



MONASH University

**THE EFFECTS OF BACKPACK LOADS
AND PLACEMENTS ON POSTURAL
DEVIATION IN HEALTHY
MALAYSIAN SCHOOL CHILDREN**

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at Monash University in 2016

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ABSTRACT

Background: Studies on the effects of children's backpacks continue to receive attention from researchers despite it being extensively discussed over the past decade. This concern has a strong basis because scientific literature has revealed significant associations between carrying heavy backpacks and the immediate or future health effects on children, including musculoskeletal pain as well as physiological, biomechanical and psychosocial effects. The purpose of this study was to investigate the effects of backpack load and placement on postural deviation in healthy Malaysian school children.

Methods: A randomized control experimental study was conducted on 136 healthy school children in Malaysia using systematic random sampling. Inclusion criteria were school children aged between 6 and 12 years old, free from any musculoskeletal diseases or disorders, able to stand upright and happy to wear biking shorts and tight t-shirts. Nine postural angles were measured during interventions namely the trunk, neck, gaze, head on neck, lower limb, tragus, acromion and pelvic. An intervention condition comprises the combinations of three backpack loads (5%, 10% or 15% BW) and three placements on the back (T7, T12 or L3). Photographs of the sagittal and frontal plane were taken during unloaded (baseline) and interventions. Postural angles were measured using the UTHSCSA Image Tool software. Changes in postural angles were assessed using the repeated measures ANOVA. The Pearson's correlation test was performed to determine the relationship between postural angles with the participants' characteristics (age, gender and BMI) while the Chi-square test

was performed to identify the association between participants' physical characteristics and perception of discomforts.

Results: The angle of the trunk, neck, gaze, head on neck, lower limb changes significantly when carrying the backpack load of 10% BW placed at T7 and T12. All postural angles (the trunk, neck, gaze, head on neck, lower limb, tragus, acromion and pelvic, tragus, acromion and pelvic) changed significantly when carrying a backpack load of 15% BW regardless of placement (T7, T12, L3); $p < 0.01$. A significant association was also found between age and the angle of trunk and neck as well as BMI and the angle of the neck and lower limb; $p < 0.05$. However, no significant association was found between participants' physical characteristic and perceptions of discomfort.

Conclusions: School children should not carry backpack loads exceeding 15% BW and the backpack should be placed at a lower location on the back (L3) to reduce postural deviations.

Keywords: Backpack, school children, load limit, placement.

PUBLICATIONS DURING ENROLMENT

I hereby declare that this thesis contains no material which has been accepted for the award of any other degree or diploma at any university or equivalent institution and that, to the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

This thesis includes (1) original papers published in peer-reviewed journals and (1) unpublished publications. The core theme of the thesis is the backpack load and placement for healthy primary school children. The ideas, development and writing up of all the papers in the thesis were the principal responsibility of myself, working within the Occupational Therapy Department under the supervision of Dr Rachael McDonald and Dr Shapour Jaberzadeh.

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Date: 25th August 2016

The undersigned hereby certify that the above declaration correctly reflects the nature and extent of the student and co-authors' contributions to this work.

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ABBREVIATIONS

ANOVA	Analysis of variance
BDC	Body Discomfort Chart
BMI	Body Mass Index.
BW	Body weight
CAP	Consumers Association of Penang
CHA	Cranio-horizontal angle
CI	Confidence interval
COG	Centre of gravity
CVA	Cranio-vertebral angle
df	Degree of freedom
e.g.	for example
etc.	and so forth
et al.,	multiple authors and have already provided the full citation
ES	Effect size
FEV ₁	Forced expiratory volume in 1 second
FVC	Forced vital capacity
HNOTA	head on neck on trunk angle
HONA	head on neck angle
i.e.	that is
kg	kilogram
kg/m ²	kilogram/meter ²
LA	Lordosis Angle
M	mean
m	meter
Mdn	Median
MOE	Ministry of Education
MOH	Ministry of Health
MSDs	Musculoskeletal disorders
n	Number of participants in each group or subset of the sample
N	Number of participant in the total sample

NEISS	National Electronic Injury Surveillance System of the United States.
NHMRC	National Health and Medical Research Council
NHMS	National Health Morbidity Survey
NGOs	Non-Governmental Organizations
p	probability
PEF	Peak expiratory flow
PTAs	Parents and Teachers Associations
RA	Research Assistant
s	second
SD	Standard deviation
SPP	Sagittal shoulder posture
TFL	Trunk Forward Lean
UK	United Kingdom
USA	United States of America
VAS	Visual Analogue Scale
vs.	versus
χ^2	Chi-square

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CHAPTER 1

INTRODUCTION

1.1 Background

Backpacks are widely used by children to carry their belongings to and from school (Goodgold et al., 2002; Ramadan & Al-Shayea, 2013). Backpacks have become a popular choice due to their versatility (Knapik, Harman, & Reynolds, 1996), are easily available in the market, affordable and often appealing to children (Mackie, Legg, Beadle, & Hedderley, 2003). The backpack was designed to maintain physical and bodily symmetry and stability, thus making it theoretically suitable for use by school children, with their developing musculoskeletal system (Knapik et al., 1996). Yet, the theory does not always apply in practice, and thus, a number of studies have been conducted related to backpack use amongst school-going children. These studies include various epidemiologic, physiological and biomechanical studies (Balagué, Kovron, & Nordin, 1995; Bygrave, Legg, Myers, & Llewellyn, 2004; Chansirinukor, Ilson, Grimmer, & Dansie, 2001).

Regular use of a heavy backpack and over long periods of time may contribute to musculoskeletal pain (Aundhakar, Bahatkar, Padiyar, Jeswani, & Colaco, 2015;

Chiang, Jacobs, & Orsmond, 2006; Michael, Gregory, & Donna, 2007). When children carry heavy backpacks daily to and from school, the risks are likely to be exacerbated (Ashraf, Jouko, Anssi, Hannu, & Marja, 2004; Balagué, Troussier, & Salminen, 1999). Several authors have suggested that carrying a heavy backpack is a factor that contributes to musculoskeletal disorders (Balague', Dutoit, & Waldburger, 1988; Negrini & Carabalona, 2002; Whittfield, Legg, & Hedderley, 2001). However, some authors refuted the direct relationship between musculoskeletal pain and backpack use in children (Goodgold et al., 2002; Robert & Harold, 2007; Young, Haig, & Yamakawa, 2006). As such, this remains an area of controversy.

The issue of children carrying heavy backpacks has raised concerns in Malaysia since 2002 when several scientific articles from other countries reported the effects of carrying heavy backpacks on children's health (Shasmin, Abu Osman, Razali, Usman, & Wan Abas, 2006). In Malaysia, children carry numerous heavy textbooks to and from school on a daily basis. Parents' concerns about heavy backpack loads are augmented by the publication of an article by Mohd Tamrin et al. (2005) which associated the prevalence of back pain among primary school students in Malaysia with carrying heavy backpacks (Mohd Tamrin, Lim, Hamzah, Yunus, & Siti, 2005). According to this article, 58.3% of the children studied suffered from back pain associated with backpack carriage that constituted more than 15% body weight (BW) i.e. higher than the recommended load limits by researchers from other countries (Brackley & Stevenson, 2004; Hong & Cheung, 2003; Kistner, Fiebert, & Roach, 2012).

Following Mohd Tamrin et al.'s (2005) publication, the issue has been highlighted, thus garnering much publicity in Malaysia. In 2007, the President of the Consumers Association of Penang (CAP) urged the Malaysian government to address this problem as a check on the effect of heavy backpack loadings on the current and future health of school children. An article in the mainstream press called for the Ministry of Education (MOE) to formulate a national educational policy on this issue, including addressing school management and teachers, planning an effective curriculum and highlighting the role of parents in reducing the amount of weight carried (Utusan Malaysia Online, 2012).

To date, various measures have been implemented to address the issue of heavy loaded backpacks amongst school children in Malaysia. One of the strategies that has been implemented by the MOE is the introduction of the periodic table and serial textbooks to reduce the backpack load (Ismail, Mohd Tamrin, & Hashim, 2009; Shasmin et al., 2006). The Department of Textbooks in the MOE has urged publishers to reduce the thickness of textbooks by dividing books that contain 128 pages or more into two volumes besides directing public schools to only use the exercise books endorsed by the MOE (Fazrolrozi & Rambely, 2008). Various initiatives have also been undertaken by the school management and Parent Teacher Associations (PTAs) such as demonstrating the correct way to carry a backpack and asking parents to monitor the weight of their children's backpack. Yet, such efforts have appeared to be ineffective in resolving the usage of heavy backpacks amongst these children.

The MOE in collaboration with the Ministry of Health (MOH) had also conducted several studies in Selangor, Putrajaya, Kuala Lumpur, and Terengganu in 2008 and 2009. According to the Deputy Health Minister's (Malaysia) statement in the Hansard Parliament of Malaysia, several studies have been conducted particularly to investigate cases of scoliosis amongst standard six students (12-year-olds). The results illustrated that of the 13,340 students, only 129 (0.97 %) students were suspected of having scoliosis (Utusan Malaysia Online, 2010). The results of these studies have reduced society's concerns about the heavy backpack load issue to some extent. Yet, students still have to carry heavy backpacks to meet the curriculum and the learning system requirements as defined by the school and the MOE. In fact, this practice is considered normal for Malaysian children, particularly those who attend public schools.

In addition to backpack weight, a number of studies found that backpack placement on the back may also contribute to postural deviations (Devroey, Jonkers, de Becker, Lenaerts, & Spaepen, 2007; Fiolkowski, Horodski, Bishop, Williams, & Stylianou, 2006; Karen Grimmer, Dansie, Milanese, Pirunsan, & Trott, 2002). However, research in this area has received less attention from the researchers. As a result, there has been no consensus on the suitable location for placing the backpack on school children. Further studies are required to investigate the impact of backpack placement on postural deviations so that a proposal can be made on the ideal placement.

As it stands, there have been no specific guidelines established by the Government of Malaysia regarding the safe load carriage limits for school-going children. Although

there have been efforts by local researchers to identify the appropriate load to be carried by school children in Malaysia (Sharifah Alwiah, Azmin Sham, & Rokiah Rozita, 2009; Shasmin et al., 2006), yet no single study has investigated or determined the appropriate location of the backpack for these children. The studies conducted have been largely preliminary and not comprehensive enough for developing guidelines on the safe backpack load limits for students in Malaysia. Therefore, more research is required not only in determining the load limits but also in identifying the most appropriate location on the back to place the load as both were reported as contributing factors to postural deviations.

1.2 Statement of the Problem

The incidence of back pain not only occurs among adults but also involves children and adolescents (Balague' et al., 1988; Burton, Clarke, McClune, & Tillotson, 1996; Troussier, Davoine, de Gaudemaris, Fauconnier, & Phelip, 1994). Several studies consistently reported that carrying heavy backpacks can be a contributing factor to low back pain among school children (Chansirinukor, Wilson, Grimmer, & Dansie, 2001; Troussier, Davoine, de Gaudemaris, et al., 1994). According to a study by Negrini et al. (1998), children with back pain reported (a) the use of heavy backpacks to and from school, (b) often complain of fatigue, and (c) experience more difficulty carrying their backpacks than their peers without back pain (Negrini, Carabalona, Pinochi, Malengo, & Sibilla, 1998). Of concern is the likelihood that back pain during childhood increases the chance of chronic back pain during adulthood. This may affect their potential productivity, independent living and general health condition.

A preliminary study was conducted on 175 first and second year primary school children (boys and girls aged between 7 and 8 years) in Malaysia (Fazrolrozi & Rambely, 2008). The purpose of this study was to investigate the weight and content of school bags carried by school children in Malaysia. The results showed that the first year students carried more than 25% BW while the second year students carried more than 15% BW. However, the researchers did not provide any specific reasons to explain the discrepancy. Essentially, the report concluded that these young children were carrying backpacks with far heavier loads than the limits suggested by research and evidence (American Academy of Pediatrics, 2002; Bauer & Freivalds, 2009).

Frequent use of heavy backpacks by children whose musculoskeletal systems have yet to mature make them more vulnerable to changes in posture and has the potential to lead to lower back pain (Brackley & Stevenson, 2004; Karen Grimmer & Williams, 2000; Li & Hong, 2004). In his study, Mohd Tamrin et al. (2005) observed that 58.3% of students aged between 8 and 11 years had complained of back pain and more importantly, they also discovered a relationship between back pain and carrying backpacks with loadings of more than 15% BW (Mohd Tamrin et al., 2005). The back pain occurred due to the postural changes that take place when carrying heavy backpacks. Postural changes, also called postural deviation, causes compensatory muscle contractions, increases intradiscal pressure which may ultimately lead to low back pain (Marras et al., 1993).

In addition to musculoskeletal pain, children who carry heavy backpacks are also at risk of increased oxygen consumption and blood pressure (Hong, Li, Wong, & Robinson, 2000), changes in gait pattern (Hong & Brueggemann, 2000), at risk of

getting other musculoskeletal injuries (Wiersema, Wall, & Foad, 2003) and musculoskeletal deformities (Hong & Cheung, 2003; Koroivessis, Koureas, Zacharatos, & Papazisis, 2005). Notably, several studies have reported a significant association between childhood and adulthood musculoskeletal problems with negative impacts on quality of life (Gregory, 2008; Hestbaek, Leboeuf-Yde, Kyvik, & Manniche, 2006; Penha, João, Casarotto, Amino, & Penteado, 2005).

In Malaysia, even though the issue of heavy backpack usage continues to be debated, very few scientific studies have focussed on school backpack usage. To date, seven studies were published in International Journals but only two of the studies focused on determination of load limits for school children (Sharifah Alwiah et al., 2009; Shasmin et al., 2006). However, none of the published findings look at the impact of load placement on posture deviations. As the backpack load and placement simultaneously contributed to the postural deviation, it is essential to combine these two factors in order to reduce postural deviation when carrying backpacks. With this combination, it is expected that the results obtained will be more precise in order to reduce the chances of postural deviation under these specific circumstances. Investigation of backpack load and placement may help us to understand and address the impact of these factors on postural deviation. Results from this study may be used as a reference source for establishing any guidelines on backpack use amongst school children in Malaysia, particularly with regard to load limits and placement of backpacks on students' backs.

1.3 Conceptual Framework

To date, hundreds of studies have been carried out in relation with school backpacks. In general, these studies can be classified into four categories, namely the children's characteristics, school environment, activities outside school, and the backpack related factors (Figure 1.1).

The children's characteristics that are frequently studied are gender (Kellis & Emmanouilidou, 2010; Rodríguez-Oviedo et al., 2012), age (Mohd Azuan et al., 2010; Talbott, 2005), BMI (Sheir-Neiss, Kruse, Rahman, Jacobson, & Pelli, 2003; Talbott, 2005), spinal abnormalities (Sahli et al., 2013), injuries and accidents as well as family history (Balagué et al., 1995; Murphy, Buckle, & Stubbs, 2007).

School environment factors such as locker facilities (Mwaka, Munabi, Buwembo, Kukkiriza, & Ochieng, 2014; Skaggs, Early, D'Ambra, Tolo, & Kay, 2006), school furniture (Brewer, Davis, Dunning, & Succop, 2009; Trevelyan & Legg, 2006), curriculum and the attitude of teachers and school management (Legg & Jacobs, 2008) were often reported as contributors to musculoskeletal pain in children.

Activities outside school such as time spent in physical activities and sports (Karen Grimmer & Williams, 2000; Ismail, Mohd Tamrin, et al., 2009), time spent on computer, games and television (Balague' et al., 1988; Troussier, Davoine, de Gaudemaris, et al., 1994), method of traveling to and from school (Haselgrove et al., 2008; Siambanes, Martinez, Butler, & Haider, 2004), duration of backpack carriage (Brewer et al., 2009; Mohan, Singh, & Quddus, 2007), part-time job (Harreby,

Nygaard, & Jessen et al., 1999; Watson et al., 2003) and parent awareness of children's backpacks (Javadivala, Allahverdipour, Iman, & Bazargan, 2012) are often published in peer review journals.

The last but not least are the factors related to the backpack including backpack design (Brackley & Stevenson, 2004; Ramadan & Al-Shayea, 2013), the amount of load carried (Devroey et al., 2007; Hong & Brueggemann, 2000) and location of the backpack on the back (Karen Grimmer et al., 2002; Talbott, 2005).

Since this study was limited by time constraints, lack of manpower and research grants, the focus lay on the study of children's factors such as age, gender, height, weight and BMI. However, it was also subject to the results of the review of the related literature (Chapter 2) and the systematic review (Chapter 3).

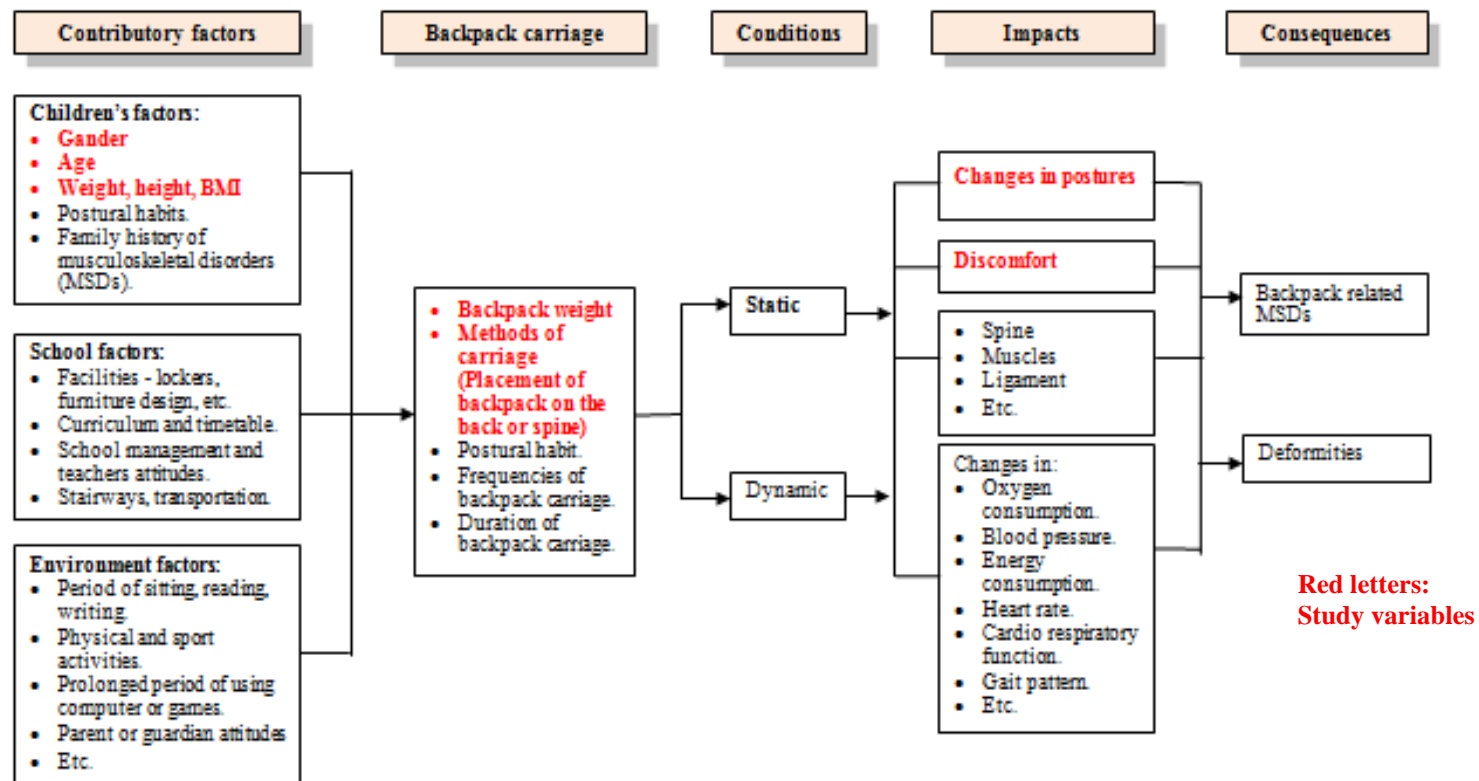


Figure 1.1: Conceptual framework of the effects of carrying heavy backpacks amongst school children

1.4 Rationale

Several studies have reported that musculoskeletal pain in childhood and adolescence is associated with musculoskeletal pain in adulthood (Brattberg, 2004; Hestbaek et al., 2006). If this is so, and the use of heavy backpacks is allowed to continue unchecked, then Malaysian children will be placed at risk of chronic back conditions. The country will bear substantial losses in productivity and possibly independent living, resulting in treatment costs and loss of human resources due to regular sick leave or long-term disability. In the long term, this will result in the escalation of demand for resources such as health care costs, attendant care costs over and above the reduced work as well as contributions to society and the economy. Some developed countries such as the United States, France and Austria have developed laws and regulations restricting the load carried by children in order to reduce the risk of musculoskeletal pain (Cardon & Balague, 2004). Such preventive measures have yet to materialise in Malaysia.

The reports indicate that students in public primary schools in Malaysia, carry school bags of up to 45% BW (Fazrolrozi & Rambely, 2008), which is three times more than the proposed limits quantified by objective measures (Brackley & Stevenson, 2004). This situation should not be overlooked because it would eventually adversely affect children's health, in particular, causing acute and chronic muscle pain. In fact, it also indirectly affects the children's daily activities either inside or outside of the classroom, and this may affect their school attendance due to illness (Lockhart, Jacobs, & Orsmond, 2004; Moore, White, & Moore, 2007). Furthermore, asymmetrical postures may also cause negative impacts on quality of life during childhood and adulthood (Penha et al., 2005).

A study conducted by the Educational Planning and Research Division in Malaysia revealed that backpacks carried by Malaysian school children contain the books and stationery needed for school as well as other belongings such as food packs, drinks, umbrellas, and attire (Education Planning and Research Division, 1995). The presence of these items increases the load carried by the students in their backpacks. This indicates the lack of monitoring by parents due to their lack of awareness about the health effects of carrying loads on children. The literature on backpack carriage has focused more on the load than the load placement. Although several studies reported that the placement of backpacks causes postural deviation, research in this area is very limited.

To date, findings from different studies on backpack load placement in primary and secondary students remain inconsistent. Although most of the studies concluded that placing the centre of gravity of the backpack at the lower spine may minimize postural deviation, the suggested locations were inconsistent. A study on Australian adolescence suggested that the backpack's centre of gravity (COG) should be placed at the third lumbar (L3) vertebrae (Karen Grimmer et al., 2002). Studies in Canada and Europe also concur that lower spine placements may minimize postural deviations but were unable to recommend the exact location due to inconsistent results (Brackley, Stevenson, & Selinger, 2009; Devroey et al., 2007). On the other hand, another study in Canada disagreed with Grimmer et al.'s (2002) suggestions (Frank, Stevenson, & Stothart, 2003). According to them, while placement of backpacks at the third lumbar vertebrae (L3) minimizes the reaction forces at the shoulder and lumbar areas, at the same time, it produces more deviation on the head and neck.

