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Backpack-back pain complexity and the need for multifactorial safe weight recommendation

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The study analysed backpack-related back pain in school children by investigating the possibility of multiple interactions among causative factors, which may be responsible for the non-conclusive findings on the issue. Using data from 444 prepubescent schoolchildren, a mixed method design combining survey, observation and direct measurement strategies was implemented. Using a multivariate structural equation modelling approach, the study investigated interactions among anthropometry, posture, backpack volume, rating and back pain constructs, with each construct made of 2–4 indicators. Additionally, regression analysis was used to determine the feasibility of considering the two additional factors of age and body mass index along with the globally accepted recommendation of a load of 10–15% of body weight. Our model demonstrated an acceptable model fit and revealed direct and indirect effects of the factors. Obese children were recommended to carry a one-third lighter load than other children. The application of systematic/multiple strategies provided an explanation for some of the issues associated with school children's backpack-related back pain.

1. Introduction

Studies have identified the prevalence of back pain among backpack users in schools (Adeyemi et al., 2014a; Calvo-Muñoz et al., 2013; Trevelyan and Legg, 2011). Various efforts, including a safe weight recommendation of a load of 10–15% of body weight (Hong et al., 2008; Mackie and Legg, 2008; Moore et al., 2007; Motmans et al., 2006), the development of new backpack safety features (Hong et al., 2011; Mackie et al., 2003; Ramadan and Al-Shayea, 2013), awareness of the health effects of carrying heavy backpacks and government intervention, have been recommended to help resolve the backpack-related back pain problem (Jayaratne, 2012). However, these efforts have yielded limited results, and the problem persists at an unacceptable level. A major recommendation that has been widely investigated is the safe schoolbag weight, which was limited to 10% of schoolchildren's body weight in Europe and Australia, and up to 20% in United States of America (Dockrell et al., 2013; Mackie and Legg, 2008). Studies showed that this recommended safe weight limit has not been effective in curbing the problem among many schoolchildren (Al-Hazzaa, 2006; Amiri et al., 2012; Dianat et al., 2013). A major factor responsible for the ineffectiveness might be the children's poor compliance with the specified schoolbag weight limits, as recent studies showed that schoolchildren still carry load that exceeded the limits (Adeyemi et al., 2014a; Dockrell et al., 2015). The failure of this recommendation has led to inconsistency, and the development of multiple guidelines has not yielded the desired solution (Dockrell et al., 2013). This inconsistency has also been highlighted in a recent study by Dockrell et al. (2015).

Moreover, the complexity and multifactorial nature of back pain might be a major obstacle in resolving the backpack-related back pain problem (Korovessis et al., 2010; Trigueiro et al., 2013; Kristjansdottir and Rhee, 2002; Poussa et al., 2005; Gilkey et al., 2010; Barr and Barbe, 2004; Dockrell et al., 2013; Grimes and Legg, 2004; Smith and Leggat, 2007; Negrini et al., 2004). Most studies have studied the problem by focusing on the unilateral direct effect, without sufficient consideration of the interaction and mediating effects among various contributing factors. This serves as justification for applying a systematic approach to investigate and arrive at a widely applicable solution (James et al., 2012; Marras, 2008; Negrini et al., 2004; Smith and Leggat, 2007). Studies have established that the load carrying capacity of the spine can be

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influenced by biomechanical, physiological, psychosocial and individual factors (Cardon and Balagué, 2004; Davis and Marras, 2003; Ferguson et al., 2012; Lanfranchi and Duveau, 2008; Li and Buckle, 1999; Marras, 2008). Interestingly, these factors are not completely independent, and there are close interactions among these major risk factors, such as the biomechanical-physiological factors and the psychosocial-individual factors (James et al., 2012).

Apart from highlighting the complexity and multifactorial nature of the problem, the literature has provided little evidence of studies attempting to solve the problem using multifactorial approach in primary school children. Therefore, this paper attempted to explore the interactions among the multiple causative factors using structural equation modelling (SEM). Though the literature has identified numerous factors (Smith and Leggat, 2007; Trevelyan and Legg, 2006), our study was limited to investigating the interaction among five main factors: anthropometry, posture, backpack volume, rating ability and back pain factors. Thereafter, from the multifactorial backpack-back pain model, we identified additional variables that can be used to formulate a safe weight recommendation with greater success.

2. Theoretical justification for backpack-related back pain conceptual constructs

The conceptual backpack-related back pain model in this study consists of five constructs, which are anthropometry, posture, backpack volume, rating ability and back pain as shown in Fig. 1. Although these constructs have not been specifically classified in previous studies, research findings and reports from various studies were used to justify these manifest variables. Three of the constructs, i.e. back pain, rating ability and backpack volume, were identified from the exploratory factor analysis of a previous study (Adeyemi et al., 2014a), whereas the anthropometric and posture constructs have strong theoretical justification, as presented below.

