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# Schoolbag carriage: design, adjustment, carriage duration and weight.

A thesis presented in  
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**Hamish William Mackie**

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## Abstract

There is anecdotal and scientific evidence to suggest that schoolbag carriage is associated with musculoskeletal discomfort (MSD) and possibly long-term back pain. Thus schoolbag carriage is an area of concern for students, parents and both education and health professionals. A schoolbag weight limit of 10% of body weight (BW) is currently recommended. However, it is based on subjective observations rather than objective findings and does not consider other aspects of schoolbag carriage such as schoolbag design and adjustment or carriage patterns. Five studies were conducted in order to determine the effects on students' responses to schoolbag carriage of schoolbag design, adjustment, carriage duration and weight. Backpack design had a significant effect on reported musculoskeletal discomfort and choice of backpack. Schoolbag hip-belt and shoulder strap adjustment and weight significantly affected shoulder strap tension forces and shoulder interface pressure in simulated schoolbag carriage. Using activity monitoring, school students were found to spend approximately two hours carrying their schoolbags each day. This usually comprised 11-15 times per day of 8-9 minutes of carriage. Using this temporal pattern information, 16 boys (13-14 years) were exposed to a simulated school day using schoolbags weighing 0, 5, 10, 12.5 and 15% BW and an additional condition of 10% BW with tighter shoulder straps. Posture, rating of perceived exertion (RPE), muscular strain and reported ability to walk and balance were significantly affected when schoolbag load reached 10% BW. However, despite these findings, the magnitude of self reported muscular strain and MSD suggested that 15% BW may be too heavy for school students. Thus, 10% BW may be an appropriate upper schoolbag weight limit for a typical school day. Using a psychophysical approach the mean (standard deviation) maximum acceptable schoolbag weight (MASW) selected by 16 school boys (13-14 years) was 10.4(3.8) %BW. This finding agrees with the findings of the previous study and supports the current schoolbag weight recommendation of 10% BW. The results of the five studies can be used in developing schoolbag carrying guidelines to help reduce the prevalence of MSD amongst school students.

# Acknowledgements

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## List of publications from thesis

- Mackie, H. W., Legg, S. J., Beadle, J. and Hedderly, D. I. (2003). Comparison of four different backpacks intended for school use. *Applied Ergonomics*, 34, 257-264.
- Mackie, H. W., Legg, S. J. and Beadle, J. (2003). Development of activity monitoring for determining load carriage patterns in school students. *Work: A Journal of Prevention, Assessment, & Rehabilitation*, 22, 231-237.
- Mackie, H. W., Stevenson, J. M., Reid, S. A. and Legg, S. J. (2004). The effect of simulated school load carriage configurations on shoulder strap tension forces and shoulder interface pressure. *Applied Ergonomics*, 36, 199-206.
- Mackie, H. W. and Legg, S. J. (2004). Measurement of the temporal patterns of schoolbag carriage using activity monitoring and structured interview. *Ergonomics*, In Press.
- Mackie, H. W. and Legg, S. J. (2004). Postural and subjective responses to realistic schoolbag carriage. *Submitted to Ergonomics*.
- Mackie, H. W., Legg, S. J. and Walt, S. E. (2004). A psychophysical approach to determining an upper schoolbag weight. *Submitted to Applied Ergonomics*.
- Mackie, H. W., Stevenson, J. M., Reid, S. A. and Legg, S. J. (2003). Responses to schoolbag carriage. Proceedings of the XVth Triennial Congress of the International Ergonomics Association. Aug 24<sup>th</sup>-29<sup>th</sup>, Seoul, South Korea.

# Thesis structure

This thesis comprises five studies addressing the effects of schoolbag design, adjustment, carriage duration and weight on students' responses to schoolbag carriage. Each study forms an individual chapter of the thesis (chapters 2-6). These five chapters are preceded by an introduction to the thesis topic and chapter 1, which is a review of literature. This builds a rationale for the thesis aim.