In order to examine the effects of backpacks on posture as a whole, the research should involve both static (standing upright) and dynamic (walking or running) studies. In this study, only static conditions (standing upright) were tested. This study is the first step to establishing a guideline on backpack carriage for school students in Malaysia. The next step for developing comprehensive guidelines is to carry out a backpack study involving dynamic tasks, which is not the focus of this study.

1.5 Objectives

1.5.1 General objective

To investigate the effects of backpack loads and placement on postural deviations of the skeleton in healthy Malaysian school children.

1.5.2 Specific objectives

- a) To investigate the comfort/discomfort felt by the participants during different states of backpack use.
- b) To compare the mean baselines postural angles (the trunk, neck, gaze, head, neck and lower limbs) whilst wearing a backpack.
- c) To determine the effects of backpack loads and placements on postural deviations (the trunk, neck, gaze, head on neck, lower limb, tragus, acromion and pelvic angles) in healthy school aged children.
- d) To explore whether there is a relationships between gender, age, and BMI of the children with postural deviations (the trunk, neck, gaze, head on neck, lower limb, tragus, acromion and pelvic angles).

- e) To determine whether there is a relationship between gender, age, and BMI with perceptions of discomfort.

1.6 Hypotheses

- a) There will be no significant differences between the three mean baseline postural angles on healthy school children (the trunk, neck, gaze, head, neck and lower limbs) measured over consecutive days.
- b) There will be no significant changes in the trunk, neck, gaze, head on neck, lower limb, tragus, acromion and pelvic angles when carrying the backpack at different loads and placements compared to the baseline angles in healthy school aged children.
- c) There will be no significant relationship between gender, age, and BMI with the deviations of trunk, neck, gaze, the head on neck, lower limb, tragus, acromion and pelvic angles in healthy school aged children.
- d) There will be no significant association between gender, age, and BMI with perceptions of discomfort in healthy school aged children.

1.7 Scope

This study has certain limitations based upon the inclusion and exclusion criteria. The results of this study cannot be applied:

- a) to a person younger than 6 or older than 12 years;
- b) to a person who suffers from musculoskeletal diseases or disorders including recent fractures or muscle or tendon sprain or strain anywhere in the body;
- c) to a person who suffers from neurological disorders;

- d) if the method of carrying the backpack is asymmetric and the placements are other than T7, T12 and L3.

1.8 Summary

This study is significant because the issue of heavy school bags has still not been addressed since a decade ago. Preliminary studies by local researchers indicate that backpack loads carried by children in public schools exceed the limits suggested by researchers in developed countries. This situation may expose children to various adverse health effects such as musculoskeletal pain and discomfort, spinal abnormalities and physiological effects in the short or long term. Hopefully, the results from this study will provide useful information to the government, especially the MOE to address the issue of heavy backpacks amongst primary school children in Malaysia.

CHAPTER 2

REVIEW OF RELATED LITERATURE

2.1 Background

Backpacks are used by more than 90% of school children worldwide (Al-Hazzaa, 2006). School backpacks have become controversial since literature relate it with acute and chronic health impacts (Daneshmandi, Rahmani-Nia, & Hosseini, 2008; Golriz, 2013; Hong et al., 2000; Leboeuf-Yde & Kyvik, 1998; Sahli et al., 2013; Siambanes et al., 2004). Yet, other literatures have refuted the association between backpack carriage and prevalence of musculoskeletal pain (Goodgold et al., 2002; Young et al., 2006). Interest in this area of study has, however, received increase coverage over the years and various studies have been conducted related to school backpacks including the design, load distribution, load limit, perceptions of load, musculoskeletal pain or discomfort, method of carriage, physiological adaptation, psychosocial factors, spinal diseases and so forth (Adeyemi, Rohani, & Abdul Rani, 2014; Kim, Kim, & Oh, 2015; Sahli et al., 2013; Simpson, Munro, & Steele, 2012).

Globally, thousands of such studies have been conducted over time. Until June 2012, a total of 3,796 backpack articles had been published in seven selected databases and more than 313 are related to school backpacks (Abdullah, McDonald, & Jaberzadeh,

2012). It is believed that the number of articles are on the increase as there are still many issues that have not been dealt with, mainly those related to risk factors (personal, school and environment, load limit, placement, duration of carriage, etc.), immediate and chronic impacts (postural deviation, discomfort, oxygen consumption, musculoskeletal disorders and deformities, etc.).

In Malaysia, various studies have been conducted on school backpacks (Table 2.1) but their limited scope means there is still a lack of robustness and a lack of guidance about the best use of backpacks among school children. The existing findings regarding load carriage are still not comprehensive enough to be used as references for establishing specific guidelines on load limits for Malaysian school children. In addition, none of the local studies explored the best methods in using backpacks. Further investigation on load limits and the mechanisms of backpack usage is highly required in order to establish guidelines for Malaysian school children.

The purpose of this chapter is to report the findings of prior studies and identify the gaps that require further investigation. The search engines used include Google scholar and PubMed. The search strategy used covered all study designs published in English and Malay while the quality of the articles was assessed using a Critical Appraisal Skills Program (CASP) tools comprises of cross-sectional, review, case control, RCT and cohort articles as shown in Appendix 1-5. The quality of evidence was based on appraisal scores; High (9-12), Moderate (5-8) and Low (1-4).

Table 2.1: Studies on backpack usage in Malaysia

Authors	N	Age (years)	Results/Conclusions	Quality of evidence
Azuan et al. (2010)	100	8, 11	School bag and classroom furniture significantly influenced the prevalence of MSD.	Intermediate
Fazrolrozi et al. (2008)	175	7-8	First year students carry loads more than 25% BW while the second year students carry more than 15% BW.	Intermediate
Ismail et al. (2009)	229	8, 11	MSD among school children is caused by multiple factors.	Intermediate
Rambely et al. (2007)	2	Not stated	There were significant differences in step length and duration of stance, double leg support and swing while carrying the loads of 0%, 10% and 20% BW.	Low
Shasmin et al. (2006)	7	9 - 11	Loads limits should not exceed 15% BW.	Low
Syed Abd. Rahman et al. (2009)	2	6.5	Carrying 15% and 20% BW loads caused significant increase in the trunk inclination angle.	Low
Tamrin et al. (2005)	-	7 - 12	Backpack load affects the erector spinae of primary school children.	Low

2.2 Personal Factors

Despite the suggestion that carrying heavy backpacks contributes to musculoskeletal symptoms, personal characteristics are also deemed to influence the occurrence of such symptoms. Personal characteristics that are often associated with backpack-related musculoskeletal symptoms are gender, age, BMI, spinal abnormalities, injury and a family history of muscle pain.

2.2.1 Gender

Studies to compare the effects of carrying school backpacks between boys and girls, particularly related to musculoskeletal pain and discomfort, were inconsistent in their findings. Whilst some reported that girls have higher risk of back pain compared to boys (Karen Grimmer & William, 2000; Harreby et al., 1999; Kellis & Emmanouilidou, 2010; Rodríguez-Oviedo et al., 2012), others reported that boys are more likely have lifetime prevalence of neck and lower back pain compared to girls (Mohd Azuan et al., 2010).

The postural deviations while carrying the backpacks between boys and girls remain controversial between literatures. According to Talbott (2005), girls had more postural deviation while carrying the backpacks compared to boys, yet, another study suggested no significant difference in postural deviations between boys and girls (Karen Grimmer et al., 2002). The details of the studies are summarized in Table 2.2.

Table 2.2: Studies on the effects of backpack carriage on children of different gender

Authors	N	Age (years)	Results/Conclusions	Quality of evidence
Azuan et al. (2010)	100	9 & 11	Lifetime prevalence of neck and lower back pain more likely in boys compared to girls.	Intermediate
Grimmer & William (2000)	1,269	12-18	Girls were more likely than boys to report recent low back pain.	Intermediate
Grimmer et al. (2002)	250	12-18	No significant association between gender and postural deviation.	Intermediate
Harreby et al. (1999)	1,389	13-16	Girls have a significant association with severe low back pain.	Intermediate
Kellis, & Emmanouilidou (2010)	703	6-14	Girls are twice more likely to experience fatigue compared to boys.	Intermediate
Rodríguez-Oviedo et al. (2012)	1,403	12-17	Girls have higher risk of back pain compared to boys.	Intermediate
Sheir-Neiss et al. (2003)	1,126	12-18	Girls have a significant association with back pain.	Intermediate
Talbott (2005)	40	12	Gender has an influence on postural deviation while carrying backpack.	Intermediate

2.2.2 Age

Most studies reported that the younger age group experience worse impact from the backpack carriage compared to the elder. A cross-sectional study reported that the lifetime prevalence of neck, upper back and lower back pain was more likely in 8 year olds compared with those aged 11 (Mohd Azuan et al., 2010). In contrast, another study revealed no significant association between age with low back pain (Korovessis, Koureas, Zacharatos, & Papazisis, 2004).

In addition, age is also related to postural deviation and stability while carrying the backpack. A randomized control study reported no significant difference of postural deviation between boys and girls while carrying the backpack (Karen Grimmer et al., 2002) while another showed that age influenced stability and posture while carrying backpacks (Talbot, 2005). The details of the studies are summarized in Table 2.3.

Table 2.3: The studies on the effects of backpack carriage on children of different age

Authors	N	Age (years)	Results/Conclusions	Quality of evidence
Azuan et al. (2010)	100	9-11	Lifetime prevalence of neck, upper back and lower back pain more likely in 8 year olds than those aged 11.	Intermediate
Grimmer et al. (2002)	250	12-18	No significant association between age and postural deviation.	Intermediate
Korovessis et al. (2004)	3,441	9-15	No significant correlation between age and low back pain.	Intermediate
Talbot (2005)	40	12	Age may also change stability and posture while carrying backpack.	Intermediate

2.2.3 Body Mass Index (BMI)

Literature regarding the effects of backpack carriage on different BMI is very limited. It was reported that BMI has a significant association with back pain but the authors did not specify the classification of the BMI, whether overweight or obese (Sheir-Neiss et al., 2003). In another study, it was reported that BMI may influence stability and posture while carrying backpacks (Talbot, 2005). The details of the studies are summarized in Table 2.4.

Table 2.4: The studies on the effects of backpack carriage on children with different BMI

Authors	N	Age (years)	Results/Conclusions	Quality of evidence
Sheir-Neiss et al (2003)	1126	12-18	BMI was significantly associated with back pain.	Intermediate
Talbott (2005)	12	40	BMI may also affect stability and posture while carrying backpacks.	Intermediate

2.2.4 Spinal abnormalities

The study was not only conducted on healthy children but also those who had spinal abnormalities such as scoliosis, kyphosis and lordosis. Studies that involved this group involved the determination of load limits (Chow et al., 2005, 2006) and body mechanics while walking with the backpacks, balance while walking (Sahli et al., 2013) and body mechanics (Syczewska, Łukaszewska, Górak, & Graff, 2006). The details of the studies are summarized in Table 2.5.

Table 2.5: Studies on the effects of backpack carriage on children who have spinal abnormalities

Authors	N	Age (years)	Results/Conclusions	Quality of evidence
Chow et al. (2005)	35	11-12	Load limit of 10% BW may not be applicable to schoolgirls with adolescent idiopathic scoliosis (AIS).	Intermediate
Chow et al. (2006)	40	10-15	Load limit recommendations on normal children should not be applicable to children with AIS .	Intermediate
Sahli et al. (2013)	14	13-15	Backpack carriage of 10% BW load seems to influence the AIS balance.	Intermediate
Syczewska et al. (2006)	25	12-16	AIS may affect body mechanics while walking and carrying backpacks	Intermediate

2.2.5 Previous injury or accidents

The relationship between previous injury and accidents with musculoskeletal pain in children who carry backpacks is still unclear and need further investigation. Notably, a study reported the association between previous injury or accidents (Murphy et al., 2007) although another study discovered no significant association (Ismail, Tamrin, & Hashim, 2009). The details of the studies are summarized in Table 2.6.

Table 2.6: Studies on the association between previous injuries or accidents with musculoskeletal pain

Authors	N	Age (years)	Results/Conclusions	Quality of evidence
Ismail et al. (2009)	229	8 and 11	No significant association between previous injuries or accidents with back pain.	Intermediate
Murphy et al. (2006)	679	11-14	Low back pain was associated with previous injuries or accidents.	Intermediate

2.2.6 Family history of back pain

Although the literature in this area is very limited, they consistently reported that family history of back pain was significantly associated with children's back pain (Balagué et al., 1995; Murphy et al., 2007; Salminen, 1985). The details of the studies are summarized in Table 2.7.

Table 2.7: Studies on the association between family history of back pain and children back pain

Authors	N	Age (years)	Results/Conclusions	Quality of evidence
Balagué, et al. (1994, 1995)	1,755 and 615	8-16, 12-17	Significant association between parents' history of low back pain and their children.	Intermediate
Murphy et al. (2007)	679	11-14	Low back pain was associated with family history.	Intermediate
Salminen (1984)	370	11, 13, 15 & 17	Significant association between parents and sibling history of back pain with children back pain.	Intermediate

2.3 School Factors

While the individual characteristics are significantly associated with musculoskeletal problems in children, there were also literatures that associated it with the school environment such as the unavailability of student lockers, school furniture design, curriculum and timetable, as well as school management and teachers' attitudes.

2.3.1 Locker facilities

The provision of student lockers may reduce backpack loads carried by students because they can keep the unnecessary books in the provided locker. However, not every school can afford to provide lockers for all students, especially public school. Some studies revealed that the provision of student lockers may reduce the musculoskeletal pain related to backpack carriage (Mwaka et al., 2014; Skaggs et al., 2006; Whittfield et al., 2001) The details of the studies are summarized in Table 2.8.

Table 2.8: The association between student lockers and back pain

Authors	N	Age (years)	Results/Conclusions	Quality of evidence
Mwaka et al. (2014)	532	13	Schools need to provide lockers to avoid excessive loading and repetitive strain injuries.	Intermediate
Skaggs et al. (2006)	1540	11-14	Children with lockers reported less back pain	Intermediate
Whittfield et al. (2001)	140	14	Lack of access to lockers may contribute to a higher risk of developing musculoskeletal symptoms.	Intermediate

2.3.2 School furniture design

The majority of intervention studies undertaken in a school setting have focussed on the effects of school furniture (Trevelyan & Legg, 2006). Results from the peer-reviewed articles revealed that the association between the school furniture design and musculoskeletal pain or discomfort was inconsistent between studies. Murphy et al. (2007) reported that school furniture had a significant association with back pain, in contrast to those that reported the design of school furniture had limited impact on musculoskeletal pain and body discomfort (Brewer et al., 2009; Trevelyan & Legg, 2006). More interestingly, another article claimed there was no clear evidence to support the association between school furniture design and the development of neck and/or low back pain (Grimes & Legg, 2004). The details of the studies are summarized in Table 2.9.

Table 2.9: The association between school furniture and musculoskeletal pain or body discomfort

Authors	N	Age (years)	Results/Conclusions	Quality of evidence
Brewer et al.(2009)	Not stated		Desks and chairs had limited impact on the body discomfort	Intermediate
Grimes et al. (2004)	Review article		No clear evidence to support the association between the school furniture design with neck and/or low back pain.	Intermediate
Murphy et al. (2007)	679	11-14	Low back pain was associated with school furniture features.	Intermediate
Trevelyan & Legg (2006)	Review article		The school furniture had less association with back pain.	Intermediate

2.3.3 Curriculum and timetable

Most studies on ergonomics in schools have focused on desk and chair designs with less focus on macro-ergonomics issues such as learning environments, ergonomics pedagogy and curriculum content/structure (Legg & Jacobs, 2008). For Malaysian public schools, the responsibility of developing the curriculum is under the jurisdiction of MOE to ensure that the contents are consistent with government policy. However, the implementation of the curriculum is under the jurisdiction of the school management and teachers. They can organize a smart timetable so that the books brought by the students every day are not too heavy. The number of subjects taught, exercise books and textbooks used in school may be influenced by the daily timetable. Although this proposal seems reasonable, more studies are needed to assess its effectiveness in order to address the heavy school backpack issue.

2.3.4 Other school environment factors

In addition to the above factors, there are also other factors that may contribute to musculoskeletal pain such as stairways (Chung, Lee, Lee, & Choi, 2005), duration of standing and sitting (Malleon & Clinch, 2003; Mwaka et al., 2014), reading and writing as well as the attitudes of the school management and teachers (Chiang et al., 2006; Mary, 2004). While we are conscious of the need to improve these factors, research in this area is rare and thus, there is no concrete evidence that associates these variables with musculoskeletal pain.

2.4 Environmental Factors

Beside the school factors, environment factors may also contribute to musculoskeletal pain and discomfort in school-going children. Several peer-reviewed articles had significantly associated environmental factors to musculoskeletal pain such as physical activity and sports, time spent watching television, use of computers and playing games, the attitude of parents in monitoring their children's backpacks, mode of travelling to and from school and doing part-time jobs after school hours.

2.4.1 Physical and sport activities

The benefits of physical activity are widely known but at the same time, the risk of musculoskeletal injury is an unfavourable consequence of such activities (Taimela, Kujala, & Osterman, 1990). In addition, several studies have consistently reported that participation in physical activity and sports may contribute to musculoskeletal problems (Karen Grimmer & Williams, 2000; Harreby et al., 1999; Ismail, Mohd Tamrin, et al., 2009; Salminen, 1985). The details of the studies are summarized in Table 2.10.

Table 2.10: The association between physical and sport activities with musculoskeletal pain and injuries

Authors	N	Age (years)	Results/Conclusions	Quality of evidence
Grimmer et al. (2000)	1,269	12-18	Low back pain was significantly associated with time playing sport.	Intermediate
Harreby et al.(1999)	1389	13-16	Boys involved in competitive sports were significantly associated with low back pain.	Intermediate
Ismail et al. (2009)	229	8 and 11	Sport injuries were significantly associated with musculoskeletal problems.	Intermediate
Salminen (1985)	370	11, 13, 15, 17	Musculoskeletal pain was significantly associated with physical activities.	Intermediate

2.4.2 The time spent on computers or games and watching television

The relationship between musculoskeletal pain and/or discomfort with the time spent on computer or games and watching television is widely reported by several peer-reviewed articles. Generally, all articles consistently suggested that it has a positive relationship, meaning that the longer the time spent, the higher the risk of pain (Balague' et al., 1988; Burton et al., 1996; Troussier, Davoine, & de Gaudemaris et al., 1994). Similarly, a study in Malaysia specifically reported that using the personal computer or watching television exceeding 2 hours a day represented the main risk factor of upper musculoskeletal pain among school children (Ismail, Mohd Tamrin, et al., 2009). The details of the studies are summarized in Table 2.11.

Table 2.11: The association between the time spent on computers or games and watching television with musculoskeletal pain

Authors	N	Age (years)	Results/Conclusions	Quality of evidence
Balague' et al. (1988)	1,755	8-16	Low back pain was significantly associated with time spent watching television.	Intermediate
Ismail et al. (2009)	229	8 and 11	Using personal computers or watching television exceeding 2 hours a day was the main risk factor of upper musculoskeletal pain among school children	Intermediate
Troussier et al. (1994)	1,178	Not stated	Low back pain was significantly associated with time spent watching television.	Intermediate

2.4.3 Method of travelling to and from school

Children commute to and from school using various methods either on foot or by bicycles, motorcycles, cars and buses. Each method involves different durations and methods of backpack carriage. All peer-reviewed literature consistently reported that method of travelling to and from school was significantly associated with musculoskeletal pain, particularly the back, neck, shoulder, hand/wrist (Haselgrove et al., 2008; Siambanes et al., 2004; Viry, Creveuil, & Marcelli, 1999). Recent studies also reported that backpack loads and walking to school were significantly associated with back pain (Aundhakar et al., 2015). The details of the studies are summarized in Table 2.12.

Table 2.12: The association between methods of travelling to and from school with musculoskeletal pain

Authors	N	Age (years)	Results/Conclusions	Quality of evidence
Aundhakar et al. (2015)	625	12-16	Students carrying more than 15% BW and walked to school were significantly associated with back pain	Intermediate
Haselgrove et al. (2008)	1,202	14	Method of travelling to school was significantly associated with back and neck pain.	Intermediate
Siambese et al. (2004)	3,498	Not stated	Walking to and from school was significantly associated with back pain.	Intermediate
Viry et al. (1999)	123	14	Method of carrying schoolbags was significantly associated with hand/ wrist and shoulder symptoms.	Intermediate

2.4.4 Duration of backpack carriage

The adverse effect of school backpack carriage is also often associated with duration of carriage. Various literatures consistently revealed that the longer the period, the higher the risk of getting musculoskeletal symptoms (Chiang et al., 2006; Dianat, Sorkhi, Pourhossein, Alipour, & Asghari-Jafarabadi, 2014; Haselgrove et al., 2008; Whittfield et al., 2001). Besides the duration, some literature also relate it to the loads of more than 15% BW (Brewer et al., 2009; Mohan et al., 2007). The details of the studies are summarized in Table 2.13.

Table 2.13: The association between duration of backpack carriage and musculoskeletal pain

Authors	N	Age (years)	Results/Conclusions	Quality of evidence
Brewer et al. (2009)	625	12-16	Backpack load and duration may contribute more to the discomfort of students	Intermediate
Chiang et al. (2006)	100	13-14	There was a significant association between the duration of backpack carriage and adolescents' low back pain.	Intermediate
Dianat et al. (2014)	307	7-12	The time spent carrying a schoolbag was associated with hand/wrist and upper back symptoms.	Intermediate
Haselgrove et al. (2008)	1,202	14	Duration of carriage to school is associated with back and neck pain.	Intermediate
Mohan et al. (2007)	60	11-15	Backpack load and duration influenced cervical and shoulder posture	Intermediate
Whittfield et al. (2001)	140	14	Long carriage durations could contribute to musculoskeletal symptoms.	Intermediate

2.4.5 Part-time jobs

Part-time jobs exposed children to various ergonomic risk factors such as awkward posture, repetitive tasks and excessive force. Carrying heavy school backpacks increases the risk of musculoskeletal symptoms of these children compared to other students who did not have part-time jobs. Literature has consistently reported a significant association between part-time jobs with musculoskeletal pain. The details of the studies are summarized in Table 2.14.

Table 2.14: The association between part-time jobs and low back pain

Authors	N	Age (years)	Results/Conclusions	Quality of evidence
Harreby et al.(1999)	1,389	13-16	Heavy jobs during leisure time were significantly associated with low back pain.	Intermediate
Watson et al. (2003)	1,446	11-14	Children who had a part-time jobs had 60% risk of reporting low back pain.	Intermediate

2.4.6 Parents awareness about the characteristics of healthy backpacks

Parent awareness on school backpacks may help to mitigate risks of heavy school backpacks. A Malaysian study conducted found that students' backpacks not only contained books and stationaries but also paraphernalia such as food packs, drinks, umbrellas, and physical education attire (Education Planning and Research Division, 1995). Knowledge on characteristics of healthy school backpacks such as its design, load limit and load placement etc. may help parents to monitor their children's backpacks. Unfortunately, only few studies have explored the knowledge, attitudes and practices of the parents with regard to their awareness of these risks. Additionally, past studies reported that one-third of parents never checked the contents of their children's backpacks (Forjuoh, Little, Schuchmann, & Lane, 2003) and more than half of the parents interviewed were not aware of the recommended weight limits (Javadivala et al., 2012). The details of the studies are summarized in Table 2.15.

