

# Perceived school bag load, duration of carriage, and method of transport to school are associated with spinal pain in adolescents: an observational study

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**Question:** Are use and perceived load of school bags and the prevalence of spinal pain different between male and female adolescents? Is use of school bags related to perceived load of school bags? Are use and perceived load of school bags related to spinal pain? **Design:** Cross-sectional observational study. **Participants:** 1202 adolescents recruited from the 'Raine' Cohort Study. **Outcome measures:** Use and perceived load of school bags as well as spinal pain were measured by questionnaire. **Results:** The prevalence of back and neck pain was approximately 50%; 53% of females reported neck pain compared with 44% of males ( $p < 0.01$ ). Almost half of participants carried their school bag for more than 30 minutes per day with 85% carrying their bag over both shoulders. School bags were felt to be heavy by 54% and to cause fatigue by 51%. Carrying a school bag for more than 30 minutes daily and taking an inactive form of transport to school (car or bus) increased the odds of having both back (OR 1.40, 95% CI 1.08 to 1.82) and neck pain (OR 1.47, 95% CI 1.13 to 1.91). **Conclusion:** Neck pain is as common as back pain amongst adolescents. Perceived school bag load, duration of carriage and method of transport to school are associated with back and neck pain. Physical activity in the form of walking or riding to school may offset the potentially provocative effects of prolonged bag carriage and warrants further investigation. [Haselgrove C, Straker L, Smith A, O'Sullivan P, Perry M, Sloan N (2008) Perceived school bag load, duration of carriage, and method of transport to school are associated with spinal pain in adolescents: an observational study. *Australian Journal of Physiotherapy* 54: 193–200]

**Key words:** Adolescent, Back pain, Neck pain

## Introduction

Spinal pain, defined as pain originating in the back and/or neck, is an important impairment amongst adolescents. The reported lifetime prevalence of spinal pain in adolescence varies between 32% and 64% (Goodgold et al 2002, Negrini 2000), and adolescent spinal pain has been linked to adult spinal pain (Harreby et al 1995). It is therefore important to ascertain risk factors in this age group in order to reduce the burden of spinal pain on both adolescents and adults. School bags have long been thought to be associated with back and neck pain in adolescents (Malhoutra and Sen Gupta 1965), and clinicians are frequently asked for advice on school bag carriage and its contribution to back and neck pain (Wigram 2002). The focus to date has been on the effects of school bag weight on back pain, and evidence suggests that carrying a school bag weighing more than 15% of body weight increases the risk of back pain (Brackley and Stevenson 2004). Current recommendations for school bag carriage are mainly concerned with reducing bag weight and optimising bag design in order to minimise postural changes when carrying a school bag (Australian Physiotherapy Association 2006). However, other factors including duration of school bag carriage and perception of school bag load may also be important.

Total school bag use (in terms of physical exposure) is determined not only by the weight of the bag but also by

the duration and method of carriage. However, there has been little research into the latter two factors. A longer duration of carrying a school bag may increase the risk of adolescent back pain, but this has been shown in only one study (Grimmer and Williams 2000), and to date no studies have investigated whether duration of school bag carriage is associated with adolescent neck pain. Furthermore, significant postural changes can occur when carrying a bag over one shoulder (Korovessis et al 2005, Negrini and Carabalona 2002) and postural deviations have been shown to be associated with spinal pain (Adams and Dolan 2005). Hence, carrying a bag over one shoulder has been hypothesised to contribute to back and neck pain, but there is little direct evidence to support this theory (Siambanes et al 2004, van Gent et al 2003, Watson et al 2003). In addition, the method of transport to school (either actively walking and cycling or passively going by car or bus) may also contribute to back and neck pain. Previous studies have found that students who actively walked to and from school reported lower rates of low back pain than students who were passively transported to school (Balague et al 1995, Sjolie 2003, Szpalski et al 2002). However this finding has been contradicted by Siambanes et al (2004) and Viry et al (1999) who found that an active journey to school was associated with a higher prevalence of back pain. This conflicting evidence may be due to factors such as duration of school bag carriage and school bag weight interacting

