



## Effect of load carriage on spinal compression

D.H.K. Chow\*, M.F. Li, A. Lai, M.H. Pope

Department of Health Technology and Informatics, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong SAR

### ARTICLE INFO

#### Article history:

Received 14 January 2010

Received in revised form

1 March 2011

Accepted 2 March 2011

Available online 22 March 2011

#### Keywords:

Spinal compression

Stadiometer

Adult

Posterior carriage

Anterior carriage

### ABSTRACT

Backpack is commonly carried either posteriorly or anteriorly. Although load carriage has been shown to have significant effects on postural alignment and spinal muscle activity, its effect on spinal loading was not studied. The objective of this study is to investigate the effect of different load carriage methods on spinal loading over time via the measurement of spinal compression. Eight male adults participated in this study. They were asked to carry a load equivalent to 15% of their body weight either anteriorly or posteriorly for 20 min followed by 10 min of unloading. Their statures were measured before load carriage and every 2 min after carrying the load. The sequence of loading conditions was randomized and the participants took a 20-min rest with Fowler's posture for spinal length recovery prior to each testing condition. The amount of spinal compression was found to be associated with carrying duration. Spinal compression during anterior carriage was larger than that of posterior carriage. There was a mild recovery of spinal compression after the removal of the carried load for both the anterior and posterior carriage conditions.

**Relevance to industry:** Short-term putting a backpack anteriorly might be useful for temporarily relieving postural changes induced by posterior carriage. However, prolonged anterior carriage is not recommended. The effects of load carriage on spinal compression should be considered in the design of a load carriage system with load partially or completely positioned in the front

© 2011 Elsevier B.V. All rights reserved.

### 1. Introduction

Load carriage is common among schoolchildren, adolescents and adults for daily transferring of personal belongings, books, stationeries and laptops to and from workplaces or schools. The load is commonly carried using backpack, shoulder bag or briefcase, and backpack was found to be the most common type of load carriage method (Pascoe et al., 1997) which is also widely used in armed forces and recreational hikers. When carrying a backpack, the load is directly applied to the spine through the shoulder straps and many studies have been conducted to investigate its effects on the body, including trunk posture (Al-Khabbaz et al., 2008; Chow et al., 2006, 2007; Hong and Cheung, 2003; Singh and Koh, 2009), spinal curvature (Chow et al., 2006, 2007, Devroey et al., 2007; Korovessis et al., 2005) and spinal muscles (Al-Khabbaz et al., 2008; Bobet and Norman, 1984; Hong et al., 2008; Kim et al., 2008; Motmans et al., 2006) as well as spinal motor control (Chow et al., 2007; Chow et al., 2010). It was shown that backpack carriage significantly increased trunk forward lean with flattened lumbar spine and increased extension in cervical spine. Spinal

repositioning ability was also affected by backpack carriage and the effects were found to be dependent on the amount of the load carried.

The posteriorly carried backpack is sometimes carried anteriorly (namely front pack). Motmans et al. (2006) compared the activity of spinal muscles (i.e. rectus abdominis and erector spinae) when carrying a load equivalent to 15% of body weight with different carriage methods. They found that the muscle group activated was associated with the position of load carried. An increase in activity of rectus abdominis muscle with decreased erector spinae activity was observed when the backpack was carried posteriorly. When the same amount of load was carried in the front, the activity of erector spinae obviously increased. Moreover, Fiolkowski et al. (2006) compared the gait pattern between anterior and posterior carriages of 15% of the participant's body weight. They found that in comparison to anterior carriage, carrying a load on the back significantly increased hip flexion and forward head position and the effects increased over time. They concluded that carrying a load anteriorly could maintain a more upright posture in gait than carrying the same load on the back.

In summary, both anterior and posterior carriages demonstrated significant effects on body and spinal alignment as well as spinal muscle activity. However, there is still a lack of evidence regarding the spinal loading between anterior and posterior carriages.

\* Corresponding author. Tel.: +852 2766 7674; fax: +852 2334 2429.  
E-mail address: [htdaniel@polyu.edu.hk](mailto:htdaniel@polyu.edu.hk) (D.H.K. Chow).