Table 2.15: Parents' awareness about the characteristics of healthy school backpacks

Authors	N	Age (years)	Results/Conclusions	Quality of evidence
Furjuoh et al. (2003)	745	6-11	34% students reported their parents never checked their backpack content.	Intermediate
Javadivala et al. (2012)	250	Not stated	51.6% of the parents were not aware of the recommended weight limits.	Intermediate

2.5 Backpack Factors

Studies on backpack factors such as the design, load limit and the location for placing the backpack are essential to reduce the adverse health effects on children. The information is important not only to manufacturers of backpacks but also to parents who can then choose appropriate backpacks and monitor their usage.

2.5.1 Backpack design

The purpose of designing a backpack is to provide comfort to the user when it is used. A well-designed backpack should have an appropriate size, wide padded shoulder straps, padded back, chest and hip belts, compression straps, external and internal frame as well as multiple compartments. The wheeled backpacks were also introduced for reducing the load placement on shoulders. There are very limited peer-reviewed journals regarding the design or features of school backpacks. All literature consistently agreed that a well-designed backpack may reduce backpack-related problems and some proposed further investigation on its design as no conclusion can be made from previous studies. The details of the studies are summarized in Table 2.16.

Table 2.16: Studies on backpack design

Authors	N	Age (years)	Results/Conclusions	Quality of evidence
Brackley et al. (2004)	Critical review article		Recommend further research on backpack design.	Intermediate
Brackley et al. (2009)	15	10	Backpack designs should place loads lower on the spine in order to minimize postural deviation.	Intermediate
Fong et al. (2008)	13	6-11	A backpack design significantly reduced the trunk posture.	Low
Ramadan & Al-Shayea (2013)	238	6-20	Modified backpacks may help in reducing muscular and cardiac activities.	Intermediate

2.5.2 Backpack load limit

Determination of the safe load to be carried is essential to reduce backpack-related problems. According to Lindstrom-Hazell (2009), efforts to set a safe load limit began more than 15 years by biomedical and biomechanical researchers (Lindstrom-Hazel, 2009). However, there is still no consensus on the load limits to be carried by school children. Regulations on load limits are difficult to implement due to a lack of studies on the acute and chronic effects of backpack use (Talbot, 2005).

Numerous studies have been carried out to determine the safe load limits on school backpacks. Various approaches have been used including (1) biomechanical study, which investigates the effects of the load to postural deviation, (2) epidemiological study, which identifies the prevalence of backpack-related pain, fatigue and discomfort due to backpack carriage and (3) physiological study, which determines the impact of backpack carriage on physiological function.

Several load limits have been recommended by peer-reviewed articles using various outcome measures including (1) less than 10% BW (Hong & Brueggemann, 2000; Lai & Jones, 2001), (2) 10% BW (Bauer & Freivalds, 2009; Chow et al., 2005; Michael et al., 2007), (3) between 10% - 15% BW (Brackley et al., 2009), (4) not more than 15% BW (Shasmin et al., 2006; Singh & Koh, 2009a), not more than 20% BW (Talbot, 2005). The details of the studies are summarized in Table 2.17.

Table 2.17: Studies on the determination of load limits for school backpacks

Authors	N	Age (years)	Load (%BW)	Outcome measures	Results/Conclusions	Quality of evidence
Brackley et al. (2009)	15	11	15	Literature review	Epidemiologic, physiologic, and biomechanical data support the suggested weight limit of 10% to 15% BW.	Intermediate
Bauer & Freivalds (2009)	20	11-14	5, 10, 15, 20	Muscle activities (EMG), postural changes, heart rate, perceived exertion and perceptions of pain.	A recommended load limit is 10% BW.	Intermediate
Chow et al. (2005)	22	10 and 15	7.5, 10, 12.5, 15	FVC, FEV ₁ , PEF, FEF	A critical load is approximately 10% BW	Intermediate
Devroey et al. (2007)	20	21-26	5, 10, 15	Angle of head, neck, thorax, spine, pelvic, hip.	Carrying the loads of 10% BW and above should be avoided.	Intermediate
Grimmer et al. (2002)	250	12-18	3, 5, 10	Anatomical point (tragus of ear, spinous process C7, mid acromion shoulder, lateral superior iliac crest greater trochanter and mid joint knee)	No evidence to support that backpack weight should be 10% BW.	Intermediate
Hong & Brueggeman (2000)	15	10	10, 15, 20	Gait pattern, heart rate and blood pressure.	Load limits should not exceed 10% BW.	Intermediate

Authors	N	Age (years)	Load (%BW)	Outcome measures	Results/Conclusions	Quality of evidence
Hong & Cheung (2003)	11	9 and 10	10, 15, 20	Trunk inclination angle.	Loads should not exceed 15% BW.	intermediate
Iman Dianat (2013)	307	7-12	10	Prevalence of musculoskeletal pain.	Load limits of 10%-15% BW may not be appropriate for primary school children.	Intermediate
Kistner et al. (2012)	11	8-11	10, 15, 20	CVA	Backpack loads carried by schoolchildren should be limited to 10% BW.	Intermediate
Lai & Jones (2001)	43	9	10, 20, 30	FEV ₁ , FVC and PEF.	Load limit should not exceed 10% BW.	Intermediate
Michael et al. (2007)	531	12-18	10	Prevalence of musculoskeletal pain	A recommended load limit is 10% BW.	Intermediate
Singh & Koh (2009)	17	9-10	10, 15, 20	TFL	Loads above 15% BW should be avoided.	Intermediate
Shasmin et al. (2007)	6	9-10	10, 15, 20	FVC, FEV ₁ ,	Loads should not exceed 15% of BW	Low
Talbott (2005)	40	10-14	10, 20	Postural deviation (shoulder, temporal, ankle, knee, hip)	Loads of 20% BW should be avoided to minimize the risk of abnormal posture	Intermediate

BW – body weight, FVC - Forced vital capacity, FEV₁ - Forced expiratory volume, PEF - Peak expiratory flow, FEF - Forced expiratory flow

2.5.3 Backpack placement

The location for placing the backpack is essential because it may affect posture and physiological functions such as blood pressure and lung function (Brackley et al., 2009; Chow, Ting, Pope, & Lai, 2009; Singh & Koh, 2009a). Numerous studies have been conducted to determine the appropriate location for placing school backpacks, with various locations used as placements and different outcome measures were tested to investigate the effects. Until today, no guidelines have been established related to the appropriate backpack location for children because the findings on this matter are still inconsistent between studies. Generally, most studies reported that placing the backpack at lower locations on the back is better compared to middle and higher locations because it minimized postural deviations. In contrast, another found that although both shoulder and lumbar forces are significantly less when the backpack is lower on the back, the head lean is significantly greater (Frank et al., 2003). Thus, further investigation is required to determine the appropriate location for school children backpacks. The details of the studies are summarized in Table 2.18.

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Table 2.18: Studies on the determination of placement for school backpacks

Authors	N	Age (years)	Placement	Outcome measures	Results/Conclusions	Quality of evidence
Brackley et al. (2009)	15	10	Above L5, below L5	TFL, CVA, LA	Backpacks should be placed lower on the spine	Intermediate
Chow et al. (2009)	12	12	T7, T12, L3	FVC, FEV ₁ , PEF	No significant effect of load placements on the pulmonary function	Intermediate
Chow et al. (2010)	19	11	T7, T12, L3	Angle of cervical, thoracic, lumbar, pelvic tilt.	Placing the centre of gravity of the backpack at T12 caused less effect on spinal deformation and repositioning error in schoolchildren.	Intermediate
Devroey et al. (2007)	20	21-26	T, L	Angle of head, neck, torax, spine, pelvic, hip.	Placing backpacks on the lumbar increased spinal flexion, reduced pelvic anteversion and rectus abdominis. No conclusion made on thorax placement.	Intermediate
Frank et al. (2003)	17	9 and 11	C7, T7	Anatomical point of head, shoulder, elbow, wrist, knuckle, hip, knee, ankle, toe, heel	Although both shoulder and lumbar forces are significantly less when the pack is lower on the back, the head lean is significantly greater.	
Grimmer et al. (2002)	250	12-18	T7, T12, L3	Anatomical points of tragus of ear, spinous process C7, mid acromion shoulder, lateral superior iliac crest	Backpacks should be placed at waist or hip level.	Intermediate

Authors	N	Age (years)	Placement	Outcome measures	Results/Conclusions	Quality of evidence
				greater trochanter and mid joint knee.		
Singh & Koh (2009)	15	10	Superior and inferior to T8 - T9	TFL	Lower placement is better than higher ones.	Intermediate
Talbott (2005)	40	12	T7 and inferior angle of the scapula	Angle of ankle, knee, and hip.	No significant differences between placements.	Intermediate

TFL - trunk forward lean, CVA - cranio-vertebral angle, LA - lordosis angle, FVC - Forced vital capacity, FEV₁ - forced expiratory volume in 1 second, PEF - peak expiratory flow, CG - centre of gravity.

2.6 The Effect of Backpack Carriages

The improper use of backpacks may cause an immediate effect such as postural deviation, changes in gait, pain, discomfort, reduced lung function, increased blood pressure, etc.) and long-term effects such as musculoskeletal symptoms, spinal curvature, injuries and deformities (Rai & Agarwal, 2014).

2.6.1 Postural deviations

One of the immediate impacts of carrying heavy backpack is a postural deviation, otherwise termed as awkward posture. The persistent changes in both spinal curvature and repositioning ability revealed an increased risk of spinal injury even after the backpack was removed, and the effects on the neck and back pain (Hung-Kay Chow, Kit-Fong Hin, Ou, & Lai, 2011). While there is no standard method of measuring posture, various outcome measures have been used to assess postural deviation as shown in Table 2.19.

Table 2.19: The effect of backpack carriage on postural deviation

Authors (year)	N	Age (years old)	Load (% BW)	Plane	Outcome measures	Results/ Conclusions	Quality of evidence
Brackley et al. (2009)	15	10	15	Sagittal	Trunk Forward Lean (TFL), Craniovertebral Angle (CVA) and Lordosis Angle (LA)	A significant changes in TFL and CV angles while carrying backpack load of 15% BW compared to no backpack.	Intermediate
Chansirinukor et al. (2001)	15	13-16	15	Sagittal	Craniohorizontal Angle (CHA) and CVA	Carrying a backpack load of 15% BW increased forward lean of the trunk and neck, and it is too heavy to maintain standing posture for adolescents.	Intermediate
Goodgold et al. (2002)	2	9 and 11	8.5, 17	Sagittal	TFL	The TFL increased with increases in backpack load.	Intermediate
Grimmer et al.(2002)	250	12- 18	3, 5, 10	Sagittal	Changes of body markers at head, neck, shoulder, hip, thigh, knee and ankle	There were no significant changes seen at all anatomical points when carrying 3%, 5%, and 10% BW load compared to the baseline condition.	Intermediate
Li & Hong (2001)	25	10	10, 15, 20	Sagittal	TFL	A 20% BW load induced significant TFL and decreased trunk movement range.	Low
Li & Hong (2004)		6 and 12	10, 15, 20	Sagittal	TFL	Carrying a load heavier than 15% of body weight resulted in a significantly increased of TFL compared to the baseline condition.	Intermediate

Authors (year)	N	Age (years old)	Load (% BW)	Plane	Outcome measures	Results/ Conclusions	Quality of evidence
Kistner et al. (2012)	11	8-11	10, 15, 20	Sagittal	CVA	A statistically significant change in CVA when carrying the backpacks containing 15% and 20% BW.	Intermediate
Mackie & Legg (2008)	18	13-14	5, 10, 12.5, 15	Sagittal and frontal	Changes of body markers at ear, eye, ankle, knee, hip, shoulder and seventh cervical.	The 15% BW load may be excessive for a typical school day.	Intermediate
Moa et al. (2013)	12	10	10, 15	Sagittal and frontal	Sagittal plane: CHA, CVA and shoulder angle. Frontal plane: Head and shoulder angle.	Significantly changes at CHA while carrying 10% and 15% BW compared to baseline condition.	Intermediate
Mohan et al. (2007)	60	10-15	10	Sagittal	CHA, CVA, Sagittal Shoulder Posture (SSP)	A significant change in CVA was found when loading backpack load of 10% BW compared to the baseline condition.	Intermediate
Ramprasad et al. (2010)	200	12	5, 10, 15, 20, 25	Sagittal	CVA, head on neck (HON), head and neck on trunk (HNOT), trunk, and lower limb angles.	The CVA changed significantly after 15% BW load.	Intermediate

Authors (year)	N	Age (years old)	Load (% BW)	Plane	Outcome measures	Results/ Conclusions	Quality of evidence
Singh & Koh (2009)	15	10	10, 15, 20	Sagittal	TFL	A significant change in TFL while carrying a backpack load of 10%, 15%, and 20% BW compared to no backpack. Load above 20% BW should be avoided.	Intermediate
Talbott (2005)	40	12	10, 20	Sagittal	Changes of body markers at ankle, knee, hip, shoulder, temporal	Significant changes in the shoulder, hip, ankle and temporal angles while carrying a backpack of 10% and 20% BW compared to no backpack.	Intermediate

CHA - cranio-horizontal angle, CVA - cranio-vertebral angle, TFL - trunk forward lean, LA – lordosis angle, HON - head on neck, HNOT - head on neck on trunk, SPP - sagittal shoulder posture, BW - body weight

2.6.2 Musculoskeletal pain

The relationship between backpack use and musculoskeletal pain among children and adolescents is a controversial issue in the literature. Various methods have been used to measure pain as shown in Table 2.20. Although many studies observed a significant relationship between carrying heavy backpacks and musculoskeletal pain (Karen Grimmer & Williams, 2000; Negrini, Politano, Carabalona, Tartarotti, & Marchetti, 2004), there were others that refuted the association (Whittfield, Legg, & Hadderly, 2005; Young et al., 2006). Further investigation is required to determine the association.

Table 2.20: The association between backpack carriage and musculoskeletal pain

Authors	N	Age (years)	Method	Results/Conclusions	Quality of evidence
Grimmer & Williams (2000)	1,193	8-12	Digital electronic scale, Questionnaires	Pain was associated with the backpack load and time spent carrying it.	Intermediate
Mohd Azuan et al. (2010)	100	8 and 11	Self-administered questionnaires	School backpack load influenced the prevalence of MSDs.	Intermediate
Negrini et al. (2004)	Not stated	10-12	Questionnaires.	Backpack load was associated with pain.	Intermediate
Navuluri & Navuluri (2006)	61	12-13	Borg Scale, questionnaires.	The positive, significant correlation between pain and backpack load.	Intermediate
Syazwan et al. (2009)	229	8 and 11	Self-administered questionnaires	Students with heavy backpack loads had higher risks in developing MSDs.	Intermediate
Skaggs et al. (2006)	1,540	11-14	Questionnaires.	Back pain associated with a heavy backpack.	Intermediate
Siambanes et al. (2004)	3,498	11-15	Digital electronic scale, Questionnaires	Significant association between carrying backpack with back pain.	Intermediate
Whittfield et al. (2005)	140	13-14	Nordic Musculoskeletal, Questionnaires	No association between backpack weight and back pain.	Intermediate
Young et al. (2006)	184	11-12	Questionnaires, scale.	No association between back pack weight and back pain.	Intermediate

2.6.3 Discomfort

Beside musculoskeletal pain, there were also efforts to assess discomfort while carrying the school backpack through various methods (Table 2.21). The findings were inconsistent between studies where some literatures reported significant association between backpack carriage and discomfort (Chiang et al., 2006; Jacobson, Cook, Altena, Gemmell, & Hayes, 2003) while the recent literatures refuted such associations (Dockrell, Simms, & Blake, 2015; Rai & Agarwal, 2014).

Table 2.21: The association between backpack carriage and discomfort

Authors	N	Age (years)	Methods	Results/Conclusions	Quality of evidence
Chiang et al. (2006)	100	13-14	Questionnaires	Backpack carriage may cause musculoskeletal discomfort in adolescents.	Intermediate
Dockrell et al. (2015)	529	9-11	Body Discomfort Chart (BDC) and Visual Analogue Scale (VAS)	None of the physical factors (absolute/relative schoolbag weight, carrying an additional item, duration of carriage, method of travel to school) were associated with schoolbag-related discomfort.	Intermediate
Jacobson et al. (2003)	16	18-23	VAS	Significant differences in shoulder, neck and lower back discomfort for 2 weeks measurement.	Intermediate
Negrini & Carabalona (2002)	237	11	Questionnaires	Daily backpack carrying is a frequent cause of discomfort in schoolchildren although the relationship is not direct.	Intermediate
Rai & Agarwal (2014)	300	10-13	Questionnaires, BDC	No significant differences of postural discomfort in neck, shoulder, arms, finger, leg, knees and toes but in the upper back and lower back same discomfort found due to heavy backpacks.	Intermediate

BDC - Body Discomfort Chart, VAS - Visual Analogue Scale

2.6.4 Other effects of backpack carriage

Other impacts related to carrying heavy school backpacks are also reported in the peer-reviewed literature such as changes in gait (Hong & Brueggemann, 2000; Małgorzata, Anna, Beata, & Krzysztof, 2006), reduced lung function (Bygrave et al., 2004; Chow, Ting, Pope, & Lai, 2009), increased blood pressure (Hong et al., 2000), spinal curvature (Goodgold et al., 2002; Hong & Li, 2001), injuries and deformities (Carri & John, 2006; Youlian Hong & Cheung, 2003; Lohman & Wang, 2002), reduced stability while standing and walking (Ou, 2010; Rugelj & Sevšek, 2011), increased oxygen consumption, heart rate and pulmonary capacities (Hong & Brueggemann, 2000; Kristin, Daniel, & Amanda, 2004; Liu, 2007), increased risk of musculoskeletal pain and/or discomfort (Golriz & Walker, 2011; Simpson et al., 2012), increased muscle activity (Bauer & Freivalds, 2009; Mackie & Legg, 2008; Pedersen, Stokke, & Mamen, 2007) and so forth. These fields still require further investigation as the findings had failed to obtain consensus.

2.7 Biomechanics

Biomechanics is a study of forces and their effects on living systems (McGinnis, 2013). The application of biomechanics principles to humans may improve the performance or treatment of injury or reduce it (Knudson, 2003). Numerous biomechanics studies were conducted in backpack use such as posture responses (Brackley et al., 2009; Hong & Cheung, 2003; Sharifah & Azmin, 2011), gait pattern (Chow et al., 2005; Song, Yu, Zhang, Sun, & Mao, 2014; Songab, Yuc, Zhangab, Sunab, & Maoab, 2014), pressure under the foot (GRF) (Gillet, Leteneur, & Barbier, 2007; Shasmin et al., 2006; Singh & Koh, 2009b; Watanabea & Wang, 2013) and

muscle activity (EMG) (Al-Khabbaz, Shimada, & Hasegawa, 2008; Bauer & Freivalds, 2009; Cook & Neumann, 1987)

2.8 Summary

The literature search in this study identified many gaps in the backpack study that calls for further investigation. However, this study focuses on children's characteristics (age, gender, BMI) as well as load and placement of the backpacks. A systematic review is required to identify the appropriate protocols to be used in the main study in Malaysia. The methods used and results of the systematic review are presented in Chapter 3.

CHAPTER 3

SYSTEMATIC REVIEW

3.1 Introduction

Normal posture is difficult to define as everyone has a unique anthropometric and biomechanical profile (Trew & Everett, 2001). The ideal standing posture in the sagittal plane includes consideration of a straight line that passes through the ear lobe, the seventh cervical vertebra, the acromion, the greater trochanter, just anterior to the midline of the knee and slightly anterior knee and lateral malleolus (Kendall, McCreary, Provance, Rodgers, & Romani, 2005). Postural deviation refers to any deviation from this ideal posture. Placing an excessive load on the back, as occurs when carrying a backpack, commonly causes postural deviations (Karen Grimmer et al., 2002), musculoskeletal pain (Iyer, 2001, 2002; Koroivessis et al., 2005) and may contribute to deformities such as scoliosis, kyphosis and lordosis (Koroivessis et al., 2005; Lai & Jones, 2001). Some studies have reported that low back pain in childhood is a strong predictor of persistent low back pain in adulthood (Brattberg, 2004; Hestbaek et al., 2006).

Over the last 15 years, efforts have been made to set a safe load limit for students, but universal safe limits remain elusive, due to inconsistent results from scientific articles (Lindstrom-Hazel, 2009). Most studies have found that an acceptable load limit for school children is between 10% to 15% of their body weight (BW) (Bauer & Freivalds, 2009; Brackley & Stevenson, 2004; Kistner et al., 2012), though some studies have suggested it should not exceed 10% BW (Hong & Brueggemann, 2000; Mohan et al., 2007). Despite this, students often have to carry more than 15% of their BW (Negrini & Carabalona, 2002; Pascoe, Pascoe, Wang, Shim, & Kim, 1997) as there is no legislation to protect them such as that applied to adults in occupational or workplace settings. This is particularly alarming for students, who are yet to develop mature musculoskeletal systems and are therefore vulnerable to injury.

In addition to the weight of a heavy backpack, backpack placement may also contribute to postural deviation. Literature indicates that carrying a backpack at different locations affects the spinal muscles and, therefore, affects posture in both children and adults (Devroey et al., 2007; Fiolkowski et al., 2006; Karen Grimmer et al., 2002). It is crucial to investigate where best to position the backpack on the spine because at present there are no clear guidelines regarding this matter (Brackley et al., 2009; Chow, Ou, Wang, & Lai, 2010). Although numerous studies have been carried out to identify the effects of backpack carriage on posture, there are no studies that identify and appraise the research evidence, in order to recommend the most appropriate position for the backpack on the back, particularly in school-aged students. The primary purpose of this systematic review is to investigate the effects of backpack load and placement on postural deviation in healthy students.

3.2 Methods

3.2.1 Search strategy

A 'Problem, Intervention, Comparison and Outcomes' (PICO) search strategy was used to identify articles published until June 2012. Searches of eight databases related to this area were performed i.e. Medline, Cochrane Database, Allied and Complementary Medicine (AMED), CINAHL, Scopus, PubMed and Google Scholar.

The search strategy employed was as follows:

- a) Keywords: (child* OR "school child*" OR adolescen* OR student*) AND (backpack* OR "school bag*" OR "school backpack") AND ("load place*" OR "centre of mass") AND (posture* OR deviation OR "postural deviation*")
- b) Inclusion criteria: studies on static standing posture in healthy participants aged between 6 and 12 years.
- c) Exclusion criteria: Studies that include participants with spinal abnormalities (scoliosis, kyphosis or lordosis).
- d) Included study design: All study designs included.
- e) Outcomes measures: Measuring the effect of load and placement on the postural deviation.
- f) Publications: Published in English.