**Table 1.** Number (%) of participants for use and perceived load of school bag by gender.

Use and perceived load of school bag	Males	Females	Total
<b>Use of school bag</b>			
Duration of carriage ( <i>min</i> )	(n = 611)	(n = 584)	(n = 1195)
< 5	33 (5)	33 (6)	66 (6)
5 to 10	76 (12)	75 (13)	151 (13)
10 to 15	73 (12)	93 (16)	166 (14)
15 to 30	116 (19)	123 (21)	239 (20)
> 30	313 (51)	260 (45)	573 (48)
Method of carriage	(n = 605)	(n = 581)	(n = 1186)
Both shoulders	550 (91)	460 (79)	1010 (85)
One shoulder	55 (9)	121 (21)	176 (15)
Time taken to school ( <i>min</i> )	(n = 611)	(n = 585)	(n = 1196)
< 5	69 (11)	65 (11)	134 (11)
5 to 10	125 (21)	134 (23)	259 (22)
10 to 15	194 (32)	160 (27)	354 (30)
15 to 30	148 (24)	129 (22)	277 (23)
> 30	72 (12)	97 (17)	172 (14)
Method of transport to school	(n = 610)	(n = 584)	(n = 1194)
Car	220 (36)	262 (45)	482 (40)
Bus	195 (32)	185 (32)	379 (32)
Bike	86 (14)	12 (2)	98 (8)
Walk	109 (18)	126 (22)	235 (20)
<b>Perceived load of school bag</b>			
Feeling school bag heavy	(n = 611)	(n = 585)	(n = 1196)
Never	216 (35)	110 (19)	326 (27)
Almost never	123 (20)	104 (18)	227 (19)
Sometimes	187 (31)	216 (37)	403 (34)
Often	72 (12)	112 (19)	184 (15)
Always	13 (2)	43 (7)	56 (5)
Feeling fatigue during carriage	(n = 611)	(n = 585)	(n = 1196)
Never	208 (34)	118 (20)	326 (27)
Almost never	142 (23)	118 (20)	260 (22)
Sometimes	168 (28)	200 (34)	368 (31)
Often	66 (11)	118 (20)	184 (15)
Always	27 (4)	31 (5)	58 (5)

with factors such as time taken and method of transport to school in influencing back and neck pain.

Perception of school bag load may provide a useful general measure of load as perception will take into account personal characteristics such as strength and endurance. Reporting the school bag to be heavy or fatiguing may indicate poor trunk muscle endurance and control which are known risk factors for back pain (Negrini and Carabalona 2002). Decreased trunk muscle strength has been associated with back pain in adolescents (Salminen et al 1992), indicating these personal factors are related to the development or continuation of spinal pain. However the relationship between perceived school bag load and back and neck pain is not yet known.

The aim of this study was to determine the association between spinal pain and use and perceived load of school bag, and to see if there was any variation between the genders. The research questions were:

1. Are use and perceived load of school bags and the prevalence of spinal pain different between male and female adolescents?
2. Are use of school bags (ie, duration of carriage, method of carriage, time taken to get to school, and method of transport to school) related to perceived load of school bags (ie, perceived weight and perceived fatigue)?
3. Are use and perceived load of school bags related to spinal pain?

## Method

### Design

A cross-sectional epidemiological survey was conducted. Participants were recruited from the Western Australian Pregnancy Cohort 'Raine' Study. At around the time of the adolescents' 14<sup>th</sup> birthday, eligible cohort families were contacted and invited to participate. Families agreeing to

**Table 2.** Number (%) of participants with spinal pain by gender.

Spinal pain	Males	Females	Total
Back pain ever	(n = 605)	(n = 581)	(n = 1186)
No	338 (56)	285 (49)	623 (53)
Yes	267 (44)	296 (51)	563 (47)
Back pain carrying school bag	(n = 610)	(n = 585)	(n = 1195)
Never	330 (54)	226 (39)	556(47)
Almost never	141 (23)	165 (28)	306 (26)
Sometimes	103 (17)	137 (23)	240 (20)
Often	29 (5)	48 (8)	77 (6)
Always	7 (1)	9 (2)	16 (1)
Neck pain ever	(n = 606)	(n = 584)	(n = 1190)
No	341 (56)	272 (47)	613 (51)
Yes	265 (44)	312 (53)	577 (49)
Neck pain carrying school bag	(n = 611)	(n = 585)	(n = 1196)
Never	300 (49)	179 (31)	479 (40)
Almost never	154 (25)	159 (27)	313 (26)
Sometimes	113 (18)	173 (30)	286 (24)
Often	34 (6)	64 (11)	98 (8)
Always	10 (2)	10 (2)	20 (2)

