectively. Life prevalence was about 10% higher ($p < 0.001$) in females than males, month prevalence was 12% higher ($p = < 0.001$), but point prevalence was similar ($p = 0.48$) for females and males (Table 1).

Spinal posture and gender

When adolescents were sitting looking straight ahead they had a mean head flexion of 71 degrees (SD 10), neck flexion of 52 degrees (SD 9), craniocervical angle of 161 degrees (SD 12), cervicothoracic angle of 149 degrees (SD 8), trunk angle of 232 degrees (SD 11), lumbar angle of 129 degrees (SD 18), and pelvic tilt angle of 5 degrees (SD 15).

There were differences in angles between males and females when sitting looking straight ahead, when sitting looking down, and in the change from looking straight ahead to slump sitting (Table 2). Gender differences were generally small around the head and neck, and larger in the trunk.

Life prevalence of neck/shoulder pain, spinal posture and gender

There were some small differences in trunk angle between adolescents who had ever had neck/shoulder pain and those with no experience of neck/shoulder pain when sitting looking straight ahead and looking down (Table 3). Seven separate logistic regressions examined the value of each angle when sitting looking straight ahead in predicting neck/shoulder pain ever, controlling for gender (Table 4). No angle predicted neck/shoulder pain ever after controlling for gender (range of adjusted OR 0.99 to 1.00, range of 95% CI 0.98 to 1.01). There were also no significant interactions between gender and any angle on neck/shoulder pain ever, as demonstrated in Figure 3.

Discussion

Prevalence of neck/shoulder pain and gender

This is the first study to document the life prevalence of neck/shoulder pain; it demonstrates clearly that neck/shoulder pain in Australian adolescents is common, and a potential source of present and future disability. Given that prior neck/shoulder pain is a strong risk factor for future neck/shoulder pain in adults (Croft et al 2001), this emphasises the importance of research into adolescent neck/shoulder pain to inform appropriate clinical management. Our study is also the first to measure point prevalence for adolescent neck/shoulder pain, which is close to that which we have observed for back pain in the same cohort. It suggests that in an average classroom, one or two children may have neck/shoulder pain on any day. The week prevalence for 14 year old Australians reported by Grimmer et al (2006) lies midway between our point and month prevalences.

The greater life and month prevalence of neck/shoulder pain in females is consistent with the literature on adolescent (Grimmer et al 2006, Niemi et al 1997, Vikat et al 2000) and adult (Croft et al 2001) neck/shoulder pain. This may partly result from a different pattern across genders for certain risk factors such as stress (Rudolph and Flynn 2007) or computer use (Straker et al 2007). Also, females usually

Table 2. Mean (SD) for male (n = 765) and female (n = 715) groups, and mean (95% CI) difference between groups for all angles.

Angle *(deg)*	Groups						Difference between groups		
	Looking straight ahead		Looking down		Change from looking ahead to slump		Looking straight ahead	Looking down	Change from looking ahead to slump
	M	F	M	F	M	F	F minus M	F minus M	F minus M
Head flexion	72 (10)	71 (9)	107 (14)	104 (13)	81 (17)	77 (20)	0 (–1 to 1)	–3 (–5 to –2)	–5 (–6 to –3)
Neck flexion	53 (9.9)	51 (7)	72 (12)	67 (9)	56 (13)	55 (15)	–2 (–3 to –1)	–4 (–5 to –3)	–2 (–3 to 0)
Craniocervical	162 (12)	160 (12)	144 (12)	143 (12)	25 (12)	22 (12)	–2 (–3 to 0)	–1 (–2 to 0)	–3 (–4 to –2)
Cervicothoracic	152 (8)	145 (7)	137 (10)	131 (8)	42 (11)	36 (13)	–7 (–8 to –6)	–6 (–6 to –5)	–7 (–8 to –5)
Trunk	238 (12)	226 (11)	241 (12)	228 (11)	15 (9)	22 (9)	–13 (–14 to –12)	–13 (–14 to –12)	7 (6 to 8)
Lumbar	134 (19)	124 (16)	135 (19)	124 (16)	6 (8)	12 (8)	–10 (–12 to –8)	–10 (–8 to –12)	6 (5 to 7)
Anterior pelvic tilt	0 (16)	9 (14)	0 (16)	9 (14)	5 (9)	11 (8)	9 (7 to 11)	9 (7 to 10)	6 (5 to 7)

M = males, F = females

Table 3. Mean (SD) for no pain (n = 788) and pain (n = 682) groups, and mean (95% CI) difference between groups for all angles.