3.2.2 Hierarchy of evidence and quality appraisal

Articles were filtered based on the appropriateness of the title and whether the set criteria were met. The level of evidence of each article was determined based on National Health and Medical Research Council Evidence Hierarchy (NHMRC, 2009)

as illustrated in Table 3.1. Since articles in this area were extremely limited, we decided to accept all levels of evidence as long as the articles met the criteria.

Table 3.1: Hierarchy of evidence (NHMRC, 2009)

Level I	Systematic review
Level II-1	Randomised control trial
Level III-1	Pseudo randomised controlled trial (i.e. alternate allocation or some other method)
Level III-2	A comparative study with concurrent controls: <ul style="list-style-type: none"> ▪ Non-randomised, experimental trial ▪ Cohort study ▪ Case-control study ▪ Interrupted time series with a control group
Level III-3	A comparative study without concurrent controls: <ul style="list-style-type: none"> ▪ Historical control study ▪ Two or more single arm study¹⁰ ▪ Interrupted time series without a parallel control group
Level IV	Case series with either post-test or pre-test/post-test outcomes

The quality of each article was appraised using a PEDro (Appendix 6) scale as this is the premier scale in this field to appraise articles. Since five articles reviewed were non-RCT, the scale was modified by removing three blinding criteria from the original scale. Precedents for modification of the PEDro scale have previously been reported by Slade and Keating in their systematic review paper (Slade & Keating, 2007) because it was not possible to blind therapists while they were administering exercise. In this case, it is very difficult to blind students to wearing and not wearing a backpack. We followed the Slade and Keating (2007) criteria and removed three criteria, leaving seven criteria because no score was given for eligibility criteria, as these were clear. Answers were scored 0 or 1 for each criterion. The final scale

consists of 7 items with a maximum score of 7. Higher scores indicate a higher quality.

To further strengthen our assumption, quality of non-randomised articles were also appraised using D&B scale (Downs & Black, 1998). This checklist has been used to examine the quality of randomised and non-randomised control articles (Cappuccio, D'elia, Strazzullo, & Miller, 2010; S. C. Gorber, Tremblay, Moher, & Gorber, 2007; McMillan & Payne, 2008). There are 27 items to be answered in this checklist, reporting (10 items), external validity (3 items), bias (7 items), confounding (6 items), and power (1 item) as depicted in Appendix 7. Answers were scored 0 or 1, except for one item in the reporting subscale, which scored 0 to 2 and the single item of power, which was scored 0 to 5. However, we used a modified checklist because not all items in the original checklist related to this review (Gorber, Tremblay, Moher, & Gorber, 2007).

The quality appraisal score using modified Downs and Black checklist does not included items 5 and 8 in the reporting scale, items 11, 15 and 19 in the section on a bias, 21-26 relating to confounding and item 27 addressing power (Appendix 8). Answers were scored 0 or 1 for each item. The final checklist consists of 15 items with a maximum score of 15 points. Higher points indicate higher quality. Any dispute was resolved by discussion to obtain consensus.

3.3 Results

3.3.1 Literature search

Initially, seventy articles were identified by using all combinations of keywords; sixty-two from databases and eight from Google scholar (Table 3.2).

Table 3.2: Results of literature search

#	Keyword	Search results from database						
		PubMed	Medline	AMED	Cochrane (RCT)	Cochrane Systematic Review	Scopus	CHINAHL
1	Child*.mp.	1625995	649064	15874	52246	2943	3030723	288940
2	“School child*”.mp.	355	6055	229	1725	123	229113	1988
3	Adolescen*.mp.	1361238	601568	3333	68702	719	1836761	175802
4	Students.mp	153675	83318	5443	8719	302	586857	82689
5	1 OR 2 OR 3 OR 4	2413079	1013060	22349	105186	3148	4135389	441607
6	Backpack*.mp.	464	353	71	30	3	2493	274
7	“School bag*”.mp	18	18	6	0	0	152	11
8	“School backpack*”.mp	13	9	4	1	0	66	15
9	6 OR 7 OR 8	477	366	76	30	3	2552	280
10	“Load place*”.mp.	1118	48	14	13	0	437	12
11	“Centre of mass”.mp.	433	348	85	8	2	5276	49
12	10 OR 11	1551	385	97	21	2	5712	60
13	Posture.mp	61379	24346	4481	3176	124	115927	6324
14	“Postural deviation”.mp.	39	26	6	3	0	118	7
15	14 OR 15	61394	24354	4483	3177	124	115972	6327
16	5 AND 9 AND 12 AND 15	2	1	1	0	0	39	19

After screening the titles, only eleven articles were considered relevant to the topic. Chow et al. (2006) has been excluded from this review as participants had idiopathic scoliosis. Devroey et al. (2007) and Frank et al (2003) were removed because the age of the participants was more than 12 years old and the paper was not fully published. Three articles (Abe, Yanagawa, & Niihata, 2004; Chow et al., 2009; Zultowski & Aruin, 2008) were excluded as their studies were not related to postural deviation (Figure 3.1). From the remaining, only five articles (Brackley et al., 2009; Chow et al., 2010; Karen Grimmer et al., 2002; Singh & Koh, 2009a; Talbott, 2005) were considered appropriate for inclusion.

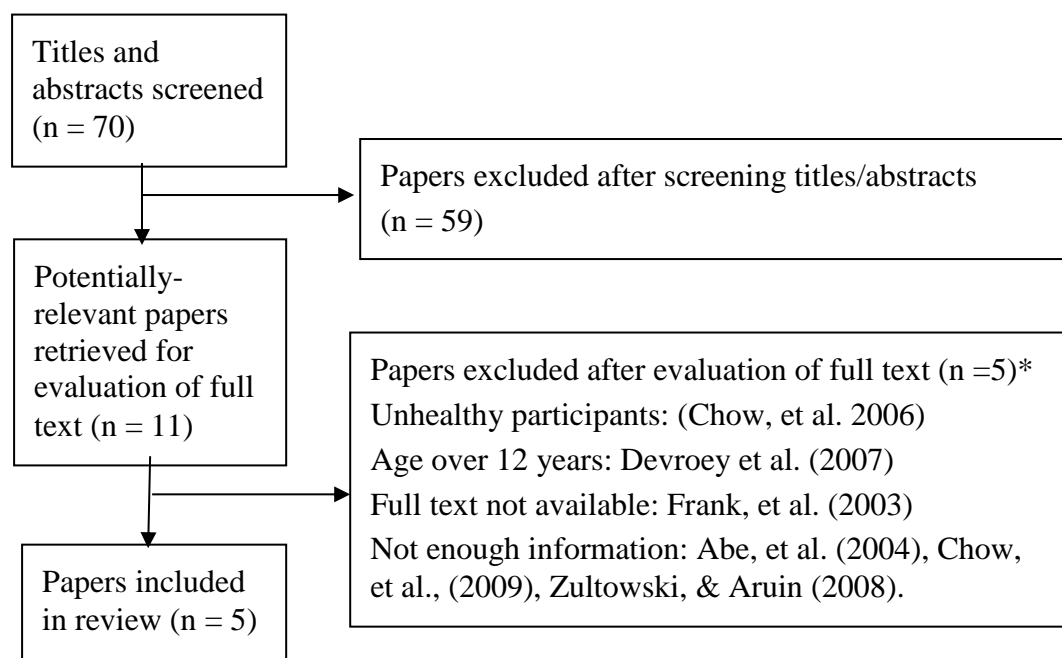


Figure 3.1: Flow of screening the literatures

* Papers may have been excluded for failing to meet more than one inclusion criteria.

3.3.2 Hierarchy of evidence and quality appraisal

Search results show the scarcity of articles from the Level I and II NHMRC levels (2009) regarding the effects of backpack load and placement on postural deviation in healthy students. Only one article was found when criteria were limited to these levels. However, as there is such a limited amount of research information on this topic, we decided to include all levels of evidence. By using a modified PEDro scale, the randomised control article has been classified as high-quality and non-randomised classified as medium and low as shown in Table 3.3.

Table 3.3: Results of the quality appraisal using the modified PEDro scale

Authors	Eligibility criteria	Randomly allocated	Allocation was concealed	Similar at baseline	More than 85% of the subjects	Intention to treat	Between group statistics comparisons	Point measures and measures of variability	PEDro Score (Modified)	Quality
Brackley et al. (2009)	1	0	0	1	1	0	1	1	4/7	Intermediate
Chow et al. (2010)	1	0	0	0	1	0	1	1	3/7	Low
Grimmer et al. (2002)	1	1	0	1	1	0	1	1	6/7	High
Singh et al. (2009)	0	0	0	0	1	0	1	1	3/7	Low
Talbott (2005)	1	0	0	1	1	0	1	1	4/7	Intermediate

* No score was given for eligibility criteria

When the non-randomised control articles were reappraised using the Downs & Black checklist, all were classified as intermediate as shown in Table 3.4.

Table 3.4: Results of quality appraisal using the modified Downs & Black checklist

Authors	Scores (value)				Quality
	Reporting (8)	External validity (3)	Internal validity (4)	Total (15)	
Brackley et al. (2009)	6	0	4	10	Intermediate
Chow et al. (2010)	6	0	4	10	Intermediate
Singh & Koh (2009)	6	0	4	10	Intermediate
Talbott (2005)	7	0	4	10	Intermediate

Due to the parameters used varies between studies, meta-analysis using forest plots to assess the clinical importance of the evidence is irrelevant.

3.3.3 The effects of load on postural deviation

The purpose of investigating the effect of load on posture was to determine how heavy the load lifted can cause significant postural deviation. Despite the various outcome measures used, all were still related to postural measurement. As illustrated in Table 3.5, most articles reported that the increase in backpack load may lead to postural deviation compared to unloaded conditions (baseline posture).

Table 3.5: Summary of reviewed literature

Author/ Date/ Study location	Mean Age (years) \pm SD	N	Study Type	Purpose/Hypotheses	Baseline (Standstill)	Follow-up (Standstill)
Brackley et al. (2009) Canada	10	5 M 10 F	Self- controlled Repeated Measures.	To examine the effects of load placement (higher, middle, and lower) on posture, specifically trunk forward lean (TFL) posture, head on neck (CVA) postures and lordosis angle (LA) for standing and walking in pre-pubescent children.	Weight: 0% BW. Placement: Not stated in article but personal communication High (\pm 26.3 cm above L5) Middle (between higher and lower) Low (\pm 10.3 cm above L5).	Weight: 15% BW. Placement: High Middle Low
Chow et al. (2010) Hong Kong	11.4 \pm 0.5	11M 8F	Repeated Measures.	To investigate the effects of different backpack placements on spinal deformation and repositioning error in schoolchildren.	Weight: 0% BW. Placement : High (T7), Middle (T12), Low (L3).	Weight: 15% BW Placement: High, Middle, Low.

Author/ Date/ Study location	Mean Age (years) \pm SD	N	Study Type	Purpose/Hypotheses	Baseline (Standstill)	Follow-up (Standstill)
Grimmer et al.(2002) Australia	12.9 \pm 0.5 12.8 \pm 0.5 13.8 \pm 0.4 13.8 \pm 0.5 14.9 \pm 0.6 14.8 \pm 0.5 15.8 \pm 0.6 15.8 \pm 0.5 16.7 \pm 0.5 16.8 \pm 0.5	25 M 25 F 25 M 25 F 25 M 25 F 25 M 25 F 25 M 25 F	Randomised Controlled.	To describe the effects on adolescent sagittal plane standing posture of different loads and positions of a common design of school backpack. The underlying study aim was to test the appropriateness of two adult 'rules-of-thumb'-that for postural efficiency, backpacks should be worn high on the spine, and loads should be limited to 10% of body weight.	Weight: 0% BW. Placement: High (T7) Middle (T12) Low (L3).	Weight: 3%, 5% BW and 10% BW. Placement: High Middle Low.
Singh & Koh (2009) Singapore	9.65 \pm 1.58	17 M	Repeated Measures.	To analyze how different load weights and the vertical positioning of these loads on the back affect trunk forward lean and spatiotemporal parameters and also how these variables in turn possibly affect balance during gait.	Weight: 0% BW. Placement: High (superior to T8-T9), Low (inferior to T8-T9).	Weight: 10%, 15% and 20% BW. Placement: High, Low.
Talbott (2005) (USA)	12.5 12.3	11 M 29 F	Repeated Measures.	To identify differences in the postural balance and posture of adolescents during static and dynamic activities with and without backpacks.	Weight: 0% BW. Placement: High (C7), Low (inferior angle of the scapula).	Weight: 10% and 20% BW. Placement: High, Low.

Article	Main outcome measures	Posture response to load (standstill condition)	Posture response to placement (standstill condition)	Conclusion
Brackley et al. (2009)	TFL CVA LA	0% vs. 15% BW (***). 0% vs. 15% BW (**). No significant differences between loads.	No significant differences between placements.	Using backpack with 15% BW cause significant changes of TFL and CVA. Backpacks should be placed lower on the spine.
Chow et al. (2010)	Cervical, higher and lower thoracic, higher and lower lumbar, pelvic tilt angles	0% BW vs. 15% BW (*)	Significant differences between placements (*) except pelvic tilt.	No conclusion for load limit. Higher position may cause more deviation compared to middle and lower.
Grimmer et al. (2002)	Coordinate of anatomical points (tragus of ear, spinous process C7, mid acromion shoulder, lateral superior iliac crest greater trochanter and mid joint knee)	0% vs. 3%, 5%, 10% BW (*).	Position backpack on the higher location produced largest deviation at all anatomical points (*) except greater trochanter and mid joint knee.	Could not find evidence that loads should be limited to 10% BW. Higher position may cause more deviation compared to middle and lower. Typical school backpacks should be positioned with the centre of backpack at waist or hip level.
Singh & Koh (2009)	Trunk forward lean (TFL) angle	0% vs. 10% , 15%, 20% BW (***) 10% BW vs. 20% BW (*).	Significant differences between placements (*).	Loads above 15% BW should be avoided. Higher position may cause more deviation compared to lower.

Author/ Date/ Study location	Mean Age (years) \pm SD	N	Study Type	Purpose/Hypotheses	Baseline (Standstill)	Follow-up (Standstill)
Talbot (2005)	Right and left ankle, left knee, right and left hip angles	A/P,	No significant differences between loads.	No significant differences between placements.	Loads above 20% BW should be avoided. Higher position may cause more deviation compared to lower.	
		M/L,				
		S/I				
	Right knee angle	A/P	0% vs. 10%, 20% BW (*).	No significant differences between placements.		
		M/L	0% BW vs. 20% BW (*).			
		S/I	0% vs. 10%, 20% BW (**), 10% vs. 20% BW (**)			
	Right shoulder angle	A/P	0% vs. 10%, 20% BW (**), 10% BW vs. 20% BW (**).	No significant differences between placements. High vs. Low (**).		
		M/L	No significant differences between loads.			
		S/I	0% vs. 10%, 20% BW (**) 10% BW vs. 20% BW (**).			
	Left shoulder angle	A/P	0% vs. 10%, 20% BW (**),	No significant differences between placements.		
		M/L	10% BW vs. 20% BW (**). No significant differences between loads.			

Author/ Date/ Study location	Mean Age (years) \pm SD	N	Study Type	Purpose/Hypotheses	Baseline (Standstill)	Follow-up (Standstill)
Talbot (2005)	Right temporal angle	S/I	0% vs. 10%, 20% BW (**), 10% BW vs. 20% BW (**).			
		A/P	0% vs. 10%, 20% BW (**), 10% BW vs. 20% BW (**).		High vs. Low (**).	
		M/L	No significant differences between loads		No significant differences between placements.	
		S/I	0% vs. 10%, 20% BW (**), 10% BW vs. 20% BW (**).		No significant differences between placements.	
	Left temporal angle	A/P	0% vs. 10%, 20% BW (**), 10% BW vs. 20% BW (**).		High vs. Low (**).	
		M/L	0% vs. 20% BW (*).		No significant differences between placements.	
		S/I	0% vs. 20% BW (*).			

(*) - $p < 0.05$, (**) - $p < 0.01$, (***) - $p < 0.001$, BW - Body weight; (A/P) - Anterior/Posterior, (M/L) - Medial/Lateral, (S/I) - Superior/Interior, TFL - trunk forward lean, CVA - cranio-vetebal angle, LA - lordosis angle, M - male; F - female; C - cervical; T - thoracic; L3 - lumbar

The uses of different loads between studies make it difficult to get consensus on the appropriate load limit for students. Grimmer et al. (2002) have reported that carrying a backpack at 3% BW had caused postural deviation in all measured parts; i.e. tragus of the ear, spinous process C7, mid acromion shoulder, lateral superior iliac crest, greater trochanter and mid joint knee. However, no significant deviation was found while carrying 10% BW load compared to less weight. Thus, they could not support the recommendation that suggests the load should be limited to 10% BW for adolescents.

In contrast, Singh & Koh (2009) found significant differences in TFL while carrying 10% BW compared to postural without backpack whilst Talbott (2005) had reported, out of ten locations measured, only three (right shoulders and both temporals) had shown significant postural deviation while carrying 10% BW. Brackley et al. (2009) and Singh & Koh (2009) used TFL to measure postural deviation but failed to get consensus due to the use of different loads (10%, 15%, and 20% BW). Results from Brackley et al. (2009) and Chow et al. (2010) strengthen the studies that lifting 15% BW caused postural deviation. In addition, Talbott's (2005) recommendation to avoid carrying 20% BW supported the likelihood that appropriate load limits for children are below 15% BW.

3.3.4 The effects of load placement on postural deviation

The purpose of investigating the effect of placing the centre of the backpack on various positions on the back was to propose the best location to place backpacks for students in order to reduce the students' postural deviation. Comparisons were made

based on whether significant postural deviation was detected when the backpack was placed in three different locations on the back; high, middle and low. The effect of load placement on postural deviation was inconsistent across the articles, as shown in Table 3.5.

Although there were no significant differences reported by Brackley et al. (2009), placing the backpack at a lower location appears better than higher and middle positions in terms of reducing postural deviation at TFL and CVA. In addition, Grimmer et al. (2002) reported that regardless of location, backpack weight caused significant postural deviation except the greater trochanter and mid join knee. Chow et al. (2010) also reported significant postural deviation in all parts measured except pelvic tilt.

Another study by Talbott (2005) reported that postural deviations, especially in the right shoulder and head, were detected when placing the backpack in different locations. Even though Singh & Koh (2009) studied the effects of placement on TFL in static and dynamic conditions, less explanation was given in static postures. In summary, all articles reported that placement on the lower back reduced postural deviation compared to higher and middle positions. The best location to place the backpack involves less postural deviation because there are studies reporting that even small deviations from the normal posture may result in adverse mechanical tension in the central nervous system (Harrison, 1992).

3.4 Discussion

This systematic review shows that there is a lack of quality information on what maximum load should be carried by students and where the backpack should be placed on their backs. The load limit for students seems to meet the consensus that loads should be limited to 10% - 15% of BW (Brackley & Stevenson, 2004). The studies that have been performed relating to safe backpack loads were not only related to the changes in posture but also to direct effects of backpack loads on children such as oxygen consumption, blood pressure, energy consumption (Hong et al., 2000), heart rate (Bauer & Freivalds, 2009; Hong & Brueggemann, 2000), cardiorespiratory (Daneshmandi et al., 2008), pulmonary function (Danial et al., 2005) and gait pattern (Hong & Brueggemann, 2000).

According to Talbott (2005), legislation of load limits is difficult to establish because of the lack of studies on the acute and chronic effects of backpack use. Furthermore, to establish a policy on universal load limits, both static and dynamic conditions must be analysed in order to understand the whole picture related to posture (Brackley et al., 2009). There remain inconsistent results between scientific articles as to the maximum amount and the influence of backpack loads. For example, does a load of 10% of body weight for a 6-year-old weighing 20 kg have the same effect on the posture of 10% body weight of a 12-year-old weighing 45kg? Is there a difference between children who have lower and higher Body Mass Index (BMI)? (Bauer & Freivalds, 2009). These questions should also be considered in order to propose appropriate load limits for healthy school age students.

The issue of best backpack placement requires further investigation. There is no consensus of information concerning whether to carry it high on the back, in the middle of the back or lower. This is further hampered by the inconsistency of definition of positions (high, middle and low) on the back. Some authors (Chow et al., 2010; Karen Grimmer et al., 2002) are very specific about their terminology and placement, whereas others are less precise (Brackley et al., 2009; Devroey et al., 2007) specifying only a region of the back. However, it is impossible to analyse all six studies together, as the classifications of higher, middle and lower positions are inconsistent, and, in some cases, the lower placement in one study is the higher placement in another.

Unfortunately, the inconsistency of results is of concern. Furthermore, it may be that backpack placement is related to the individual - where the child's centre of gravity is situated, or related to age or body structure (endomorph vs. ectomorph body types for example). Current evidence recommends that children should carry backpacks that are less than 10% BW, but absolutely below 15% BW. It is difficult to recommend the best location to place the backpack on the back, but the best evidence suggests that the backpack should be positioned with the centre of the backpack at waist or hip level (closer to the centre of body mass). However, more high-quality studies are required to support the current evidence in order to establish universal guidelines or legislation. This means that further work is required, but that lower limits should be adhered to as the best practice.

At present, in term of articles on load limit and posture, only one study (Karen Grimmer et al., 2002) is considered the highest in quality by a long way, despite the

age of the article. The evidence on the effect of load placement on the postural deviation in students is limited, with the majority of articles categorized as an intermediate hierarchy of evidence. The results between articles were also inconsistent because some articles found statistically significant differences but some did not find significance between placements. This may be due to different outcome measures and different definitions between articles of position (high, middle, and low) where the backpack was placed on the back (Table 3.5). As to the load limit, the locations of loads on the back also need consistent results on both standstill and dynamic posture's before a universal guideline can be established. Thus, we would support the recommendations that further study on larger populations and stratified age ranges are performed (Brackley et al., 2009; Talbott, 2005).

3.5 Limitations

Our review is limited to the articles published in English. Since there is no standard approach for measuring posture (McEvoy & Grimmer, 2005), the use of different measures between articles may have also contributed to inconsistent findings.

3.6 Conclusions

In conclusion, the findings on the determination of the load limit in children associated with the postural deviation are still not consistent. The literature shows that placing a backpack of less than 15% BW on the back may cause postural deviation, and even high-quality articles also reported that postural deviation occurred at as little as 3% BW. Based on the most current literature (Bauer & Freivalds, 2009; Ramprasad, Alias, & Raghuveer, 2010), students should not carry more than 15%

BW. To date, there is no consensus as to the best position on the back to carry a backpack. This is mainly due to the inconsistency of definition of backpack position. However, based on the best available evidence it appears that carrying a backpack with the weight centred between the third and fifth lumbar (L3-L5) is recommended.