2.1. Anthropometry and pain

The anthropometry construct was measured using four manifest variables: stature height (Hgt), backpack vertical height from the floor (Bvh), centre of mass position (COM) of the children and body weight (Bwt). Body anthropometry serves as a predictor of back pain (Grimes and Legg, 2004), and the literature abounds with studies that have reported the association between anthropometry and spinal symptoms (Milanese and Grimmer, 2004; Rose et al., 2013; Steele et al., 2001). Nissinen et al. (1994) found trunk asymmetry and sitting height to be modest predictors of low back pain among 11- to 13-year-old girls, whereas stature and sitting height were predictors in boys. Steele et al. (2001) also found that adolescents at different age groups had different anthropometric predictors of low back pain. A study by Poussa et al. (2005) that covered a wider age range also observed that the body height significantly predicted back pain among 11- to 14-year-olds but not 15- to 22-year-olds. This might be due to the growth spurt associated with early adolescence. Furthermore, the role of anthropometry in back pain is not limited to children, and back pain is more frequently reported among taller adults than among shorter ones (Marras, 2008; Poussa et al., 2005). However, the findings regarding the effect of body weight and body mass index on back pain among backpack users have been inconsistent. Body mass index is being used to classify both adults and children into normal, overweight and obese categories. Obese children are reported to be less stable when carrying a backpack (Pau et al., 2012); as a result, they often adopt postural control strategies when carrying backpacks.

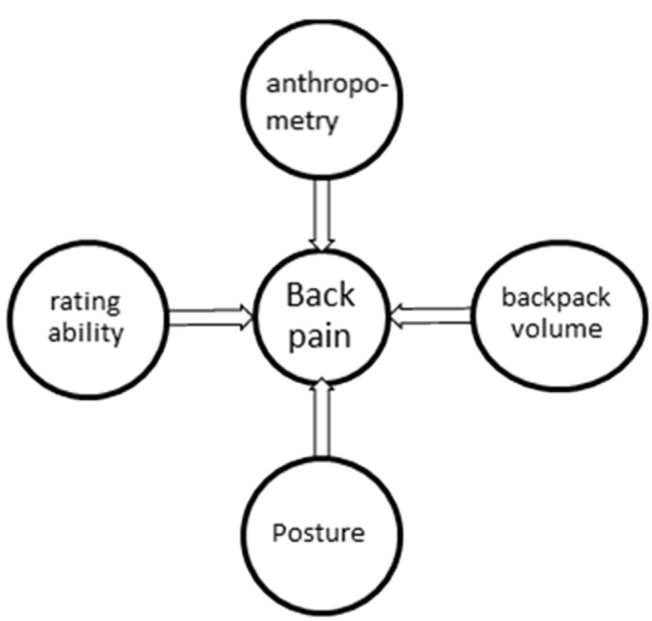

Figure 1. Conceptual model of the backpack-related back pain constructs.

2.2. Posture constructs and back pain

The posture construct consists of back inclination (bak2), neck inclination (nek2) and bag weight (Bgw) as manifest variables. Postural alteration, particularly of the back and neck, has been a major physical indicator of biomechanical-physiological changes resulting from schoolchildren's backpack weight. The schoolchildren's postures are modified to minimise energy expenditure, which is an indication of trunk imbalance and excessive strain on the trunk (Kim et al., 2008). Backpack is believed to alter postural control in children because an increase in weight of backpack reduces postural stability (Chow et al., 2010; Pau et al., 2012). Children compensate for instability arising from the excessive weight of the backpack by walking with their head or neck postures altered to move the centre of mass position forward, in alignment with their feet (Brackley et al., 2009; Motmans et al., 2006). The leaning forward of the trunk to compensate for the excess posterior load leads to changes in shear forces because of the changes in the muscle tension and surface alignment (Kistner et al., 2013).

2.3. Backpack volume and pain

The backpack volume (BPV) construct was measured using the quantity of books (Qty) and backpack content (Ctn) as manifest variables. While quantity of books refers to the number of textbooks and stationeries, backpack content identifies other materials such as food, water and toys brought to school by the children. Children's bags often contained unnecessary academic and non-academic materials (Adeyemi et al., 2014a; Kistner, 2011; Negrini et al., 2004). However, the children often do not have control over the content of the bag, as Kistner (2011) observed that the weight of government recommended textbooks alone exceeded 15% of the children's body weight. Additionally, children may carry meals and drinks to school, together with personal games and electronics (Adeyemi et al., 2014a). Identifying the effect of the schoolbag content could assist in designing an effective schoolbag load intervention programme.

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