participate were sent consent forms and an appointment time was arranged to complete a questionnaire about the use of school bags, the perceived load of school bags, and spinal pain (see eAddenda for Appendix 1).

**Participants**

The adolescents in the Raine study are part of a long term project aimed at collecting data on a wide range of health and developmental issues in childhood and adolescence. The Raine study began as a pregnancy cohort of women attending antenatal clinics at King Edward Memorial Hospital in Perth between 1989 and 1991. All members of the cohort were invited to participate in this 14 year follow up study. No exclusion criteria applied to the participants in this study.

**Outcome measures**

Use and perceived load of school bags as well as spinal pain was measured with a questionnaire which participants completed on a laptop with the help of a research assistant. They were given as much time as needed to complete all questions. The questionnaire contained 130 multiple choice questions concerning a broad range of physical, medical, nutritional, psychosocial, and developmental issues. Only those questions pertaining to the use of school bags and spinal pain prevalence are reported here. Questions investigating the use of school bags were taken from a previously validated questionnaire (Negrini et al 2002) and covered duration of carriage, method of carriage, time taken to get to school, and method of transport to school as well as perceptions of the load (perceived weight and perceived fatigue). The questionnaire was modified slightly to exclude ‘a moped’ and include ‘bag on wheels’ to reflect the Australian context. Back and neck pain were evaluated in terms of lifetime prevalence (in categories of Yes or No) and pain felt during bag carriage (in categories of Never, Almost never, Sometimes/Once a month, Often/Once a week, or Always/Every day). The questions regarding the lifetime prevalence of back and neck pain were based on a questionnaire used in previous research, which has acceptable reliability and validity (Fairbank et al 1984, Jones and Hitchen 2000).

**Data analysis**

Descriptive statistics were used to examine the use and perceived load of school bags and the prevalence of spinal pain, both for the whole sample and male and female subgroups. Relationships between the use and perceived load of school bags were examined using Spearman’s correlation for ordinal variables and chi-square tests for nominal variables. The chi-square test was then used to evaluate the associations between use and perceived load of school bags and spinal pain. Those variables with a significant association to spinal pain in this univariate analysis were then included in a multivariate model. Logistic regression was used to determine which variables had an independent effect on spinal pain. Before the logistic regression, variables included in the model were dichotomised so that ‘Never or Almost never’ was considered ‘No’ and ‘Sometimes, Often or Always’ was considered ‘Yes’. Results were considered significant when the alpha probability was less than 0.05.

**Table 3.** Relationship within and between use of school bag and perceived load of school bag.

	Duration of carriage	Method of carriage	Time taken to school	Method of transport to school	Perceived weight
Method of carriage	$\chi^2 = 18.6$ $p = 0.001$				
Time taken to school	$\rho = 0.13$ $p < 0.001$	$\chi^2 = 2.9$ $p = 0.58$			
Method of transport to school	$\chi^2 = 118.5$ $p < 0.001$	$\chi^2 = 23.1$ $p < 0.001$	$\chi^2 = 351.9$ $p < 0.001$		
Perceived weight	$\rho = -0.18$ $p = 0.45$	$\chi^2 = 3.6$ $p = 0.55$	$\rho = 0.06$ $p = 0.02$	$\chi^2 = 19.1$ $p = 0.09$	
Perceived fatigue	$\rho = 0.09$ $p < 0.001$	$\chi^2 = 3.8$ $p = 0.44$	$\rho = 0.09$ $p < 0.001$	$\chi^2 = 21.6$ $p = 0.04$	$\rho = 0.46$ $p < 0.001$

Table 4. Relationship between use and perceived load of school bag and % participants with spinal pain from univariate ( $\chi^2$ ) analysis.

