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

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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.

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Professor Stephen Legg has quite simply been an excellent supervisor. Stephen has a very positive leadership style and a keen eye for detail. Together these attributes are complimentary – on occasions where I stared blankly at a returned manuscript that was covered with the contents of an entire red pen, Stephen's last comments would be "keep up the good work!". Stephen has also been committed as a supervisor. Frequently, Stephen would compensate for overseas absences by scrutinizing chapters on long-haul flights or undertaking late night and weekend work on his return in order to provide timely feedback.

My wife, Julia, has put up with a lot, but has always been supportive and diplomatic. Julia has basically kept a family of three ticking along for the past 19 months and has accepted my absences (both physically and mentally) by 'digging in' when times were tough. However, Julia has a very astute memory and it may take me three to four years to repay the debts!

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Lastly, I also owe thanks to the team at the Ergonomics lab at Queens University in Ontario, Canada. In particular, Joan Stevenson was extremely welcoming in allowing me to use their load carriage simulator for the data collection for chapter 3. Sue Reid also offered substantial technical support.

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 24th-29th, 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.

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Appendix 6. Information letter to students with consent form

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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)

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