3.7 Suggestions for Future Research

Both load limit and load placement are still open issues to be debated. Although several studies attempted to identify the appropriate load limit by studying the load and posture, most of them are classified under low quality of evidence. Studies on load placement seem more complicated due to inconsistent definition of the position of the load on the back. More rigorous studies are required to protect backpack users from immediate and future musculoskeletal problems. Priority should be given to school-aged children because they are at risk of musculoskeletal-related problems and their risk remains uncertain in terms of the long-term implications of these problems (Jones & Macfarlane, 2005).

CHAPTER 4

FEASIBILITY STUDY ON THE EFFECTS OF BACKPACK LOADS AND PLACEMENTS ON POSTURAL DEVIATION IN HEALTHY SCHOOL CHILDREN

4.1 Introduction

Studies on the effects of children's backpacks continue to receive attention from researchers despite it being extensively discussed over the past decade (Aundhakar et al., 2015; Haisman, 1988; Knapik et al., 1996). This concern has a strong basis because scientific literature has revealed significant associations between carrying heavy backpacks and its immediate or future health effects on children, including musculoskeletal pain (Dianat et al., 2014; Iyer, 2001), as well as physiological (Hong et al., 2000; Legg & Cruz, 2004), biomechanical (Connolly et al., 2008; Milanese & Grimmer-Somers, 2010) and psychosocial effects.

Prior literature has consistently reported that carrying heavy backpacks may contribute to postural deviation (Al-Khabbaz et al., 2008; Chansirinukor, Wilson, et al., 2001; Hung-Kay Chow et al., 2011). Such reports have raised much concern as until today, the load limit for school children is still inconsistent between studies. A review of the literature found that the recommended load limits for children and adolescents range between 5% and 15% BW (Brackley & Stevenson, 2004).

However, several studies proposed it less than 10% BW (Al-Hazzaa, 2006; Zachary, David, Jennife, & Catherine, 2010) and below 20% BW (American Academy of Pediatrics, 2002; American Occupational Therapy Association, 2012). Furthermore, recent literature argued that general guidelines on the correct backpack carriage might be more appropriate compared to proposing the load limit (Dockrell, Simms, & Blake, 2013).

Apart from the heavy load, the placement of backpacks on the back may also contribute to postural deviation (Brackley et al., 2009; Dreier, Hignight, Palmer, Roberts, & Sorell, 2014). Prior literature suggested that placing the backpack at the lower part of the back may minimize postural changes compared to higher placements (Devroey et al., 2007; Talbott, 2005). In contrast, another study claimed that placing the backpack lower down the back might cause significant changes to the head lean compared to higher placements (Frank et al., 2003). To date, no consensus has been reached on the appropriate location for placing of the backpack. A meta-analysis of past studies to formulate a conclusion is also unsuitable because the placements suggested vary between studies, i.e. between T12 and L5.

The purpose of the current feasibility study was to test the protocol to be used in the main study. Following the systematic review, we chose to replicate the protocol established by Grimmer et al. (2002), as this study showed the highest level of evidence as well as a reproducible protocol. The protocol was modified and modernised, besides being tested for feasibility prior to data collection amongst school children in Malaysia in the main study. Moreover, this study also intends to test the reliability of the rater employed to measure all postural angles. Reliability in

taking measurements is a crucial aspect in quantitative research because it will determine the precision of measurements in the actual study. In addition, it also intends to identify problems prior to the commencement of the main study.

4.2 Objectives

4.2.1 General objective

To test the feasibility of the study protocol prior to data collection amongst school children in Malaysia.

4.2.2 Specific objectives

- a) To compare the three baseline postural angles.
- b) To determine the reliability of the rater in measuring postural angles.
- c) To identify the effects of load and placement on postural deviation.
- d) To determine the correlation between gender, age and BMI with postural deviations.
- e) To determine the association between gender, age and BMI with perceptions of discomfort.
- f) To appraise the techniques to be used in the main study particularly on getting approval from the authorities, participants' recruitment, the accuracy of positioning body markers and backpack placement and how to avoid postural sway.

4.3 Hypotheses

- a) There will be no significant differences between the three baseline postural angles.
- b) There will be no reliability of the rater in measuring postural angles.
- c) There will be no significant changes in postural angles when carrying the backpack at different loads and placements compared to the baseline condition.
- d) There will be no significant correlation between gender, age and BMI with postural deviations.
- e) There will be no significant association between gender, age and BMI with perceptions of discomfort.

4.4 Methodology

4.4.1 Study design

In the present study, all participants were measured under nine different conditions in random order based on the Latin square pattern. Based on this condition, the design of this study is called repeated measures (Portney & Watkins, 2000).

4.4.2 Study location

The study was conducted at the Monash University Peninsula Campus (MUPC). Participants comprised the children of the MPUC staff who fulfilled all the inclusion and exclusion criteria listed in section 4.4.4.

4.4.3 Recruitment of the participants

The recruitment process started after obtaining written approval from the Monash University Human Research Ethics Committee (MUHREC) (Appendix 9) and the Attorney General's Office. Invitations to participate were sent to all e-mail users of Monash University, Peninsula Campus. Following an expression of interest, an Explanatory Statement (Appendix 11) and Consent Form (Appendix 13) were sent to the parents or guardians involved. Parents or guardians who expressed interest in joining the study were asked to return the signed Consent Forms via e-mail. Subsequently, another email was sent to verify the date, time and place of measurement. Finally, confirmation of attendance was also made via phone calls a day before the experiment date.

4.4.4 Inclusion and exclusion criteria

Prospective participants must fulfil all the criteria stated in section 4.4.4 (a) and (b). Screening for inclusive criteria was carried out by the researcher while assessment for exclusion criteria was conducted by a professional.

a) Inclusion criteria

- i. Primary school children aged between 6 to 12 years.
- ii. Free from any musculoskeletal diseases or disorders including recent fractures or sprains anywhere in the body.
- iii. Able to stand upright at least 30 minutes.
- iv. Happy to wear biking shorts and tight t-shirts during the experiment.

b) Exclusion criteria

- i. Those with spinal abnormalities such as scoliosis or kyphosis or lordosis.
- ii. Those with any neurological disorders that may affect the normal standing position.

4.4.5 Sampling method

This study involves both quantitative and qualitative data. The participants must meet all the criteria stated in section 4.4.4. Written consent from their parents or guardians is also required. Based on these conditions, the sampling method for this study is called 'convenience sampling', which is one of the non-probability samplings. This sampling method is not necessarily representative of the entire population. The rationale for using this method is because it is fast, inexpensive and easy to be conducted.

4.4.6 Sample size

Sample size calculation for a feasibility study was based on the Journal of Clinical Epidemiology (Cocks & Torgerson, 2013). According to this article, the sample size for the pilot study should have at least 9% of the sample size of the main study which has 80% one-sided confidence interval. Upon calculation, the minimum sample size was determined as 11.

Prospective participants were given a month to respond to invitations to participate in the study. During this period, only eight parents and guardians consented to partake in the study. However, two participants were excluded because they were under

seven years old. The final breakdown of the sample comprised three boys and five girls.

4.4.7 Loads and placements tested

Loads of the backpack carried were calculated based on the weight of each participant, i.e. 5%, 10% and 15% BW. This load range was chosen because it is the range recommended by most of the epidemiological, physiological and biomechanical studies (Brackley & Stevenson, 2004; Dockrell et al., 2013; Kistner et al., 2012). Another reason for choosing this range was due to consistency with previous studies so that current results can be compared with the other findings in future meta-analysis studies.

Unlike the determination of load limit, the literature regarding the load placement is very limited. Even though the upper, middle and lower locations were used in previous studies, the definition of tested placements varies between these studies. Based on the literature search, the placements used by previous researchers ranged between T7 and L5. Thus, it was decided to choose T7, T12 and L3 as these placements were frequently used in the previous studies (Chow et al., 2010; Karen Grimmer et al., 2002). The selection of these placements also allows the results of this study to be used for meta-analysis in the future.

4.4.8 Static condition

The purpose of using a backpack is to transfer loads from one place to another. Therefore, carrying backpacks involve static and dynamic conditions. However, in the first phase of the study, the focus is only on the static condition (standstill). The dynamic condition will be conducted in the second phase because it requires more time, manpower and money.

4.4.9 Equipment

a) Digital weighing scale

A portable digital scale Seca 803 was used to measure the participants' body weight and the loads carried by them while undergone the experiment. The accuracy of the weighing scale was ± 0.1 kg. The weighing scale image is shown in Figure 4.1.



Figure 4.1: The digital weighing scale used to measure the participants' body weight and the backpack loads carried by participants

b) Portable height meter

The portable height meter, with a capacity for measuring heights up to 200cm, was used to measure the participants' height. An image of the said height meter is shown in Figure 4.2.



Figure 4.2: The portable height meter used to measure the participants' height

c) The backpack

Only one backpack was used in the feasibility study. The backpack used is medium-sized, has two soft shoulder straps and only one internal compartment, without an internal frame or chest and waist strap. The backpack straps can be adjusted according to the participants' height so that the centre of the bag is placed according to the tested placements (T7, T12 and L3). A backpack with the above features is used by most primary school children. The image of the backpack is shown in Figure 4.3.



Figure 4.3: The backpack used during the experiment

d) Digital camera and tripods

A digital camera Canon 450D SLR was used to capture the postural angles during the experiment. Two tripods were used for placing the camera as well as to display the identification number of participants. The image of the digital camera and tripod are shown in Figure 4.4.



Figure 4.4: The digital camera and tripod used to capture participants' postures

e) The backpacks placement on the spine

Pebbles were used as loads as a substitute for the books and stationery carried by school children on school days. The justification for using pebbles because easier to measure load to be carried based on participants' body weight compared to books. These loads were weighed and placed in sealed plastic bags of 1 kg, 500 g, 250 g, 100 g and 50 g. Rectangular polystyrenes were placed at the bottom and both sides of the load to ensure it does not move and remains in the middle of the bag. The backpack placement on the spine (T7, T12 and L3), location of pebbles and the centre of the gravity of the backpack for each placement is shown in Figure 4.5.

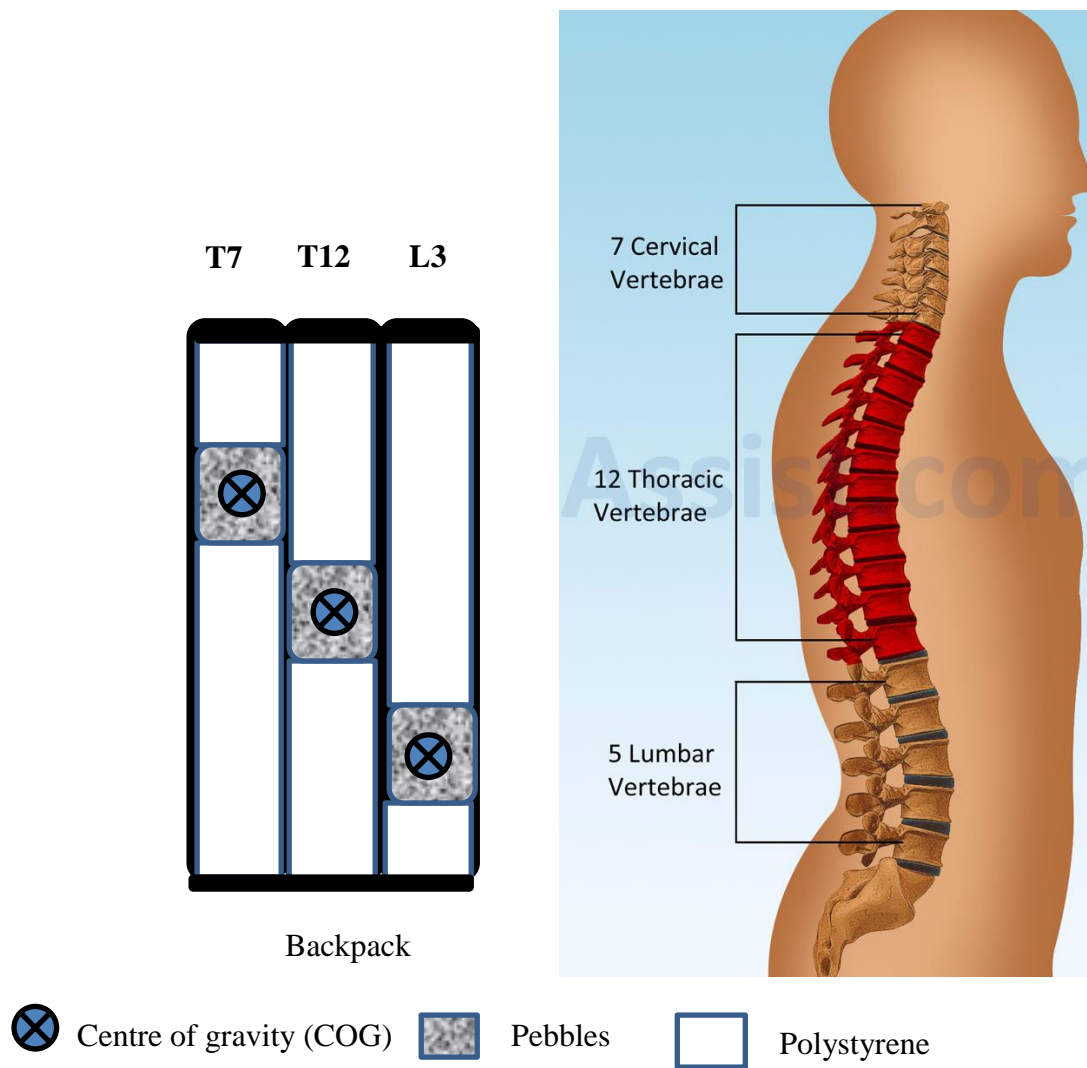


Figure 4.5: Illustration of the backpack placement on the spine (T7, T12 and L3), location of pebbles and the centre of the gravity of the backpack for each placement

f) Attire

Before the experiment, participants were asked to wear biking shorts and a tight t-shirt. However, they were also permitted to wear their preferred attire as long as it was not loose. This criterion is essential to ensure that all body markers attached to the attire did not change locations during inadvertent body movements.

g) Adhesive body markers

Foam balls of approximately 35 mm diameters were used as body markers to detect changes in postural angles. Double-sided tape was used as an adhesive so that the balls remained intact throughout the study period. The balls were placed in the following two planes:

- i. Sagittal plane - the balls placed at the right-hand side canthus of the eye, tragus of the ear, spinous process of C7, greater trochanter, and lateral malleolus.
- ii. Frontal plane - the balls placed at both sides of the tragus, acromion, and pelvis.

The locations of adhesive markers are illustrated in Figure 4.6.

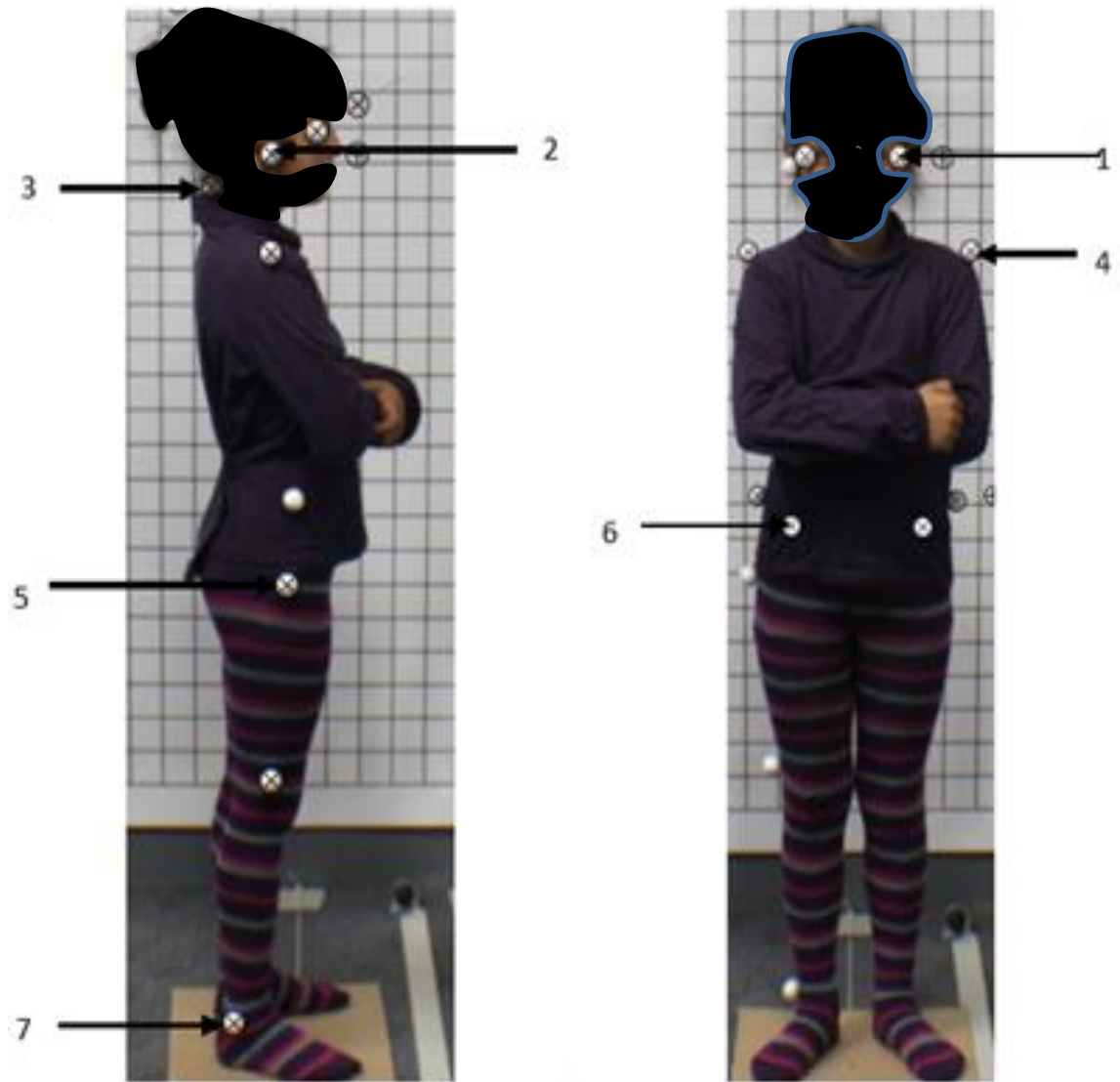


Figure 4.6: Location of adhesive markers

1 - the lateral canthus of the eye, 2 - the tragus of the ear, 3 - the spinous process of C7, 4 - the lateral part of shoulder, 5 - the greater trochanter, 6 - the anterior superior iliac spine, 7 - the lateral malleolus.

h) The UTHSCSA Image Tool program

The UTHSCSA Image Tool, a free image processing and analysis program for Microsoft Windows 95™ or Windows NT™, was developed by a group of researchers from the Health Science Centre, the University of Texas in San Santiago. This programme can be used to analyse dimensions including distance, angles, perimeters, area, as well as grey scale measurements such as point, line and area histogram with statistics. It can be free downloaded from <http://uthscsa-imagetool.software.informer.com/>.

The software has been used by many researchers for measuring postural deviation particularly in biomechanical studies (Karen Grimmer et al., 2002; McEvoy & Grimmer, 2005) particularly to measure changes in coordinates. To diversify methods of measurement, it was decided to measure postural deviation by measuring postural angles as recommended by McEvoy & Grimmer (2005). Postural deviation was determined by comparing postural angles when carrying various backpack loads with the baseline angles (without the backpack). The process of measuring postural angles is described in detail in section 4.4.10 (f).

i) Perceptions of discomfort

Apart from measuring postural deviation, we also measured perceptions of discomfort scores while carrying backpacks with various loads and placements. The aim was to ensure that the load limit and placement recommended by this study should not cause any discomfort or pain to the school children. While perception of discomfort is frequently used in the determination of load limits while carrying backpacks for short

periods (Devroey et al., 2007; Talbott, 2005), most researchers have emphasised the perception of pain during longer periods (Jones & Macfarlane, 2005; Moore et al., 2007; Puckree, Silal, & Lin, 2004). Therefore, it was decided to measure perceptions of discomfort rather than a pain in this study.

To date, not many tools have been established to measure discomfort among children compared to adults. According to Kölsch, et al. (2003), the comfort dimension can be classified into four; comfort, discomfort, fatigue and pain (Kölsch, Beall, & Turk, 2003). Furthermore, the discomfort of body parts can be assessed via questionnaires (Moore et al., 2007; Talbott, Bhattacharya, Davis, Shukla, & Levin, 2009) or body charts (Karen Grimmer, Nyland, & Milanese, 2006).

While it was initially planned to use the numeric rating scale (0-10) to assess discomfort scores, this is not suitable for children aged between 6 and 9 years. Eventually, it was decided to use the six cartoon faces adapted from the Wong-Baker Faces Pain Rating. This tool has been validated for measuring pain in children aged three years and above (Tasker, McClure, & Acerini, 2008). To minimize changes from the original version, only the term ‘hurt’ was changed to ‘discomfort’ as shown in Figure 4.7.

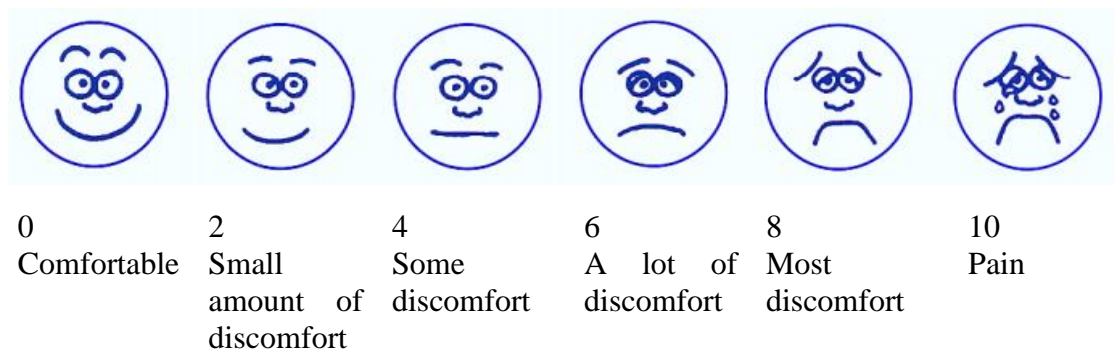


Figure 4.7: Wong-Baker Faces Pain Rating

During the assessment, participants were asked to focus on the six cartoon faces that represent discomfort levels. They were then instructed to choose one of the faces without being influenced by the researcher. All scores (0-10) were then recorded in the Discomfort Assessment Scale (Appendix 16) and finally transferred into SPSS.

To measure levels of discomfort, twelve parts of the body i.e. the neck, shoulders, upper back, upper arm, lower back, forearm, wrist, hip/buttock, thigh, knee, lower leg, and foot, were chosen (Figure 4.8). The rationale for this being that these body parts have often been reported on by previous studies (Hakala, Rimpela, Salminen, Virtanen, & Rimpela, 2002; Ismail, Mohd Tamrin, et al., 2009; Mohd Azuan et al., 2010; Tajuddin, Maqsood, & Ahmed, 2012).