Use and perceived load of school bag	Spinal pain			
	Back pain ever	Back pain carrying school bag	Neck pain ever	Neck pain carrying school bag
<b>Use of school bag</b>				
Duration of carriage ( <i>min</i> )				
< 5	49	24	41	26
5 to 10	39	20	40	25
10 to 15	45	25	48	34
15 to 30	48	29	48	35
> 30	50	31	52	37
Significance	$p = 0.18$	$p = 0.07$	$p = 0.08$	$p = 0.04$
Method of carriage				
Both shoulders	47	28	49	33
One shoulder	48	26	46	40
Significance	$p = 0.87$	$p = 0.60$	$p = 0.42$	$p = 0.07$
Time taken to school ( <i>min</i> )				
< 5	43	20	43	31
5 to 10	43	26	50	34
10 to 15	47	25	49	33
15 to 30	51	33	49	37
> 30	52	34	50	31
Significance	$p = 0.16$	$p = 0.01$	$p = 0.79$	$p = 0.69$
Method of transport to school				
Car	46	27	48	35
Bus	52	30	51	32
Bike	43	27	42	28
Walk	45	27	49	37
Significance	$p = 0.16$	$p = 0.83$	$p = 0.40$	$p = 0.32$
Duration/transport				
Low duration/any transport	45	25	45	31
High duration/passive transport	53	32	55	37
High duration/active transport	44	29	47	37
Significance	$p = 0.02$	$p = 0.08$	$p = 0.01$	$p = 0.14$
<b>Perceived load of school bag</b>				
Feeling school bag heavy				
No	41	11	45	18
Yes	53	42	51	48
Significance	$p < 0.001$	$p < 0.001$	$p = 0.04$	$p < 0.001$
Feeling fatigue during carriage				
No	43	11	41	18
Yes	52	44	56	49
Significance	$p = 0.01$	$p < 0.001$	$p < 0.001$	$p < 0.001$

## Results

### Flow of 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. Although 357 (12%) agreed to participate they did not complete any assessment, with 1860 (65%) providing some data. Data collection commenced on 7 May 2003, with

questions about the use and perceived load of school bags added on 7 June 2004, and were completed by 4 May 2006. Spinal pain data were available for 1608 adolescents (73% of those eligible). A total of 1202 adolescents (615 males and 587 females) completed the questions about school bags. The mean age of the adolescents in this analysis was 14.1 (0.2) years. Small variations in the numbers reported for different analyses are the result of some participants not answering all questions.

**Table 5.** OR (95% CI) of relationship between use and perceived load of school bag and spinal pain by gender from multivariate logistic regression analysis.

Spinal pain	Use and perceived load of school bag	Males	Females
Back pain ever	Feeling school bag heavy	1.5 (1.1 to 2.1)	1.7 (1.1 to 2.5)
	Feeling fatigue during carriage	1.2 (0.8 to 1.7)	1.0 (0.7 to 1.5)
	Low duration/any transport	0.7 (0.5 to 1.0)	0.7 (0.5 to 1.0)
	High duration/active transport	0.7 (0.5 to 1.2)	0.7 (0.4 to 1.2)
Back pain carrying school bag	Feeling school bag heavy	3.3 (2.1 to 5.1)	4.0 (2.4 to 6.6)
	Feeling fatigue during carriage	4.2 (2.7 to 6.5)	4.0 (2.5 to 6.4)
	Low duration/any transport	0.8 (0.5 to 1.3)	0.8 (0.5 to 1.3)
	High duration/active transport	0.9 (0.5 to 1.6)	1.2 (0.6 to 2.2)
Neck pain ever	Feeling school bag heavy	0.7 (0.5 to 1.0)	1.5 (1.0 to 2.1)
	Feeling fatigue during carriage	2.1 (1.4 to 2.9)	1.3 (0.9 to 1.92)
	Low duration/any transport	0.8 (0.4 to 2.9)	0.6 (0.4 to 0.9)
	High duration/active transport	0.8 (0.5 to 1.3)	0.8 (0.5 to 1.3)
Neck pain carrying school bag	Feeling school bag heavy	2.8 (1.9 to 4.3)	2.7 (1.8 to 4.1)
	Feeling fatigue during carriage	2.8 (1.9 to 4.3)	3.2 (2.1 to 4.9)
	Low duration/any transport	0.7 (0.5 to 1.1)	1.0 (0.7 to 1.5)
	High duration/active transport	0.7 (0.4 to 1.3)	2.4 (1.3 to 4.3)