Angle *(deg)*	Groups						Difference between groups		
	Looking straight ahead		Looking down		Change from looking ahead to slump		Looking straight ahead	Looking down	Change from looking ahead to slump
	No pain	Pain	No pain	Pain	No pain	Pain	Pain minus No pain	Pain minus No pain	Pain minus No pain
Head flexion	72 (10)	71 (10)	106 (13)	105 (14)	79 (19)	79 (19)	–1 (–2 to 0)	–1 (–3 to 0)	0 (–2 to 2)
Neck flexion	52 (8)	53 (9)	70 (11)	69 (10)	56 (14)	55 (15)	0 (–1 to 1)	–1 (–2 to 0)	0 (–2 to 1)
Craniocervical	161 (13)	161 (12)	143 (13)	144 (11)	23 (12)	24 (12)	0 (–1 to 2)	0 (–1 to 2)	1 (–1 to 2)
Cervicothoracic	150 (8)	148 (8)	134 (9)	134 (9)	39 (13)	39 (13)	–1 (–2 to 0)	–1 (–2 to 0)	0 (–2 to 2)
Trunk	233 (13)	231 (13)	235 (13)	233 (13)	18 (10)	16 (10)	–2 (–3 to –1)	–2 (–3 to –1)	1 (0 to 2)
Lumbar	130 (19)	129 (18)	130 (18)	129 (18)	9 (2)	10 (9)	–1 (–3 to 1)	–1 (–3 to 1)	1 (0 to 2)
Anterior pelvic tilt	4 (15)	6 (16)	4 (15)	5 (16)	7 (9)	8 (9)	2 (0 to 3)	2 (0 to 3)	1 (0 to 2)

M = males, F = females

Table 4. OR (95% CI) of angle predicting neck/shoulder pain ever adjusted for gender.

Angle *(deg)*	Looking straight ahead	Looking down	Looking down minus straight ahead
Head flexion	0.99 (0.98 to 1.00)	1.00 (0.99 to 1.00)	1.00 (0.99 to 1.01)
Neck flexion	1.00 (0.99 to 1.01)	1.00 (0.99 to 1.01)	1.00 (0.99 to 1.01)
Craniocervical	1.00 (1.00 to 1.01)	1.00 (1.00 to 1.01)	1.00 (0.99 to 1.02)
Cervicothoracic	0.99 (0.98 to 1.01)	1.00 (0.99 to 1.01)	1.00 (0.99 to 1.01)
Trunk	0.99 (0.98 to 1.00)	0.99 (0.99 to 1.01)	1.00 (0.98 to 1.01)
Lumbar	1.00 (0.99 to 1.00)	1.00 (0.99 to 1.00)	0.99 (0.98 to 1.01)
Anterior pelvic tilt	1.00 (1.00 to 1.01)	1.00 (1.00 to 1.01)	1.01 (0.99 to 1.02)

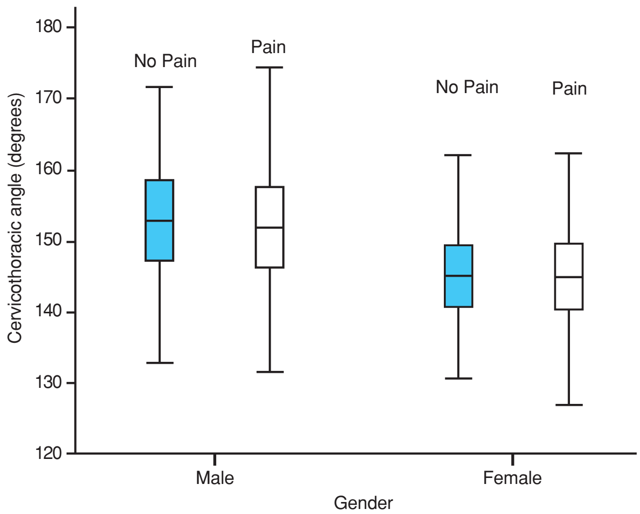

Figure 3. Median (IQR) cervicothoracic angle when looking straight ahead during sitting of male and female adolescents with and without neck/shoulder pain. The horizontal bar is the median, the lower boundary of the box is the 25th percentile, the upper boundary is the 75th percentile, and the error bars represent 1.5 interquartile ranges either side of the interquartile box.

reach puberty before males, so by the age of 14 they have undergone a longer period of rapid growth, which is a risk factor for spinal pain (Duggleby and Kumar 1997).

Spinal posture and gender

Differences in spinal posture between males and females during sitting ranged from 2 to 13 degrees. Only one other study (Briggs et al 2004) has documented habitual cervical posture in adolescents during sitting, observing head and neck flexion angles that were respectively 14 and 3 degrees higher than ours, in a group of 13–17 year olds. These differences may relate to their small sample size (n = 32) and to the posture assumed with eyes closed. Our study is the first to document thoracic, lumbar, and pelvic angles in adolescents during sitting, a position that is a possible risk factor for neck/shoulder pain in adolescents (Murphy et al 2004). Other studies have documented thoracic, lumbar, and pelvic angles in adolescents during standing (eg Mac-Thiong et al 2004, Poussa et al 2005), but comparison of values with this study is difficult as different definitions of angles were used.