Each study (chapters 2-6) is preceded by a preface. This describes the relevance of each study to the rest of the thesis. All of the studies have been published as papers in, accepted for publication in, or submitted to a journal of international scope and quality. The style of each of these chapters is in the style of the journal to which the paper has been submitted, except for heading formats. Each study is reproduced in its entirety except for the tables and figures, which have been embedded in the text and the table and figure legends which are located as a list for the whole thesis after the table of contents and list of appendices for the thesis. In some cases, 'In press' references have since been published. In these cases the most recent version of the reference is included in the main reference list for the thesis. A discussion (chapter 7) links the findings of each of the studies to create the overall thesis findings and conclusions. A post-script follows chapters 2, 3 and 4, providing additional information that would not be considered necessary for a journal article, but is necessary to provide the required depth of a thesis. Also, in some cases examiners comments are addressed in the post-scripts.

Following the thesis conclusions and references, the appendices for each study are included. Additional information that was not included within each submitted study, including summarised or raw data, is supplied. All summarised and raw data are supplied on a CD that is attached to the inside back cover of this thesis. Included in the appendices to chapter 4 is a methodological study that has been quality assured and published in a journal.

# Contents

<b>Abstract</b>	ii
<b>Acknowledgements</b>	iii
<b>List of publications from thesis</b>	iv
<b>Thesis structure</b>	v
<b>Contents</b>	vi
<b>Appendices</b>	x
<b>Tables and figures</b>	xii
<b><i>Introduction.....</i></b>	<b>1</b>
<b>Chapter 1</b>	
<b><i>Review of literature.....</i></b>	<b>3</b>
Introduction	3
1. Manual handling guidelines	5
Schoolbag carriage guidelines	10
2. Adult load carriage	12
Introduction	12
Backpack weight, distance carried and walking speed	16
Backpack adjustment	19
Backpack design	21
3. The physical capabilities of school children	25
4. School bag carriage and reported MSD	27
Studies that failed to demonstrate an association between schoolbag weight and reported MSD	29
Studies that demonstrate a positive association between schoolbag weight and MSD	32
5. Student responses to Schoolbag carriage	34
Conclusion	40
Thesis aim	41
Specific studies	41
<b>Chapter 2</b>	
<b><i>Schoolbag design.....</i></b>	<b>43</b>
Preface	43
Comparison of four different backpacks intended for school use	44
Abstract	44
Introduction	45
Methods	46
Participants	47
Questionnaire and data collection protocol	47
Results	49
Initial assessment	50
Attributes reported as being important in a backpack	50
Initially chosen backpack	50
Positive attributes of initially chosen backpack	50
Chosen backpack after initial inspection	50

<i>Positive attributes of favoured backpack after inspection of each backpack</i>	51
<i>Negative attributes of backpacks not favoured after inspection of each backpack</i>	51
<i>Practicality</i>	52
Pre-walk	52
<i>Ease of adjustment</i>	52
<i>Initial comfort while standing</i>	52
Post Treadmill Assessment	53
<i>Rating of perceived exertion</i>	53
<i>Strain on shoulders</i>	53
<i>Strain on the Back</i>	54
<i>Strain in Upper Legs</i>	54
<i>Strain in Lower Legs</i>	54
<i>Pressure on shoulders</i>	54
<i>Pressure on waist</i>	54
<i>Balance</i>	55
<i>Ease of walking</i>	55
<i>Reported musculoskeletal discomfort</i>	55
<i>Overall most preferred backpack</i>	55
<i>Positive attributes of each backpack after 20 minute walk</i>	55
<i>Negative attributes of each backpack after 20 minute walk</i>	56
<i>Reasons for choosing overall preferred backpack</i>	56
Discussion	59
Acknowledgement	61
References	62
Post-script	65
<b>Chapter 3</b>	
<b><i>Schoolbag carriage adjustment.....</i></b>	<b>68</b>
Preface	68
Abstract	69
Introduction	70
Methods	72
Results	77
Discussion	80
Conclusion	83
Acknowledgement	84
References	85
Post-script	89
<b>Chapter 4</b>	
<b><i>The temporal patterns of schoolbag carriage.....</i></b>	<b>92</b>
Preface	92
Abstract	94
Introduction	96
Methods	99