### Use and perceived load of school bags and prevalence of spinal pain by gender

The use and perceived load of school bags are reported in Table 1. Almost 50% of adolescents reported carrying their school bag for more than 30 minutes daily. Over 85% of adolescents reported carrying their school bag over both shoulders. More females than males carried their school bag over one shoulder (OR 2.63, 95% CI 1.87 to 3.70). Most adolescents (75%) took between 5 and 30 minutes to get to school. The most common methods of transport to school were car and bus (72%). More males than females cycled to school (OR 8.28, 95% CI 4.30 to 15.97). Over half of the adolescents reported their school bag felt heavy whilst carrying it at least sometimes and reported feeling fatigued at least sometimes whilst carrying their school bag. More females than males perceived their school bag to be heavy (OR 2.16, 95% CI 1.71 to 2.73) or felt fatigued whilst carrying it (OR 1.98, 95% CI 1.58 to 2.50).

The prevalence of spinal pain is reported in Table 2. Approximately half of the adolescents reported a history of back or neck pain ever or specifically when carrying school bags. Females had a higher prevalence than males for all measures of spinal pain (OR 1.32 to 2.11, 95% CI ranges from 1.05 to 1.66, to 1.66 to 2.70). Around a third of adolescents reported back pain (27%) or neck pain (34%) sometimes, often, or always when carrying school bags.

### Relationship within and between use of school bags and perceived load of school bags

The relationship between use of school bags and perceived load of school bags is presented in Table 3. Due to the large number of adolescents reporting high durations of school bag carriage (more than 30 minutes daily), a new variable

was created to further subdivide this group. Duration of bag use was related both to time taken to get to school and to method of transport to school. When comparing duration of bag carriage with time taken to get to school and subdividing results by method of transport to school, only the cycling and walking subgroups displayed a significant relationship. From this it was inferred that those adolescents cycling or walking to school carried their bags during the journey. Thus, a new variable was created using method of transport to subdivide the duration of carriage variable. This new variable, termed 'duration/transport', consisted of 3 categories:

- Low duration (< 30 minutes daily)/any transport
- High duration (> 30 minutes daily)/passive transport (car or bus)
- High duration (> 30 minutes daily)/active transport (bike or walk)

High perceived fatigue was related to high duration/passive transport ( $\chi^2 = 14.0$ ,  $p = 0.001$ ) but high perceived weight was not ( $\chi^2 = 2.3$ ,  $p = 0.32$ ).

### Relationship between use and/or perceived load of school bags and spinal pain

When treated separately, the relationship between school bag use and/or perceived school bag load and spinal pain as a result of univariate analysis are presented in Table 4.

**School bag use:** There was a U-shaped trend evident between duration of bag use and back pain, with adolescents carrying their bag for 5 to 10 minutes daily reporting less back pain than their peers. However, when genders were analysed separately only males demonstrated a statistically significant relationship ( $p = 0.04$ ). There was a linear trend

noted between duration of bag use and neck pain. When genders were analysed separately only females exhibited a significant linear association between duration of bag use and neck pain ( $p = 0.03$ ). Time taken to get to school appeared to have a weak linear relationship with back pain felt whilst carrying a school bag. Time taken to get to school was not associated with neck pain. Neither method of transport to school nor method of bag carriage were associated with back or neck pain.