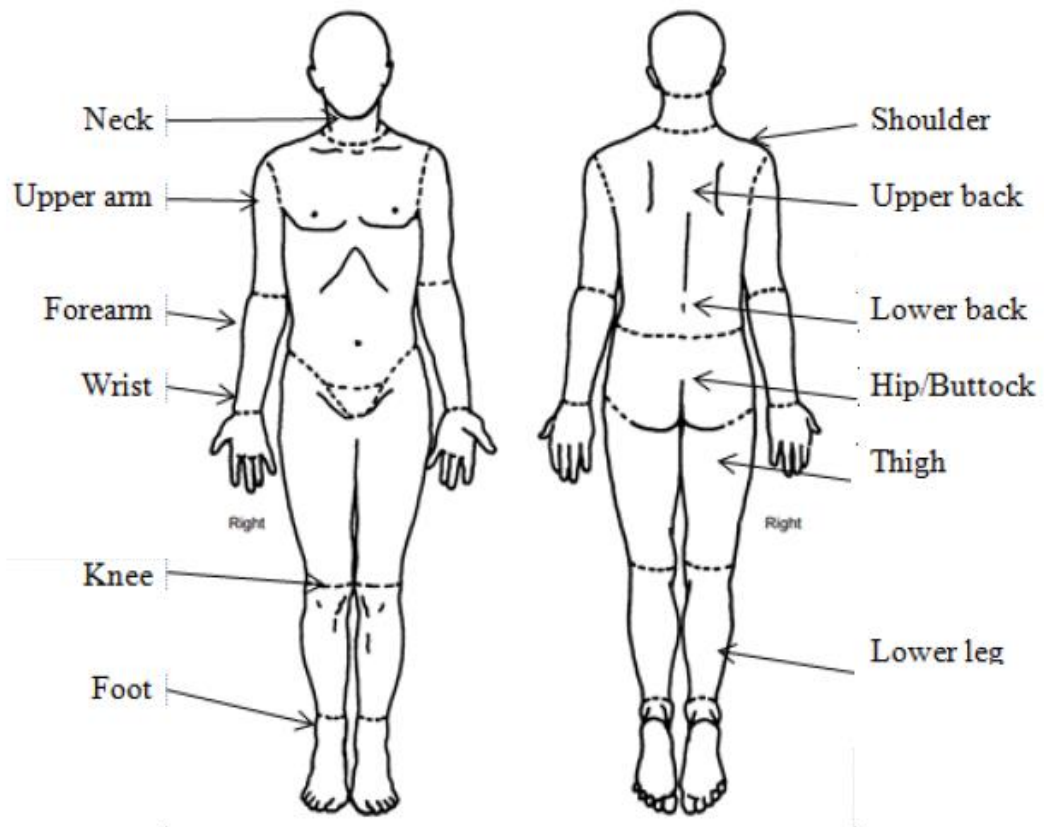


Figure 4.8: Twelve parts of the body used for assessing perception of discomfort scores

4.4.10 Ethical approval

The purpose of the ethical approval is to ensure all reasonable precaution measures were taken to protect the participants from any form of injury and adverse health effects during and after participating in the study. Therefore, a Human Ethics Certificate was obtained from the Monash University Human Research Ethics Committee (MUHREC) prior to the commencement of the study (Appendix 9). Permission was also obtained from the office of the Attorney General's Office (Melbourne) because the participants of the study were children.

4.4.11 Procedures

a) Measuring body weight

A digital weighing scale was placed on a flat surface. Participants were asked to be barefooted or wear thin socks before standing in the middle of the scale. It was necessary for the weight to be evenly distributed between both feet, with their arms hung freely on both sides of the body. The palms faced inwards towards the thighs and the medial boundary of the foot opened at an angle of approximately 60°. The participants were asked to inhale deeply about five seconds (to ensure they are in static condition) while readings were taken. All measurements were recorded to the nearest 0.1 mm. Three readings were taken from each participant, and the average reading was recorded. This procedure is described in detail by Gordon and colleagues (Gordon, Chumlea, & Roche, 1991).

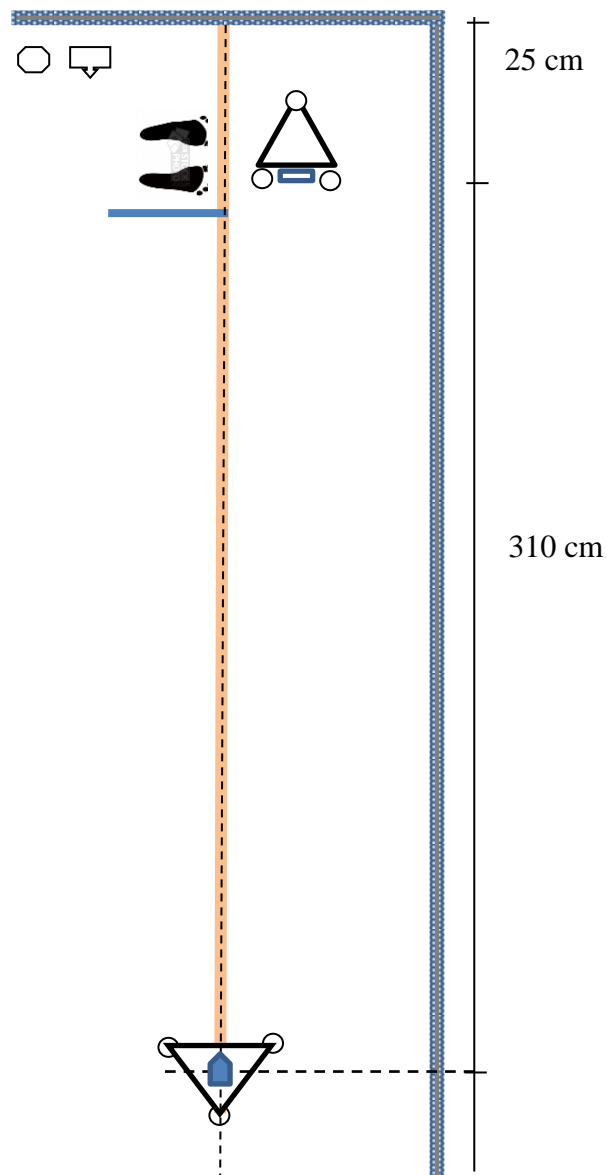
b) Measuring height

A portable body height measurement tool was mounted on a flat wall surface. Before measurement, participants were asked to be barefooted or wear thin socks. Participants were instructed to stand and distribute their weight evenly on both feet. Both hands were freely suspended at the edge of the body with palms facing inwards to the thighs. The medial border of the feet was at an angle of about 60° while their scapulae and buttocks were in contact with the wall where the measurement scale was mounted. The participants were asked to inhale deeply (to ensure they are in static condition) while readings were taken. A movable headboard was brought to the most superior point on the head. All measurements were recorded to the nearest 1 cm. Three readings were taken from each participant, and the average reading was

recorded. This procedure is described in detail by Gordon and colleagues (Gordon et al., 1991).

c) Preparation of equipment

The arrangement of equipment was done based on a study protocol developed by Grimmer (2002) as shown in Appendix 5. This protocol was tested in the Feasibility Study and considered as appropriate in the study of the effects of backpack carriage on posture in a static condition. Masking tape was used to mark out a T-shaped line on the floor. The top of the T- line was arranged pointing towards the camera. A piece of 4-meter long string was attached to the masking tape to make a straight line from the top of the T-line towards the camera. A pair of footprint stickers was placed behind the T-line to ensure that participants stand at the same location while undergoing measurement. The first tripod was placed at a distance of 3.1 meters from the footprints. The spirit level was mounted on top of the camera to ensure horizontal alignment. The digital camera Canon 450D SLR was mounted on this tripod. Adjustments were made so that the centre of the lens was positioned at 115 cm above the floor surface. The plum bulb was used to keep the camera in vertical alignment. The second tripod was placed in front of the T-line where the foot of the tripod was positioned at 5 mm from the top of the T - line. A flat soft-board (A4 size) was hung on the tripod facing the camera to display the identification number of the participants. The layout of the equipment is shown in Figure 4.9.



Legend










	Wall		Masking tape
	Foot print		Plum bulb
	Digital weighing scale		String
	Body meter		SLR Camera
	Tripod		

Figure 4.9: Layout of the equipment in the lab

d) Experimental process

Prior to the experiments, the participants were asked to wear appropriate attire. Their body weight and height were measured three times, and the mean value was recorded in the Posture Recording Sheet (Appendix 17). The loads to be carried by the participant were calculated based on 5%, 10% and 15% BW. The pebbles in sealed plastic bags were loaded in the backpacks in accordance with the percentage of the estimated body weight. Participants were then asked to stand on the footprint stickers whilst waiting for the start of the experiment.

The experiment began with measuring and photographing baseline postural angles (without a backpack). Participants were asked to stand upright facing the second tripod that displays the participant's ID, otherwise named as the sagittal plane. Participants were instructed to remain stationary and a photo was taken within 5 seconds. They were then asked to change positions and face the camera, otherwise named as the frontal plane and a photo was taken within 5 seconds. The process of measuring baseline postures was repeated after the fifth (5th) and ninth (9th) intervention (Table 4.1) while the pattern of intervention was chosen from Latin Square Table (Table 4.2). The selection of the pattern was based on their turn for measurement. For example, the first participant was selected for pattern 1. The following participants used patterns 2, 3, 4 until 9 respectively and the 10th participant started again from pattern 1.

Table 4.1: The sequence of intervention process

Baseline1 (before the 1 st intervention)	Intervention					Baseline2 (after the 5 th intervention)	Intervention				Baseline3 (after the 9 th intervention)
	1	2	3	4	5		6	7	8	9	
Standing upright without carrying the backpack.	Combination one of the load (5% or 10% or 15% BW) and one of the placement (the seventh or twelfth thoracic or the third lumbar)					Standing upright without carrying the backpack.	Combination one of the load (5% or 10% or 15% BW) and one of the placement (the seventh or twelfth thoracic or the third lumbar)				Standing upright without carrying the backpack.

Table 4.2: Latin Square Table - arrangement of test conditions

Pattern 1	Pattern 2	Pattern 3	Pattern 4	Pattern 5	Pattern 6	Pattern 7	Pattern 8	Pattern 9
T12-15%	L3-15%	L3-5%	L3-10%	T12-5%	T7-5%	T12-10%	T7-15%	T7-10%
L3-10%	T12-5%	T7-5%	T12-10%	T7-15%	T7-10%	T12-15%	L3-15%	L3-5%
T12-10%	T7-15%	T7-10%	T12-15%	L3-15%	L3-5%	L3-10%	T12-5%	T7-5%
L3-5%	T12-15%	L3-15%	T7-5%	L3-10%	T12-5%	T7-10%	T12-10%	T7-15%
T7-5%	L3-10%	T12-5%	T7-10%	T12-10%	T7-15%	L3-5%	T12-15%	L3-15%
T7-10%	T12-10%	T7-15%	L3-5%	T12-15%	L3-15%	T7-5%	L3-10%	T12-5%
L3-15%	L3-5%	T12-15%	T12-5%	T7-5%	L3-10%	T7-15%	T7-10%	T12-10%
T12-5%	T7-5%	L3-10%	T7-15%	T7-10%	T12-10%	L3-15%	L3-5%	T12-15%
T7-15%	T7-10%	T12-10%	L3-15%	L3-5%	T12-15%	T12-5%	T7-5%	L3-10%

The Latin Square Table is a matrix consisting of nine numbers of rows and columns because there were nine interventions in this study. It is designed to give a random distribution in sample selection so that each of the experiment performed occurs only once either horizontally (row) or vertically (column). Every participant in this study went through nine measurement-testing conditions. Whatever the pattern used, it involved a combination of the loads and placements. For example, the sequence of pattern 1 starts with T12-15%, L3-10%, T12-10%, L3-5%, T7-5%, T7-10%, L3-15%, T12 -5% and end up with T7-15%.

All experiments began with the sagittal plane, followed by the frontal plane. The participants were assisted by the researcher for placing and releasing the backpack from the shoulders. The shoulder straps were adjusted to ensure that the centre of gravity of the backpack was in the correct placement. Once the backpack was released, the participants were asked about their perceptions of discomfort while carrying the loaded backpack. The respondents' answers were then recorded in the Discomfort Assessment Scale (Appendix 16).

While waiting for another loading of the backpack, the participants were asked to take a break for 2 minutes to avoid fatigue. Each time the backpack was placed on the shoulders for the next test, the shoulder straps of the backpack were adjusted to ensure its accurate placement. The position of the markers was also checked so that everything remained in the correct locations (refastened if necessary). The process of photographing the sagittal and frontal planes was repeated until the test was completed. The entire process of measurement is summarized in Figure 4.10.

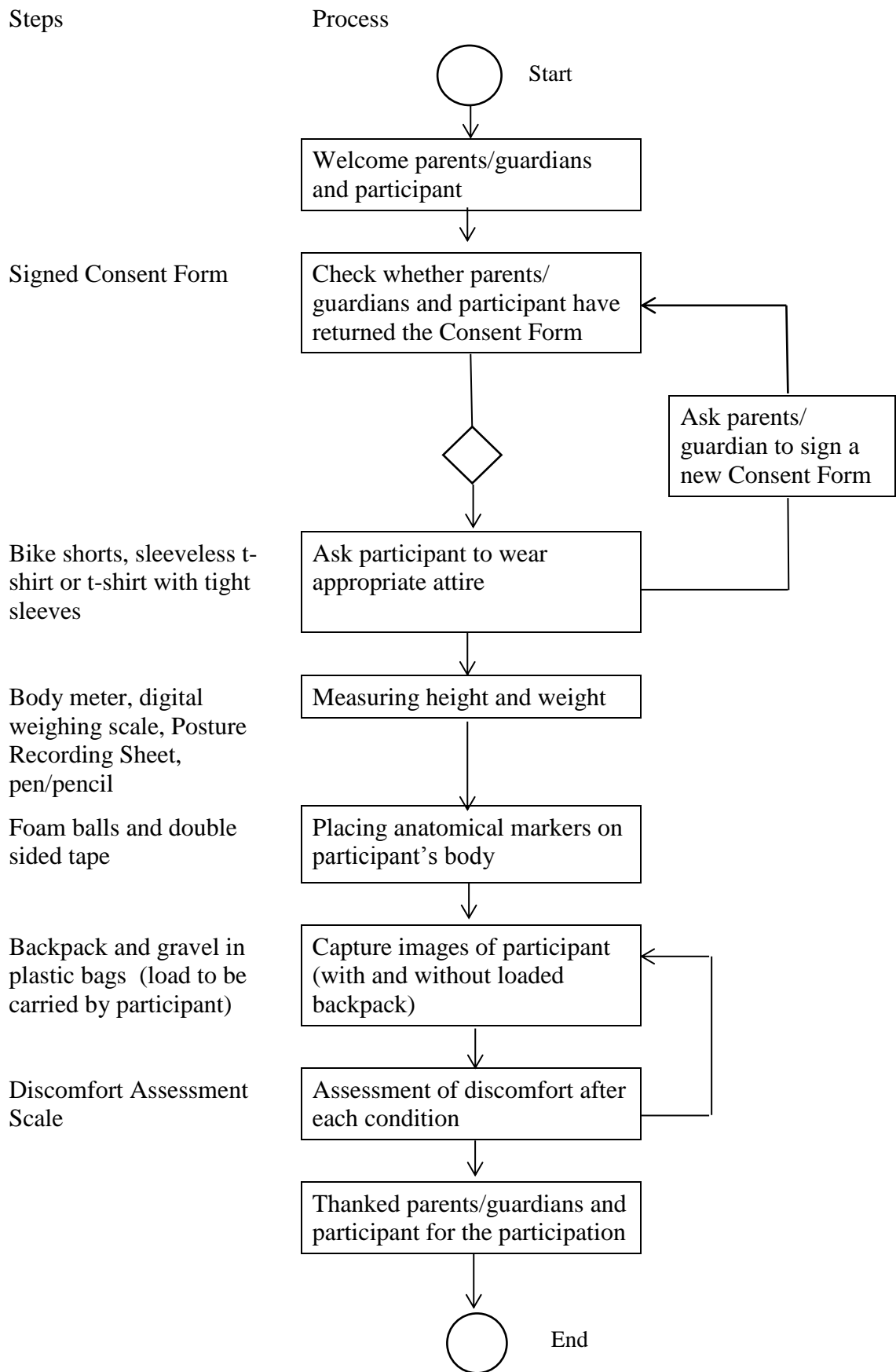


Figure 4.10: Flow chart of the measurement process

e) Measuring postural angles

A total of eight reference angles were used to determine postural deviation while carrying the backpack. The selected angles are the trunk, neck, gaze, head on neck, lower limb, tragus, acromion and pelvic. The images of the angles are shown in Figures 4.11 and 4.12. The rationale for selecting these angles were their association with typical parts of musculoskeletal pain, hence posing a risk for potential injury (Goh, Thambyah, & Bose, 1998; Lamar & Yu, 2000; McEvoy & Grimmer, 2005). The definitions of each angle are as follows:

- i. Trunk angle - the angle formed by a line drawn from the anatomical markers in C7 to the greater trochanter and vertical lines through the greater trochanter.
- ii. Neck angle - the angle formed by a line drawn from the anatomical markers in C7 to the tragus of the ear, and a line from anatomical markers in C7 until the greater trochanter.
- iii. Gaze angle - the angle formed by a line drawn from the anatomical markers at the cantus of the eye to the tragus of the ear and a horizontal line through the tragus of the ear.
- iv. Head on neck angle - the angle formed by a line drawn from anatomical markers at C7 to the tragus of the ear and a line drawn through the canthus of the eye and the tragus of the ear.
- v. Lower limb angle - the angle formed by a line drawn from the greater trochanter to the ankle, and the vertical line through the greater trochanter.
- vi. Tragus angle - the angle formed by a line drawn from the tragus of the ears (left to right) and a horizontal line through the tragus of the ear.

- vii. Acromion angle - the angle formed by a line drawn from the acromions (left to right) and a horizontal line through the acromion.
- viii. Pelvic angle - the angle formed by a line drawn through the canthus of the pelvic (left to right) and a horizontal line through the pelvic.

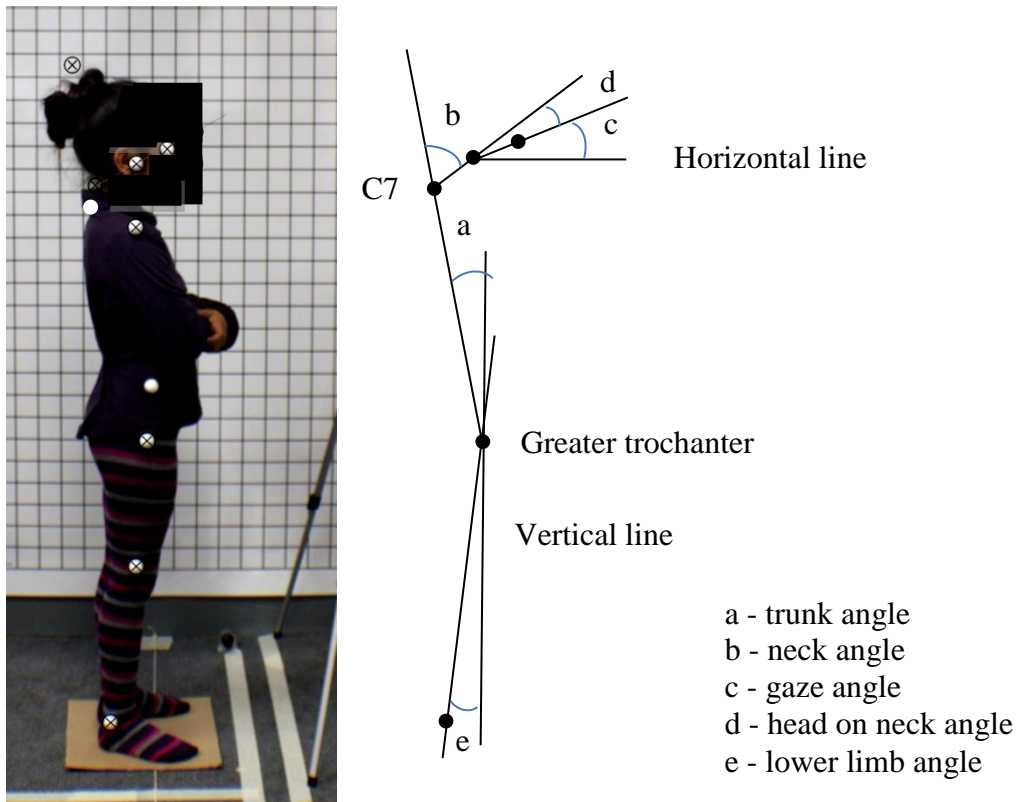


Figure 4.11: Postural angles from the sagittal plane

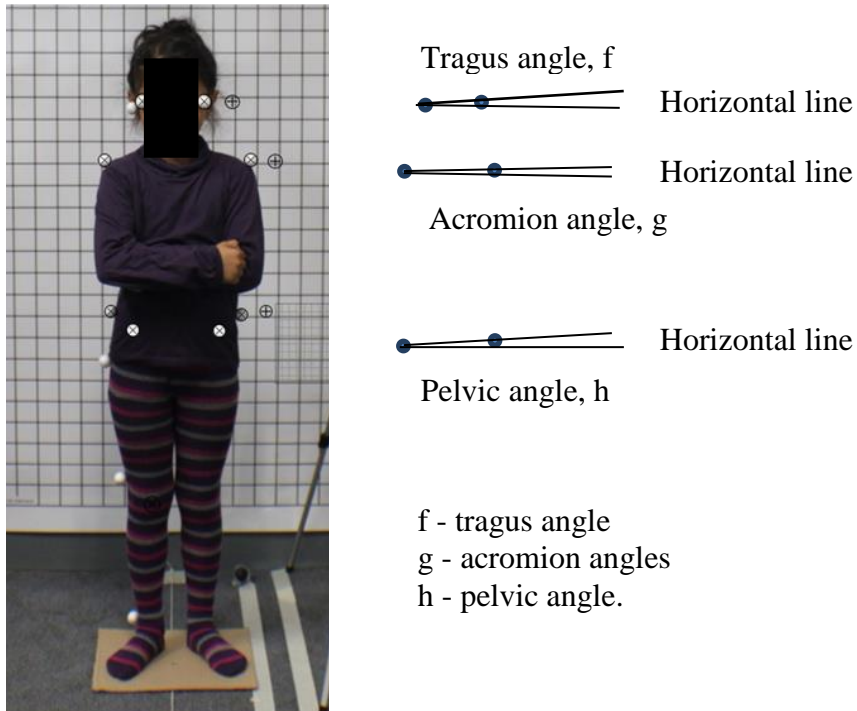


Figure 4.12: Postural angles from the frontal plane

Prior to measuring postural angles, all photographs were uploaded and saved to a computer. Each body marker in the photographs was marked with the symbol \oplus to ensure the same centre was used for repeated measurements. Upon completing the marking process, each photograph was inserted in the UTHSCSA Image Tool for measuring the postural angles.