Study design	99
Participants	99
Equipment	100
Data collection protocol	102
Data processing and statistical analyses	103
Results	104
Total schoolbag carrying time	104
Mean event schoolbag carrying time	104
Number of schoolbag carrying events	106
Travelling to and from school	106
Discussion	108
Conclusion	110
References	111
Post-script	115
<b>Chapter 5</b>	
<b><i>Schoolbag weight, shoulder strap adjustment and carriage duration.....</i></b>	<b>117</b>
Preface	117
Abstract	119
Introduction	121
Methods	124
Study design	124
Participants	124
Data collection tools	124
Data collection protocol	127
Data processing and statistical analyses	130
Results	132
Load weight	132
Shoulder strap adjustment and time of day	137
Load x time of day and straps x time of day interactions	137
Discussion	138
Load weight	138
Shoulder strap tightness and time of day	140
Load x time of day interactions	141
Conclusion	141
References	142
<b>Chapter 6</b>	
<b><i>Schoolbag weight: a psychophysical approach.....</i></b>	<b>146</b>
Preface	146
Abstract	148
Introduction	149
Methods	151
Results	155
Discussion	156
Conclusion	158
References	159

<b>Chapter 7</b>	
<b>Discussion.....</b>	<b>162</b>
Introduction	162
The effects of schoolbag design, adjustment, carriage duration and weight on students' responses to schoolbag carriage	162
Schoolbag design	163
Schoolbag adjustment	164
The temporal patterns of schoolbag carriage	166
Schoolbag weight	168
Summary	169
Limitations and recommendations for future research	170
Considerations for the development of schoolbag carriage guidelines	176
Conclusion	180
<b>References.....</b>	<b>182</b>

# Appendices

## **Chapter 2** ***Schoolbag design***

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- Appendix 1.** Participant information and consent form
- Appendix 2.** Backpack comparison questionnaire
- Appendix 3.** Summary data (refer to CD in back cover)

## **Chapter 3** ***Schoolbag carriage adjustment***

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- Appendix 4.** Force and pressure measurement reliability
- Appendix 5.** Summarised data (refer to CD in back cover)

## **Chapter 4** ***The temporal patterns of schoolbag carriage***

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- Appendix 6.** Information letter to students with consent form
- Appendix 7.** Participant interview sheet
- Appendix 8.** Activity monitor validation study:  
  
Mackie, H.W., Legg, S.J. and Beadle, J. (2004).  
Development of activity monitoring for determining  
load carriage patterns in school students. *Work: A  
Journal of Prevention, Assessment, & Rehabilitation*,  
22, 231-237.
- Appendix 9.** Summarised data (refer to CD in back cover)

## **Chapter 5** ***Schoolbag weight, shoulder strap adjustment and carriage duration***

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- Appendix 10.** Parent / Participant information sheets and consent form (applies to chapters 5 & 6)
- Appendix 11.** Questionnaire
- Appendix 12.** Questionnaire reliability (refer to CD in back cover)

**Appendix 13.** Posture measurement reliability (refer to CD in back cover)

**Appendix 14.** Questionnaire raw data (refer to CD in back cover)

**Appendix 15.** Posture summarised data (refer to CD in back cover)

## **Chapter 6**

### ***Schoolbag weight: a psychophysical approach***

---

**Appendix 16.** Raw data

# Tables and figures

## Chapter 1

### *Review of literature*

---

<b>Table 1.</b>	Weight limits for different countries for boys and girls aged up to 16 years involved in manual materials handling tasks.	8
<b>Figure 1.</b>	Shift in a person's centre of mass position when a backpack is worn, and the resultant upper-body shift that must take place in order to maintain stability.	14
<b>Figure 2.</b>	The major forces acting on the body as a result of backpacking	15