**Duration/transport:** Duration/transport displayed an inverse U-shaped trend with the lifetime prevalence of both back and neck pain. Adolescents in the high duration/passive transport category reported higher rates of back and neck pain than those adolescents in the low duration/any transport or high duration/active transport categories. This was true for both males and females. There was a similar U-shaped trend between duration/transport and back pain felt whilst carrying a bag, but no strong association noted between duration/transport and neck pain whilst carrying a bag. When analysed separately males displayed a similar inverse U-shape trend between duration/transport and back and neck pain felt whilst carrying a school bag ( $p = 0.10$  and  $p = 0.04$  respectively). However females exhibited a linear relationship between duration/transport and back or neck pain felt whilst carrying a school bag ( $p = 0.36$  and  $p = 0.02$  respectively). Females in the high duration/active transport category reported a higher prevalence of back and neck pain specific to bag carriage than those females with a lower daily school bag load exposure. Amongst females in the high duration/active transport group there was no difference in spinal pain prevalence rates between those who walked to school and those who rode to school, excluding method of transport to school as an explanation for the increase in bag specific neck pain in this group.

**Perceived load:** Perceived load, in terms of both weight and fatigue, was strongly associated with both back and neck pain. Adolescents reporting their bag to be heavy or fatiguing also reported higher levels of back and neck pain, particularly pain felt during bag carriage.

The significant factors from the univariate analysis (perceived load and duration/transport) were then fed into a multivariate analysis and the results of their relationship with spinal pain are presented in Table 5. Due to the differing relationships between males and females with regard to duration/transport and spinal pain, separate analyses for males and females were conducted. Perceived weight and perceived fatigue remained significantly associated with both back and neck pain for both genders. Amongst males, duration/transport alone (after adjusting for perceived weight and perceived fatigue) was not independently associated with spinal pain, although the direction was towards an inverse U-shape relationship. Amongst females a similar inverse U-shape relationship was evident between duration/transport and the lifetime prevalence of back and neck pain. However females in the high duration/active transport category were at a greater risk of suffering from back and neck pain felt whilst carrying their school bag. Within the whole group, the multivariate models had Nagelkerke's  $R^2$  of 0.03 and 0.04 for back pain and neck pain respectively and 0.26 and 0.21 for back and neck pain whilst carrying a bag.

## Discussion

Our study found that 85% of adolescents reported carrying

their bag over both shoulders, consistent with recent findings (Goodgold et al 2002, Grimmer and Williams 2000, Negrini and Carabalona 2002, Sheir-Neiss et al 2003, Viry et al 1999, Wall et al 2003, Whittfield et al 2001). Research conducted in the 1980s generally found carrying a school bag over one shoulder was most common amongst adolescents. This change in preferred carrying method may be due to a combination of education, changing fashion trends, and the design of more comfortable two strap backpacks.

Neck pain was equally as prevalent as back pain amongst our sample, indicating this is a substantial problem amongst adolescents. Our results are consistent with prevalence of neck pain previously reported amongst 14 year olds (Negrini and Carabalona 2002, van Gent et al 2003). To date, neck pain in adolescents has been largely overlooked, but the high prevalence found in our population suggests it should be considered in future research.

The cause of the higher prevalence of spinal pain amongst females is unknown. Research has found that females have a lower pain tolerance and lower pain thresholds (Berkley 1997), which may partially account for the increased self-report prevalence rates. Additionally females have weaker upper body strength compared to males (Miller et al 1993, Lindle et al 1997). This, coupled with the changing anthropometric features that occur with puberty amongst female adolescents, may increase their risk of spinal pain.

Perceived weight and perceived fatigue were found to be the strongest identifiers of spinal pain. Prior findings have been inconsistent. A study by Negrini and Carabalona (2002) found that perceived fatigue was positively associated with back pain amongst young adolescents but perceived weight was not. However in a similar study of 745 adolescents aged 12–14 years, the reporting of severe back or neck complaints was higher amongst students who perceived their bag to be heavy (van Gent et al 2003). Perceiving the school bag to be heavy or fatiguing may be due to neurophysiological factors (such as lower pressure pain thresholds) or physical factors (such as poor muscular control and endurance). Indeed, it has been shown that perceived fatigue is highly correlated with objective signs of muscular fatigue in the spine (Kankaanpaa et al 1997), which may be related to the development of spinal pain. However, due to the cross sectional nature of our study, it cannot be determined if these factors are causes of spinal pain. Indeed, the relationship may be in the other direction with pre-existing spinal pain resulting in increased tissue sensitivity with the consequent perception that the bag is heavy, fatiguing and painful.