The process of measuring the postural angles began by clicking the 'V' symbol on top of the toolbar. The line of the angle was formed by clicking three centres of the symbol \oplus three times as defined in section 4.4.10(a). After the third point was clicked, the readings automatically displayed the mean and standard deviation of the angle as shown in Figure 4.13. Each angle was measured at least three times before it was recorded. The same method was repeated for measuring the other angles until the

end. The mean of measurements was then transferred to IBM SPSS Statistics 20 for hypothesis testing.

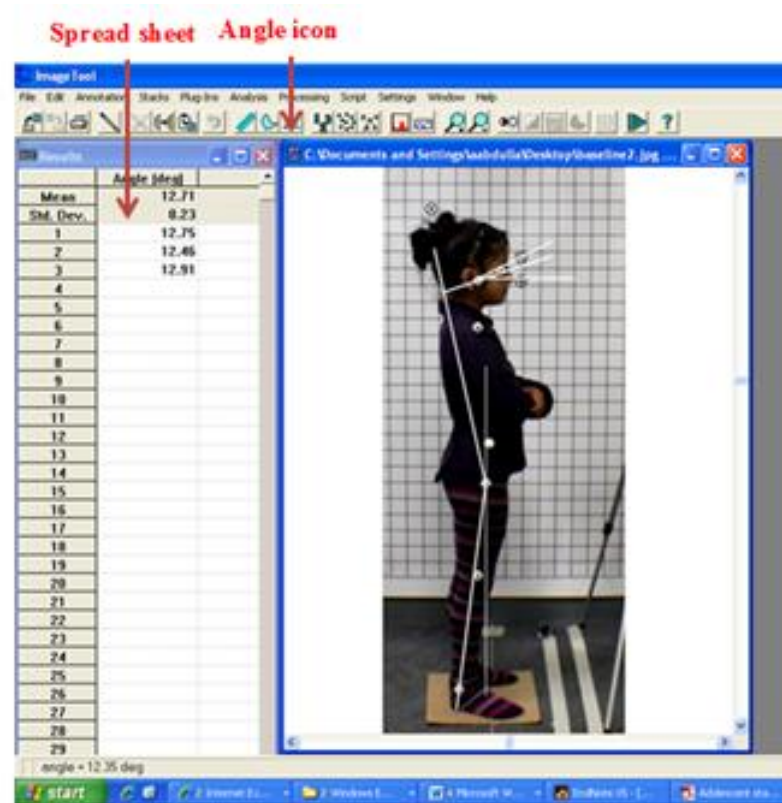


Figure 4.13: UTHSCSA Image Tool

The angle was measured by clicking the three points on the body markers. After the third point '⊕' was clicked on, the value of measured angles was automatically displayed in the spread sheet.

f) Measuring perceptions of discomfort

Prior to the assessment, all participants were briefed on how to express feelings of discomfort using the six cartoon faces as explained in Section 4.4.9 (i). Questions of discomfort were posed as soon as each measurement was completed. They were requested to select one of the cartoon faces that best represents their perceptions of

discomfort while carrying the backpacks. Their selections were based on their choices without influence from the researcher.

g) Intra-rater reliability

The quality of quantitative research depends heavily on the rater's reliability in taking measurements. In the past, reliability can be tested using correlation coefficient. Yet, this method is insufficient for measuring reliability because it only shows covariance but does not measure the agreement between tested variables (Portney & Watkins, 2000), thus requiring researchers to run the t-test in their studies. Nowadays, numerous statistics testing are used to test reliability and agreement such as Fleiss' kappa, Cronbach's alpha, inter-rater correlation, concordance correlation coefficient and intra-class correlation coefficient.

In this study, only one assessor (rater) was employed to measure all the postural angles, a condition often associated with measurement bias due to the influence of earlier results. Hence, the reliability test is essential to ensure all the measurements are consistent and undisputable. The intra-rater correlation coefficient (ICC) was performed to determine the correlation and a one-way ANOVA was conducted to test agreement between tested variables. Additionally, the simple scatter plot was employed to test for linear relationships between tested variables.

To perform the ICC test, six pictures of the participants in the sagittal and frontal planes were used. The angles measured were the trunk, neck, head on neck, lower limbs, tragus, acromion and pelvic. Each angle was measured at least three

times, and the mean reading recorded. The same measurements were repeated for five consecutive days. After the fifth day, all readings were transferred to IBM SPSS Statistics 20.

4.4.12 Analysis

The analysis process started with checking for missing values, outliers and followed by a descriptive analysis. The distribution of continuous data was also checked to ensure proper analysis is used in hypothesis testing, either parametric or non-parametric.

a) Demographic background

Descriptive statistics was performed to summarize the demographic background of the participants, i.e. age, height, weight, and BMI. The results were reported in forms of mean, standard deviation and the range of data, whichever appropriate. In addition, this statistics was also used to report the discomfort score using frequency as the data is in category form. Mann-Whitney test was performed to compare the mean of age, weight, height and BMI between genders.

b) Comparison between three baseline postural angles

This analysis involved three baselines for each postural angles (the trunk, neck, gaze, head on neck, lower limb, tragus, acromion and pelvic) which were taken before the 1st intervention, after the 5th intervention and after the 9th intervention. The results of the measured angles were recorded in continues scale. Based on these assumptions, the appropriate test to be used is a one-way repeated measures ANOVA (Andy, 2011;

Julie, 2011). Before performing the test, all the assumptions (normality of distribution, homogeneity of variance and sphericity) were checked to ensure the assumptions were met. If the assumptions were not met, Friedman test (nonparametric) performed as an alternative.

c) Intra-rater reliability

Intra-rater reliability refers to the consistency of the data from two or more measurements recorded by a rater. It can be assessed using the Intra-class Correlation Coefficient (ICC) Model 3 (Portney & Watkins, 2000). A visual analysis may also help to clarify the relationship between measurements. For example, the value of r in scatterplot indicates the strength of the relationship between the two measurements (Portney & Watkins, 2000).

d) The effects of loads and placements on postural deviation

This test compares the means between ten conditions of postural angles where the participants were involved in each condition (one baseline and nine intervention conditions). The most appropriate test to be used was a repeated measures ANOVA because it measures the mean of three or more conditions where the same participants were involved (Andy, 2011). Since the variables were not normally distributed (Shapiro-Wilk; $p < 0.05$), the Friedman test (non-parametric) was performed as an alternative. The Wilcoxon signed-rank test with a Bonferroni was also performed to identify specific differences between measured angles.

e) Correlation between postural deviations with gender, age and BMI

To perform the Pearson's correlation test, the variables must be interval or ratio, approximately normally distributed, has a linear relationship between tested variables, no significant outliers and homoscedasticity (Julie, 2011). Since the tested variables were not normally distributed and no linear relationship, the Spearman's rank order correlation test was performed to determine the relationship between tested variables.

f) Association between gender, age and BMI with discomfort scores

Chi-square test was applied to analyse the association between two categorical data measured in nominal or ordinal level and should consist two or more independent groups (Julie, 2011). Therefore, the age and BMI were converted into categorical variables prior to performing this test.

4.4.13 Quality control

To get familiar with the process and the equipment used, the researcher spent two weeks for training on the use of equipment and protocol. The training was carried out based on the adapted study protocol established by Grimmer et al. (2002), as shown in Appendix 10. Training on the palpation technique for placing the body markers was conducted in the anatomy lab under the supervision of the physiotherapist.

The aim of learning palpation techniques was to ensure the body markers were placed on the exact location before and during the measurements. In addition, palpation technique also used to place the centre of gravity of the backpack on the back. Considering the skill in palpation techniques requires experience and ongoing

training, the researchers decided to seek professional assistance for placing the body markers and the centre of gravity of the backpack on the back.

4.5 Results

4.5.1 Participants' background

A total of eight children (three boys and five girls) completed all the measurements. As illustrated in Table 4.2, the mean and standard deviation of age, weight, height and BMI of the participants were 9.75 ± 1.98 (range 7-12 years), 36.33 ± 2.50 (range 28.2-46.2 kg), 1.37 ± 0.04 (range 1.22-1.53 cm) and 19.15 ± 1.17 (range 17.42-21.12 kg/m²) respectively. The results of the Mann-Whitney test showed there were no statistically significant differences in the mean of age, weight, height and BMI between genders; $p = 0.16, 0.05, 0.05$ and 0.10 respectively.

Table 4.3: The demographic data of the participants

	N	Age (years)		Weight (kg)		Height (cm)		BMI (kg/m ²)	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
Boys	3	11.00	1.73	43.27	4.16	1.47	0.10	20.04	0.96
Girls	5	9.00	1.87	32.16	4.59	1.31	0.08	18.61	0.98
Total	8	9.75	1.98	36.33	2.50	1.37	0.04	19.15	1.17

4.5.2 Comparison between three baseline angles

The results of repeated measures ANOVA with a Greenhouse-Geisser correction showed no statistically significant differences between the mean of three baseline angles (Table 4.3). Therefore, the post hoc test using the Bonferroni correction was not performed to check the differences between the postural angles.

Table 4.4: Comparison between three baseline angles

Angles measured	Median			F	df	Sig.
	Baseline1	Baseline2	Baseline3			
Trunk	7.65	7.74	6.96	1.06	1.97	0.37
Neck	56.17	53.31	53.47	4.82	1.28	0.06
Gaze	16.55	18.14	16.90	2.30	1.73	0.15
Head on neck	32.99	31.15	30.16	0.44	1.96	0.65
Lower limb	4.06	3.39	3.53	1.59	1.30	0.25
Tragus	.99	1.14	1.33	3.32	1.48	0.09
Acromion	1.47	1.39	1.61	0.47	1.60	0.60
Pelvic	1.36	1.29	1.30	1.19	1.56	0.33

N=8

4.5.3 Reliability of the rater

The reliability of the rater can be explained by the ICC values that were approaching 1. The results showed that the variations of postural angles between 5 days of measurement were considered small (Table 4.4). The ICC value, greater than 0.75, is considered good correlation (Portney & Watkins, 2000). The linear regression equations in Figure 4.14 show a good relationship between the measurements (different day), indicating that the rater had high reliability in carrying out measurements.

Table 4.5: Reliability of the rater using ICC

Postural angle	Mean \pm SD					ICC value
	Day 1	Day 2	Day 3	Day 4	Day 5	
Trunk	7.88 \pm 2.73	8.10 \pm 2.62	8.28 \pm 2.90	7.99 \pm 2.69	8.00 \pm 3.06	.895
Neck	55.51 \pm 7.69	53.84 \pm 6.74	54.06 \pm 6.59	55.49 \pm 6.73	54.85 \pm 7.12	.951
Gaze	14.33 \pm 9.19	13.91 \pm 8.00	14.08 \pm 7.77	14.29 \pm 8.68	14.03 \pm 7.86	.981
Head on neck	26.13 \pm 13.53	24.31 \pm 13.38	25.19 \pm 13.44	24.74 \pm 13.04	25.62 \pm 13.28	.992
Lower limb	5.15 \pm 1.51	5.28 \pm 1.55	5.67 \pm 1.33	5.17 \pm 1.46	5.27 \pm 1.64	.805

N=8

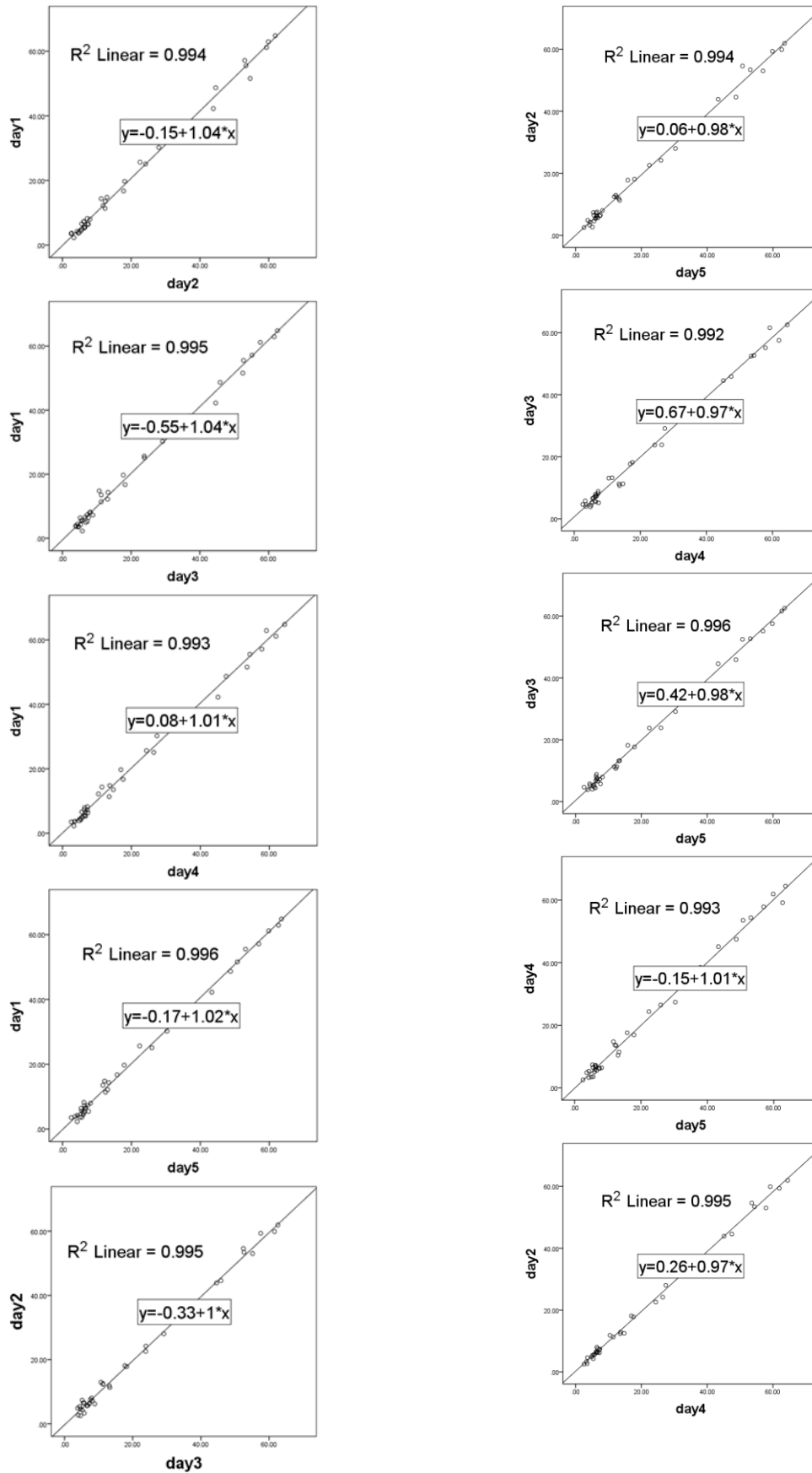


Figure 4.14: The linear relationship between five days of measurement indicates strong agreement between measurements

4.5.4 The effects of backpack loads and placement on postural deviations

The Friedman test was performed to determine the effect of backpack loads and placement on postural deviation because all the postural angles were not normally distributed (Shapiro-Wilk, $p > 0.05$). The results showed there were statistically significant differences between the baseline angle for the trunk, neck, gaze, head on neck, lower limb, tragus, acromion and pelvic angles with the nine intervention conditions (Baseline vs T7-5%, T17-5%, L3-5%, T7-10%, T12-10%, L3-10%, T7-15%, T12-15%, L3-15% BW); $\chi^2(9, n = 8) = 15.98, p < 0.05$. Because there were significant differences somewhere between the conditions, a post-hoc test was performed to identify the differences. A Bonferroni adjusted alpha value was used to control Type 1 error. Therefore, the alpha level for determining statistical significance was .05 divided by 9 = .006. Wilcoxon sign-rank results showed that there were statistically significant differences at the angles of trunk, neck, gaze, head on neck, lower limb, tragus, acromion and pelvic while carrying backpacks of 10% or 15% BW compared to the baseline conditions; $z = -0.252, p < .005$. Placing the backpack at T7 produced the largest postural deviation at all angles compared to T12 and L3. The mean and standard deviation of the postural angle during interventions are shown in Table 4.5.

Table 4.6: The mean and standard deviation of postural angles during interventions

Postural Angles	Mean (SD)									
	Baseline	T7-5%	T12-5%	L3-5%	T7-10%	T12-10%	L3-10%	T7-15%	T12-15%	L3-15%
Trunk	8.56 (2.40)	10.32 (1.89)	11.40 (1.96)	9.30 (1.64)	10.64 (1.97)	9.88 (1.34)	10.51 (1.94)	11.40 (1.96)	10.50 (2.26)	10.65 (2.12)
Neck	50.64 (5.18)	53.05 (5.26)	55.03 (4.31)	51.25 (5.05)	53.99 (5.33)	52.07 (4.98)	52.82 (5.23)	55.03 (4.31)	53.34 (5.18)	53.84 (5.50)
Gaze	16.48 (3.86)	17.38 (4.13)	21.56 (3.04)	16.73 (3.74)	19.31 (3.18)	17.05 (3.72)	18.35 (3.62)	21.56 (3.04)	18.34 (3.63)	19.69 (3.73)
Head on neck	17.84 (4.83)	20.50 (4.40)	25.35 (4.85)	18.84 (4.45)	22.70 (4.08)	18.89 (4.39)	19.79 (4.55)	25.35 (4.85)	20.62 (4.66)	22.06 (3.51)
Lower limb	5.03 (1.40)	6.31 (1.43)	8.77 (2.84)	5.54 (1.57)	7.25 (1.64)	5.97 (1.61)	6.31 (1.96)	8.77 (2.84)	6.56 (1.88)	6.90 (2.04)
Tragus	1.20 (0.91)	1.98 (0.53)	2.25 (0.80)	1.77 (0.71)	2.05 (0.70)	1.81 (0.79)	1.83 (0.84)	2.25 (0.80)	1.87 (0.71)	1.97 (0.50)
Acromion	1.52 (0.38)	1.67 (0.43)	3.10 (0.40)	1.56 (0.34)	2.29 (0.51)	1.55 (0.41)	1.97 (0.56)	3.10 (0.40)	2.04 (0.41)	2.39 (0.32)
Pelvic	1.24 (0.40)	1.55 (0.28)	2.48 (0.57)	1.49 (0.22)	1.74 (0.34)	1.54 (0.22)	1.62 (0.38)	2.48 (0.57)	1.66 (0.35)	2.06 (0.54)

Generally, all postural angles were changed from the baseline angles (unloaded condition) when carrying the backpack load as low as 5% BW. The postural deviations are obvious on the trunk, neck, gaze, head on neck and lower limb angles while carrying the backpack load of 10% and 15% BW and placed at T7 and T12. However, the deviations are almost invisible on the tragus, acromion and pelvic angles regardless of loads and placements of the backpack as shown in Figure 4.15.

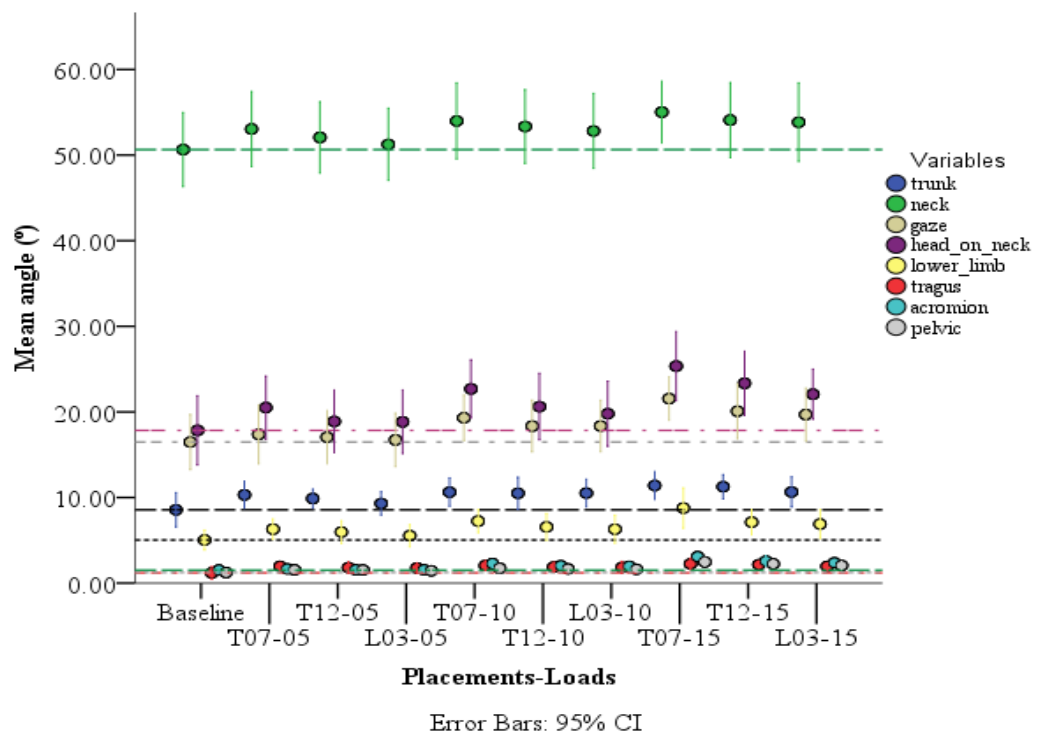


Figure 4.15: The changes of postural angles compared to baseline conditions

4.5.5 Correlation between gender, age and BMI with postural deviations

The Spearman's correlation test was performed to determine the correlations between postural deviation with age, gender and BMI. The results showed significant relationships between gender, age and BMI with postural deviation as shown in Table 4.6.

Girls are more likely to show postural deviation at the trunk, neck, gaze, head on neck and lower limb angles when carrying the backpack compared to boys. Postural deviations were also more seen in participants aged nine and ten years compared to twelve years, particularly those who are underweight.

Table 4.7: Correlation between postural deviation with age and gender

Independent Variables	Postural angles	r	Sig. (p-value)	Strength
Gender	Trunk	- 0.33*	< 0.01	Medium
	Neck	- 0.36*	< 0.01	Medium
Age	Neck	-0.35*	< 0.01	Medium
	Gaze	-0.32*	< 0.01	Medium
	Head on neck	0.33*	< 0.01	Medium
	Lower limb	0.30*	< 0.01	Medium
BMI	Trunk	0.52*	< 0.01	Medium
	Neck	0.30	0.01	Medium
	Lower limb	0.38	< 0.01	Medium

N = 8, (*) $p < 0.05$, $r = 0.30 - 0.49$ medium, $0.5 - 1.0$ large relationship (Cohen 1998, pp. 78-81)

4.5.6 Association between gender, age and BMI with perceptions of discomfort

The Pearson's chi-square test results showed that there were no statistically significant relationships between perceptions of discomfort with gender, age and BMI ($p > 0.05$). Previous literature inconsistently reported the association between the perceptions of discomfort while carrying backpacks with gender, age and BMI. The differences in findings might be due to diverse usage of assessment tools between studies such as Borg scores, Wong-Backer faces, Visual Analog Scale (VAS), etc. In the present study, we did not find any significant association between the perceptions of discomfort in boys and girls, age group 1 (7-9 years) and group 2 (10-12 years) as well as BMI group 1 (underweight and normal) and group 2 (overweight and obese). These results did not support any literature because the sample size is below the expected number.