## Chapter 2

### *Schoolbag design*

---

<b>Table 1.</b>	Reported musculoskeletal discomfort in the posterior and anterior side of the body prior to 20-minute walk.	57
<b>Table 2.</b>	Reported musculoskeletal discomfort in the posterior and anterior side of the body after 20-minute walk.	58
<b>Figure 1.</b>	Category-ratio scale (CRS) ratings of perceived regional discomfort.	48
<b>Figure 2.</b>	Preferred backpack after first impression, initial inspection and 20-minute walk.	51
<b>Figure 3.</b>	Mean (SD) reported practicality and ease of adjustment and initial comfort while standing, of each backpack after initial inspection.	52
<b>Figure 4.</b>	Mean (SD) reported physical demands following 20-minute treadmill walk.	53
<b>Figure 5.</b>	Mean (SD) reported balance and ease of walking following 20-minute walk.	56

## Chapter 3

### *Schoolbag carriage adjustment*

---

<b>Table 1.</b>	Mean and Standard deviation (SD) overall and peak shoulder strap forces (Newtons) for different load carriage configurations.* = difference statistically significant (p<0.05), ** = difference statistically significant (p<0.01), *** = difference statistically	78
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significant ( $p < 0.001$ ).

<b>Table 2.</b>	Mean and Standard deviation (SD) overall and peak shoulder pressure (raw pressure) for different load carriage configurations.* = difference statistically significant ( $p < 0.05$ ), ** = difference statistically significant ( $p < 0.01$ ), *** = difference statistically significant ( $p < 0.001$ ).	79
<b>Figure 1.</b>	Load carriage simulator used for data collection (tight shoulder straps configuration shown).	73

## **Chapter 4**

### ***The temporal patterns of schoolbag carriage***

---

<b>Table 1.</b>	Patterns of activity monitor and structured interview determined schoolbag carriage and absolute difference between methods	104
<b>Table 2.</b>	Total schoolbag carriage time (minutes) determined using activity monitor and structured interview for traveling to and from school	107
<b>Figure 1.</b>	Activity monitor with foam block used to protect and correctly orientate activity monitor within schoolbag	101
<b>Figure 2.</b>	Relationship between individual's total schoolbag carrying time determined using activity monitor and structured interview	105
<b>Figure 3.</b>	Relationship between individual's mean event schoolbag carrying time determined using activity monitor and structured interview.	105
<b>Figure 4.</b>	Relationship between individual's number of schoolbag carriage events determined using activity monitor and structured interview.	106

## **Chapter 5**

### ***Schoolbag weight, shoulder strap adjustment and carriage duration***

---

<b>Table 1.</b>	Order of schoolbag carriage conditions for all participants over six days of data collection. Each number represents the percent of bodyweight (% BW) carried for the corresponding day and 10T refers to the 10% BW with tight shoulder straps condition.	128
<b>Table 2.</b>	Template of the temporal patterns for the simulated school day.	129
<b>Table 3.</b>	Summary table of statistical results (p-values) for repeated	134

measures and subsequent t-test comparisons between loads, strap length, time of day and interactions between load and time of day and strap length and time of day.

<b>Table 4.</b>	Counts of reported musculoskeletal discomfort and reported CRS intensity for musculoskeletal discomfort in the neck/shoulder (back) and lower leg (back) regions for 0, 10 and 15% BW at the end and 15% BW at the beginning of the simulated school day.	137
<b>Figure 1.</b>	Example of joints that were digitised and backpack used during postural data collection	125
<b>Figure 2.</b>	Relative mean horizontal displacement (cm) of landmarks to the ankle joint (lateral malleolus) for different schoolbag carriage conditions (0-15% BW and tight (T) shoulder straps) at the end of the simulated school day.	135
<b>Figure 3.</b>	Mean (Standard deviation) RPE scores for different schoolbag carriage conditions	136
<b>Figure 4.</b>	Mean (Standard deviation) reported strain and ability to walk and balance scores for different schoolbag carriage conditions	136

## **Chapter 6**

### ***Schoolbag weight: a psychophysical approach***

---

<b>Table 1.</b>	Schoolbag weight adjustment protocol	154
<b>Table 2.</b>	Mean(SD) 'start empty' and 'start full' maximum acceptable schoolbag weight, difference between 'start empty' and 'start full' weights, average of 'start empty' and 'start full' weights and average weight as a percentage of bodyweight. n=16.	156
<b>Figure 1.</b>	Apparatus at each participant's data collection station.	152