In adults, there have been few studies of habitual cervical sitting postures (Grimmer 1996, Szeto et al 2002, Szeto et al 2005). Szeto et al (2002) observed neck flexion angles of around 55 degrees in symptomatic and asymptomatic adult females during relaxed sitting, which were similar to those seen in our study. Szeto et al (2005) observed head flexion angles of 67 degrees in asymptomatic female adults, which were also similar to those seen in this study, although the women were engaged in typing which limits comparison. Grimmer et al (1996) measured cervical posture with linear data, thus prohibiting comparison with our angular data. Hence there is only limited evidence to suggest that adult and adolescent sitting postures are similar, and further investigation is needed.

Gender differences in non-adult cervical habitual posture have previously been documented by Briggs et al (2004), who noted greater neck and head flexion in 4–17 year old girls than boys whilst sitting at rest. These results conflict with our findings of similar or less head flexion and less neck flexion in females than in males, and may also be due to their inclusion of younger children, sitting with eyes closed, or their small sample size.

This is the first study to document differences between genders in thoracic and lumbar sitting posture in adolescents. The greater tendency towards more erect sitting postures in adolescent females when looking straight ahead and looking down may have anatomical and/or behavioural roots, and further work is necessary to examine this. Given the more extended sitting posture of females, greater differences between looking straight ahead and slumped postures in females than males are to be expected. A recent adult study also showed females had greater lumbopelvic extension in sitting than males (O'Sullivan et al 2006), suggesting that the differences observed during adolescence in our study may be maintained at adulthood.

Life prevalence of neck/shoulder pain, spinal posture and gender

When males and females were analysed together, those with a history of neck/shoulder pain ever had a similar pattern of postures to the whole female group. Since females had a greater prevalence of neck/shoulder pain, this suggested that most of the differences in postures between neck/shoulder pain and non-neck/shoulder pain groups could be explained by gender. The analyses confirmed this as no posture associations remained after controlling for gender. These are the first precise reports of such associations between pain, posture, and gender in adolescents.

In adult studies assessing the association between habitual posture and neck/shoulder pain, Szeto et al (2002) noted a trend for an increase in head flexion in symptomatic females, and other studies have noted that the analogous posture of forward head posture is increased in neck/shoulder pain sufferers (Griegel-Morris et al 1992, Haughie et al 1995). However, with the exception of Szeto et al (2002), who used a female sample, these did not adjust for gender in their analyses and only Haughie et al (1995) measured sitting postures. Significant associations (Harrison et al 2004) and trends (Szeto et al 2002) for increased habitual neck flexion and adult neck/shoulder pain have also been observed, backed up by findings during office work tasks (Ariens et al 2001). However, it should be noted that Harrison et al (2004) did not adjust for gender in their analysis, and only Ariens et al (2001) measured posture in sitting. No adult studies have assessed the relationship between thoracolumbar spine postures and neck/shoulder pain, although Falla et al (2007) reported that different lumbopelvic postures altered patterns of muscle activation of the deep neck flexors.

Previous work on adolescent habitual posture has not considered the proximity of postures to the end of range. This may be an important consideration, because end of range lumbar spine postures in adults are associated with low back pain (O'Sullivan 2000). However in the current study, proximity of habitual posture to spinal end of range flexion (slump sitting) did not influence neck/shoulder pain after controlling for gender.

The lack of associations between neck/shoulder pain and posture after accounting for gender may have been due to a number of issues. It could be argued that using photographs to measure spinal posture in an institution may not reflect real ongoing posture. However, previous work in adult populations (Szeto et al 2005) has detected little change in cervicothoracic posture across time when typing, suggesting that habitual postures may be quite stable. Neck/shoulder pain is unlikely to be a single discrete condition, and different postural presentations may be linked with different subgroups of neck/shoulder pain. Such association may have been lost in the current analysis through a 'wash-out' effect as has been demonstrated in the lumbar spine (Dankaerts et al 2006). There was no accounting for pain intensity, level of disability, or neck/shoulder pain behaviour in these subjects which may have also influenced the results. Further, other gender-related factors including physical fitness (cardiovascular fitness, muscle performance, motor competence), activity patterns (information technology use, moderate and vigorous physical activity) and psychosocial factors (depression/anxiety, life stresses) may mediate or interact with posture and neck/shoulder pain, and thus require investigation.

What is clear from this study is that neck/shoulder pain is prevalent in adolescents, with females more at risk than males. Females and males posture themselves differently in sitting, with females displaying more lumbar lordosis and thoracic extension. However there is no clear linear relationship between neck/shoulder pain and sitting spinal posture. Clinicians should therefore be cautious when interpreting individual adolescent posture as a cause of neck/shoulder pain.

Footnotes: [a]PEAK Performance Technologies Inc, Centennial, CO, USA.

Ethics: The ethics committees of Curtin University of Technology and Princess Margaret Hospital approved this study.

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Statement regarding registration of clinical trials from the Editorial Board of *Australian Journal of Physiotherapy*

This journal now requires registration of clinical trials. All clinical trials submitted to *Australian Journal of Physiotherapy* must have been registered prospectively in a publicly-accessible trials register. We will accept any register that satisfies the International Committee of Medical Journal Editors requirements. Authors must provide the name and address of the register and the trial registration number on submission.