Previously it has been thought that high levels of spinal loading, such as that induced by prolonged bag carriage, increase the risk of spinal pain. Indeed, research has shown that high daily duration of carriage is associated with back pain in adolescents (Chiang et al 2006, Grimmer and Williams 2000, Negrini and Carabalona 2002, Sheir-Neiss et al 2003). However, our study found that physical activity whilst carrying a school bag (in the form of walking or riding to school) appeared to offset prolonged exposure as a factor identifying spinal pain. Regular activity involving loading of the spine may improve trunk musculature strength, endurance and tissue tolerance for load. Studies have shown that higher levels of physical activity are associated with greater trunk muscle strength in adolescents (Newcomer et al 1997, Salminen et al 1993), resulting in improved muscular support during sustained spinal loading. This may in turn reduce the risk of load-induced spinal injury and consequent

pain, as it has been found that weak back extensors play a role in the development of spinal pain in adolescents (Bo Anderson et al 2006, Lee et al 1999, Sjolie and Ljunggren 2001). The higher prevalence of perceived fatigue during bag carriage amongst adolescents in the high duration/passive transport category suggests that these adolescents had poor muscular endurance compared to their peers in the high duration/active transport category. However, although duration/transport was related to spinal pain on univariate analysis, the relationship lost significance on multivariate analysis amongst males probably because the relationship between perceived fatigue and duration/transport subsumed the individual effects of duration/transport on spinal pain.

The exception to this apparent protective effect of active transport was the increased risk of neck pain during bag carriage noted amongst females in the high duration/active transport category. A larger percentage of females walked to school compared to males, but *post hoc* analysis excluded walking to school as the cause of this gender difference. Other features of school bag use not covered in this study, such as bag weight and bag design, may differ between males and females and influence the ability to sustain spinal loading for long periods which may be linked to differences in tissue sensitivity and pressure pain thresholds. Alternatively it may relate to underlying gender differences in muscle strength since females are known to be weaker in the upper body than males (Miller et al 1993, Lindle et al 1997), which may predispose them to being at a greater risk of spinal pain when carrying loads on the spine for long periods.

One limitation of this study was the reliance on self-report for measuring the prevalence of spinal pain. The lifetime prevalence reported here may be an underestimate, since more adolescents reported back or neck pain during bag carriage than back or neck pain ever before. It may be that the bag-specific pain questions triggered memories of otherwise forgotten episodes of spinal pain suggesting that trigger questions should be included in future studies in order to gain a more accurate measure of prevalence of spinal pain in adolescents. This higher bag-specific prevalence also suggests that spinal discomfort linked to school back carriage is a unique phenomenon that may not transfer to other activities of daily living. A further limitation was that actual bag weight was not measured. Gaining an accurate measure of daily bag weight is difficult, as it has been shown that an average over five days is needed to get an accurate assessment (Negrini et al 2002). Additionally there is already good evidence supporting the theory that school bag weight is associated with back and neck pain. For these reasons bag weight was not assessed and perceived weight was used as a measure of bag load. Perceived weight may be a more useful measure than actual bag weight as it takes into account the impact of the load on the adolescent.

The findings from this study indicate that multiple factors of school bag carriage are associated with both back and neck pain. Although previous literature has focused on low back pain, future research should also focus on neck pain as we found this to be equally prevalent amongst adolescents. Pain or discomfort during school bag carriage is common, and society often perceives this to be due to excessive load. However duration of bag use was only weakly associated with back and neck pain, and the strong relationship between perceived load and spinal pain suggests there is a need to consider other factors such as muscular endurance

and neurophysiological factors and the interrelationship between these personal factors and school bag carriage. Physical activity in the form of walking or riding to school may offset the potentially provocative effects of prolonged bag carriage, but this relationship needs to be investigated further before any conclusive recommendations can be made.

**eAddenda:** Appendix 1 available at [www.physiotherapy.asn.au/AJP](http://www.physiotherapy.asn.au/AJP)

**Ethics:** The Human Research Ethics Committees at Curtin University and Princess Margaret Hospital approved this study. Informed consent was obtained from all participants' families, and Subject ID codes were used throughout to protect participant anonymity.

**Competing interests:** None declared.

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