4.6 Discussion

There were no significant differences in the mean of age, weight, height and BMI between genders ($p < 0.05$). Two (25.0 %) of the participants were categorized as 'underweight' and six (75.0%) were categorized as having normal BMI. There was also no significant relationship between postural deviations with age, weight and BMI ($p < 0.05$). This may be due to the small sample size involved in this study. This may be due to the small sample size involved in this study.

The reliability of the raters employed is essential in quantitative study to ensure that the measurements fall within the acceptable range. As the reliability of the rater in this study was established in measuring the postural angles at different time points, the same rater may be used to measure postural angles in the actual study.

To date, there is consensus that the proposed safe load to be carried by school children ranges between 10% - 15% BW (Bauer & Freivalds, 2009; Chansirinukor, Ilson, et al., 2001; Shasmin et al., 2006). There are also suggestions that the load should be limited at 10% BW (Hong et al., 2000; Lai & Jones, 2001) and below 15% BW (Brackley & Stevenson, 2004). However, the difficulty in setting the load limits is augmented by the lack in studies on the on the acute and chronic effects of backpack use (Talbot, 2005). Recent literature also suggests that general safety guidelines may be more appropriate than a recommended single load limit (Dockrell et al., 2013).

Prior studies on backpack placement are limited despite evidence that it contributes to postural deviation. While most studies suggest that placing the centre of gravity

(COG) of the backpack at lower placements on the back may reduce postural deviation, no consensus has been achieved. So far, the proposed location to place the COG of the backpack is between T8-L5 (Brackley et al., 2009; Chow et al., 2010; Singh & Koh, 2009a). These differences stem from the varying definitions of backpack placement between studies. More studies focusing on backpack placement are required so that the most appropriate placement can be recommended for school children to minimize potential postural deviation.

4.7 Suggestions for Improvement

The main issues identified were the inconsistent location of the participants' hands and heads throughout the experiments. The following are some suggestions for improvements in future protocols:

4.7.1 Location of participants' hands during experiment

Participants should be asked to place their hands on their chest and minimize movements so that the body markers remained at the respective locations and the foam balls on the greater trochanter may be seen clearly.

4.7.2 Placing an attractive object in front of participants

The position of the participant's head often changes throughout the experiment period. In order to avoid head movement for at least five seconds, the participants were asked to look at an object (picture of a cartoon, flower etc.) placed in front of them before capturing the photograph. This technique is amenable to reducing changes in head positions each time the photograph was captured.

4.8 Conclusion

The present feasibility study showed that backpack loads and placement may contribute to postural deviation, consistent with the results from several prior literatures. Although only eight participants participated in this study, the objective of the study, i.e. to test the protocols, was achieved. The methods were shown to be reliable, robust, and feasible to run a substantive research project to obtain meaningful and valid results.

The most important thing to highlight was that we have learnt various experiences that can be used in the main study, in particular, the process of getting approval from the authorities, participants' recruitment, the accuracy of positioning body markers and backpack on the back, techniques for avoidance of postural sway and how to manage children during the measurement period.

CHAPTER 5

METHODOLOGY FOR THE MAIN STUDY

5.1 Background

The protocol used in the main study was similar to the feasibility study with a few key differences. The pilot study determined that the measurements could be accurately taken in the field. This project had a more substantive methodology in terms of hypotheses, recruitment of participants and statistical analysis.

5.2 Study Location

This study was conducted in Kuala Selangor that is located in the state of Selangor in Malaysia. The latitude and longitude coordinate of Kuala Selangor District are 3.340184 and 101.249762. This district was chosen at random from the nine districts in Selangor (Figure 5.1).

There are 27 schools registered under the Education Department of the Kuala Selangor District. Considering the total number of sample required was around 240, we decided to take four schools only, i.e. two schools from semi-urban and the rural area respectively.



Figure 5.1: Location of study area (Kuala Selangor District)

5.3 Objectives

5.3.1 General objective

To investigate the effects of backpack loads and placement on postural deviations of the skeleton in healthy Malaysian school children.

5.3.2 Specific objectives

- a) To investigate the comfort/discomfort felt by the participants during different states of backpack use.
- b) To compare the mean baselines postural angles (the trunk, neck, head, neck and lower limbs) whilst wearing a backpack.
- c) To determine the effects of backpack loads and placements on postural deviations (the trunk, neck, gaze, head on neck, lower limb, tragus, acromion and pelvic angles) in healthy school aged children.
- d) To explore whether there is a relationships between gender, age, and BMI of the children with postural deviations (the trunk, neck, gaze, head on neck, lower limb, tragus, acromion and pelvic angles).
- e) To explore the differences of postural deviations (the trunk, neck, gaze, head on neck, lower limb, tragus, acromion and pelvic angles) between gender, age and BMI groups.
- f) To determine whether there is an association between gender, age, and BMI with perceptions of discomfort.
- g) To recommend the weight and location of backpacks for elementary school children in Malaysia.

5.4 Null Hypotheses (H_0)

- a) There will be no significant differences between the three mean baseline postural angles on healthy school children (the trunk, neck, gaze, head, neck and lower limbs) measured over consecutive days.
- b) There will be no significant changes in the trunk, neck, gaze, head on neck, lower limb, tragus, acromion and pelvic angles when carrying the backpack at different loads and placements compared to the baseline angles in healthy school aged children.
- c) There will be no significant relationship between gender, age, and BMI with the deviations of trunk, neck, gaze, the head on neck, lower limb, tragus, acromion and pelvic angles in healthy school aged children.
- d) There will be no significant association between gender, age, and BMI with perceptions of discomfort in healthy school aged children.

5.5 Methods

5.5.1 Ethical approval

A consent letter was granted by the Economic Planning Unit (EPU) of the Prime Minister's Department, Malaysia to conduct the study in Malaysia from January 1st, 2011 to December 31st, 2013 (Appendix 15). A letter of support was obtained from the Ministry of Education in Putrajaya to gain cooperation from the State Education Department and the schools selected in conducting the study. The study was also approved by the Monash University Human Research Ethics Committee (CF 10/1178 – 2010000623, Appendix 4).

5.5.2 Recruitment strategy

In order to ensure the success of the study, information regarding the protocol was explained to the school staff. Separate meetings were held with the Headmasters, Senior Assistants and teachers of each school to inform them fully of the process. In the meetings with the Headmasters, the objectives and methodology were explained, and the researcher further sought cooperation from the school management with regard to the sampling process and distribution of the Explanatory Statement (Appendix 12) and Consent Forms (Appendix 14) to the parents or guardians of prospective participants. The Senior Assistant to the Headmaster for each school represented the school management in helping the researchers throughout the study period. The researcher then met with the Senior Assistant to explain in detail the methodology of the study, going through the explanatory statement, sampling technique, the deadline for returning the signed Consent Forms and where the data would be collected.

5.5.3 Inclusion and exclusion criteria

a) Inclusion criteria

- i. Primary school children aged between 7 and 12 years.
- ii. Free from any musculoskeletal diseases or disorders including recent fractures or sprains anywhere in the body.
- iii. Able to stand upright for at least for 30 minutes.
- iv. Happy to wear biking shorts and tight t-shirts during the experiment.

b) Exclusion criteria

- i. Those with spinal abnormalities such as scoliosis or kyphosis or lordosis.
- ii. Those with any neurological disorders that may affect the normal standing position.

5.5.4 Recruitment of participants

Recruitment of participants was based on three criteria: (1) that they fulfilled all the inclusion and exclusion criteria, (2) that their participation was voluntary, and (3) that we had obtained consent from parents or guardians. The students who volunteered to participate in the study were asked to obtain permission from their parents or guardians, and returned a signed Consent Form. The screening process of the inclusion criteria was carried out by the class teachers and based on the school registry record (sampling pool) while assessment of the exclusion criteria was done by professional. Upon completion of this process, the student's name was recorded as a prospective participant.

5.5.5 Sample size calculation

Calculation of sample size is crucial to ensure the data collected is sufficient for a reliable analysis and to avoid wasting resources due to collecting more data than required. The estimation of sample size performed using the Minitab software version 17 was based on the mean and standard deviation of postural angles from the feasibility study. Five angles were used to calculate the sample size. The results of the analysis are shown in Table 5.1.

Table 5.1: Recommended sample size for the main study based on the mean and standard deviation of postural angles in the feasibility study

Postural angles	Mean	Standard deviation	Difference of mean	Sample size	Target power
Trunk	9.66	1.59	1.43	16	0.9
Neck	52.63	5.14	1.17	205	
Gaze	16.55	2.91	6.43	5	
Head on neck	20.92	4.32	6.93	7	
Lower limb	6.39	1.41	1.05	21	

The ratio of the girl and boy students was 1:1, with the aim of selecting 50% boys: 50% girls and to recruit 240 students, allowing for dropouts. The breakdown of prospective participants is shown in Table 5.2.

Table 5.2: Breakdown of prospective participants

Stratum	Year 1		Year 2		Year 3		Year 4		Year 5		Year 6	
	B	G	B	G	B	G	B	G	B	G	B	G
Target participants	40		40		40		40		40		40	
Sampling fraction	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Expected participants	20	20	20	20	20	20	20	20	20	20	20	20

B – boys, G - Girls

Previous studies have used different sample sizes even using the same outcome measures. For example Grimmer et al. (2002) has used 250 samples; Ramprasad et al. (2010), 200 samples; Mohan et al. (2007), 43 samples and Talbott (2005), 40 samples.

Although the sample size for the feasibility study was below (less than 11) the expected number, the result for sample size did not show much difference with the past studies. Therefore, 240 participants were considered reasonable for the main study.

5.5.6 Sampling method

The sampling pool comprised pupils who were enrolled in three schools from 1st January to 31st March 2011. Considering the total of students' enrolment at each school was more than 1,000, the most appropriate sampling technique was using a systematic random sampling whereby each student had an equal likelihood to be selected as a participant. Students who did not fulfil the inclusion criteria were excluded from the study and additional draws have made to replace them. The breakdown of prospective participants for each school is shown in Table 6.3.

Table 5.3: Breakdown of the participants from selected schools

Sampling Pool	The breakdown of students per school	Expected number of participants
School A (Standard 1-6)		60
School B (Standard 1-6)	5 boys and 5 girls	60
School C Standard 1-6	x 6 levels.	60
School D Standard 1-6		60
Total		240

The sampling process commenced by selecting a student from the sampling pool at random. The next participant was then chosen using a constant interval, k^{th} . The value of k was calculated using $k = N/n$; where n is the sample size, and N is the

number of students in the sampling frame. For example, suppose the number of Standard 1 boy students in the sampling pool were 200 and the sample size required were 20; so $k = 200/20 = 10$. The first participant was picked at random, and subsequent participants were selected using a constant interval of 10, for example, 5, 15, 25, and 35 and so on until 20 participants were recruited. If the number fell onto students who were not interested in participating, their names were removed from the prospective participants and the next 10th participant was taken as a substitute.

5.5.7 Equipment and procedure

The 3D analysis is the best method to investigate posture. However, we did not use the 3D methods in this study because this study involves some measurement locations including the homes of participants, halls and laboratories. Therefore, the use of 3D was not feasible in this study. In addition, previous studies have also shown that the technique is reliable for the measurement of 2D posture in a static condition.

The arrangement of equipment such as the SLR camera, tripods, foot prints, weighing scale, body meter, masking tape, plum bulb and strings were similar to the feasibility study as explained in section 4.4.11(c). The measurement process was assisted by three research assistants (RA), who were trained by the principal researcher based on the study protocol. Palpation techniques were taught under the supervision of a physiotherapist to ensure that all body markers were placed in the right location throughout the measurement period.

The first RA (RA1) assisted the principal researcher in providing the sequences of the experiments according to the Latin square. The second RA (RA2) captured the experimental photographs which comprised three baselines and nine interventions (frontal and sagittal respectively). The third RA (RA3) assisted the participants in carrying and removing the backpack after each intervention, re-checking the location of body markers and refastening them if necessary prior to the next intervention.

5.6 Analysis

Statistical analyses in the main study were both descriptive and inferential. Descriptive statistics were used to summarize the demographic background of the participants while inferential statistics were used to test the hypotheses stated in section 5.4. Before performing the parametric test, all the assumptions were checked to make sure all the assumption complied. If one of the assumptions did not comply, the non-parametric test was used as an alternative. Normal distribution was tested using the normality test, Shapiro-Wilk ($p > 0.05$), outliers or extreme values using the box-plot graph.

5.6.1 Descriptive statistics

Descriptive statistics summarised the demographic background of the participants such as age, gender, height, weight and BMI. The results were presented in the form of mean, standard deviation and the range of data, whichever was appropriate. In addition, these statistics were also used to report the discomfort scores using frequency as the data is in category form.

5.6.2 Inferential statistics

a) Comparison between three baseline postural angles

This analysis involved eight postural angles (the trunk, neck, gaze, head on neck, lower limb, tragus, acromion and pelvic) and each angle had three measurements that were taken before the 1st intervention, after the 5th intervention, and after the 9th intervention on a continuous scale. Based on these basic assumptions, the most appropriate test was a one-way repeated measures ANOVA (Andy, 2011; Julie, 2011). Before performing the test, all the assumptions (normality of distribution, no significant outliers, and homogeneity of variance) were checked to ensure all the assumptions met. Alternative to this test is the Kruskal-Wallis.

b) The effects of load and placement on postural deviation

This analysis compared the changes of eight postural angles from the baseline condition. Each test comprises of one baseline and nine intervention conditions. The most appropriate test was a repeated measures ANOVA (Andy, 2011; Julie, 2011). Before performing the test, all the assumptions (no significant outliers, variables approximately normally distributed, and homogeneity of variance) were checked to ensure that they were met.

c) The relationship between gender, age, and BMI with postural deviations

The Pearson's correlation test was performed to determine the correlation between gender, age, and BMI with postural deviations. This test was used because all the assumptions were fulfilled (variables are in continuous or dichotomous, linear relationship, no significant outliers and approximately normally distributed). The test

measured the strength and direction of the relationship between variables (Andy, 2011).

d) Comparison of postural deviation between gender, age and BMI

In order to perform this analysis, age was divided into two groups (7-9 year-old and 10-12 year-old) and BMI was divided into four groups (underweight, normal, overweight and obese). An independent t-test was performed to compare postural deviation (the trunk, neck, gaze, head on neck, lower limb, tragus, acromion and pelvic angles) between gender and age while a one-way ANOVA was performed to compare postural deviations between BMI (Andy, 2011).

e) The association between gender, age, and BMI with discomfort scores

This Pearson chi-square test was performed to test the association between gender, age and BMI. To perform this test, age, and BMI was transformed into categorical variables (Andy, 2011).

CHAPTER 6

RESULTS

6.1 Introduction

The purpose of this chapter is to present the main study results particularly with regard to the statistical analysis of descriptive and inferential statistics. The findings are presented using various methods of presentation including in text or illustrated with appropriate tables and diagrams. This chapter was organized from the most to least important results in answering the objectives and hypotheses of the present study.

6.2 Demographic Background

A total of 270 of Explanatory Statements and the Consent Forms were distributed to the respective parents/guardians through their children. The prospective participants were recruited via systematic random sampling. They were identified from the registered students in the selected schools that had met the study criteria stated in section 5.5.3. After the two-week invitation to participate period, 156 signed Consent Forms were returned, representing a 57.8% response rate. Of these, only 136 participants successfully completed the whole experiment. Two (1.43%) participants

withdrew due to shoulder pain when carrying the load of 15% BW and eighteen (11.5%) participants did not turn up during the data collection period. The distribution of participants according to gender was 74 (54.4 %) boys and 62 (45.6 %) girls. The distributions of the participants according to age, gender and BMI are shown in Table 6.1. The independent t-test result showed that there were no significant difference between the number of boys and girls, $p = 0.29$.

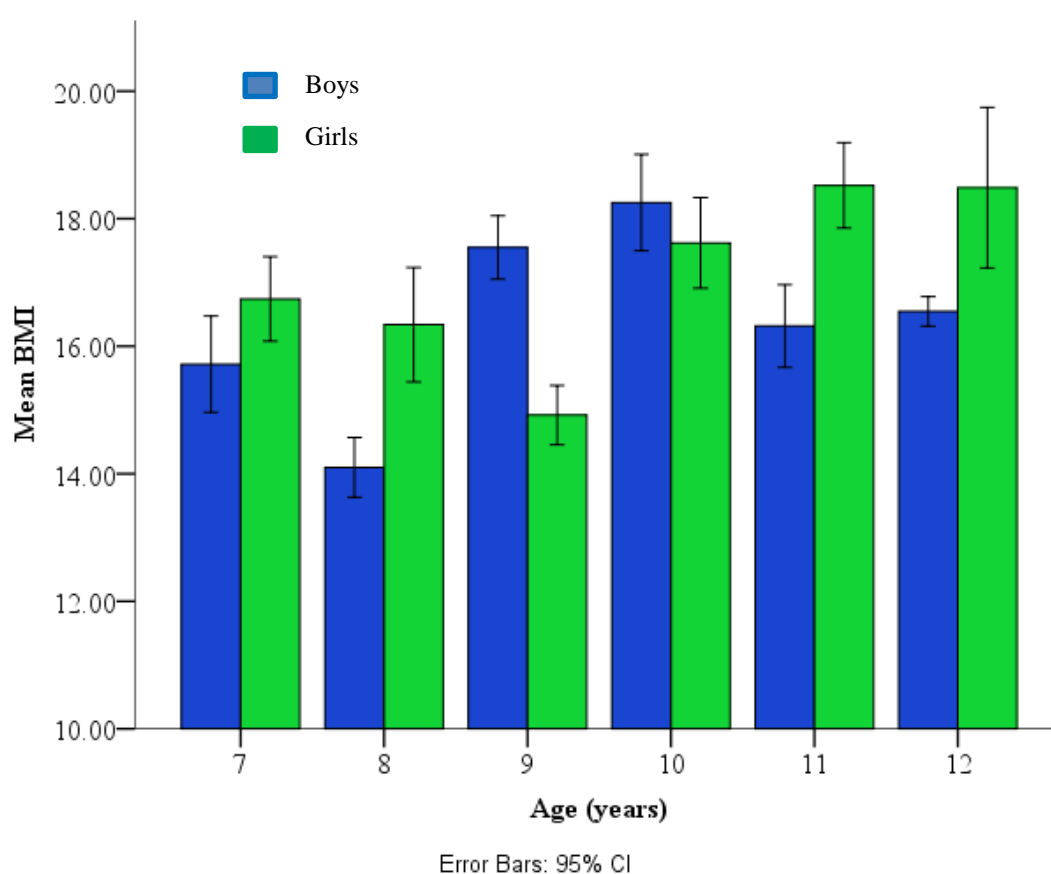


Figure 6.1: The distribution of participants according to age, gender and BMI

The mean, median and standard deviation for the age of the participants were 9.57, 10.00, ± 1.66 respectively (the range is 7-12 years). The mean, median, and standard deviation of height were 133.57, 132.00, 0.12 (the range being 110 - 166 cm) while the mean, median and standard deviation of weight were 30.77, 28.90, 10.87 (the

range being 15.0 - 82.8 kg) respectively. The Body Mass Index (BMI) was categorized using the World Health Organization growth reference, BMI-for-ages 5 to 19 years (WHO, 2007). The mean, median and standard deviation of BMI were 16.92, 16.00, 4.11 (10.20 - 35.00 kg/m²), with 45 (33.1 %) of the participants categorized as 'underweight' (BMI < 18), 59 (43.4%) classified as having normal BMI (BMI 18 - 25), 15 (11.0 %) classified as being 'overweight' (BMI > 26) and 17 (12.5 %) classed as 'obese' (BMI > 30), as shown in Figure 6.2.

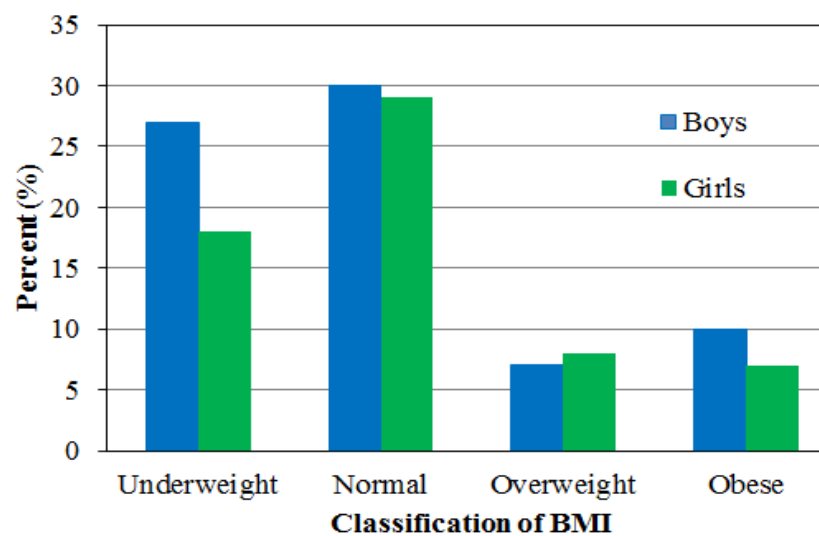


Figure 6.2: The distribution of participants' BMI according to gender

The Mann-Whitney U Test was performed to compare the BMI between boys and girls because it was not normally distributed (Shapiro-Wilk < 0.05). There was no statistically significant difference in BMI for boys (M = 16.71, SD = 4.10) and girls (M = 17.16, SD = 4.14); $p = 0.418$. When the age was divided into two groups, there was a significant difference for BMI between group 1 (7-9 year-old) and group 2 (10-12 year-old), $p = 0.01$.

6.3 Discomfort Score

The level of discomfort was measured using a modified Wong-Baker Faces Pain Scale (Figure 4.6) because of its effectiveness and reliability with children aged between 7 and 12 years. Twelve parts of the body were measured using a diagram adapted from a technique for assessing postural discomfort (Corlett & Bishop, 1976). The assessed are the neck, shoulder, elbow/forearm, hand/wrist, hip/thigh, upper back, lower back, knee, and ankle/foot (Figure 4.7). However, only five parts were reported to experience discomfort, i.e. the necks, shoulder, elbow/forearm, upper back, and lower back. Notably, none of the participants complained of discomfort at scores of 8 and 10 at any of the mentioned body parts, regardless of load and placement. The most frequent complaint accrued from the following; the shoulders, upper back and lower back which recorded discomfort scores of 2, 4, and 6. This was followed by the lower back, upper back, neck, and elbow/forearm. In terms of load and placement, the most frequent complaints were recorded at 15% BW and T7 respectively (Figure 6.3).

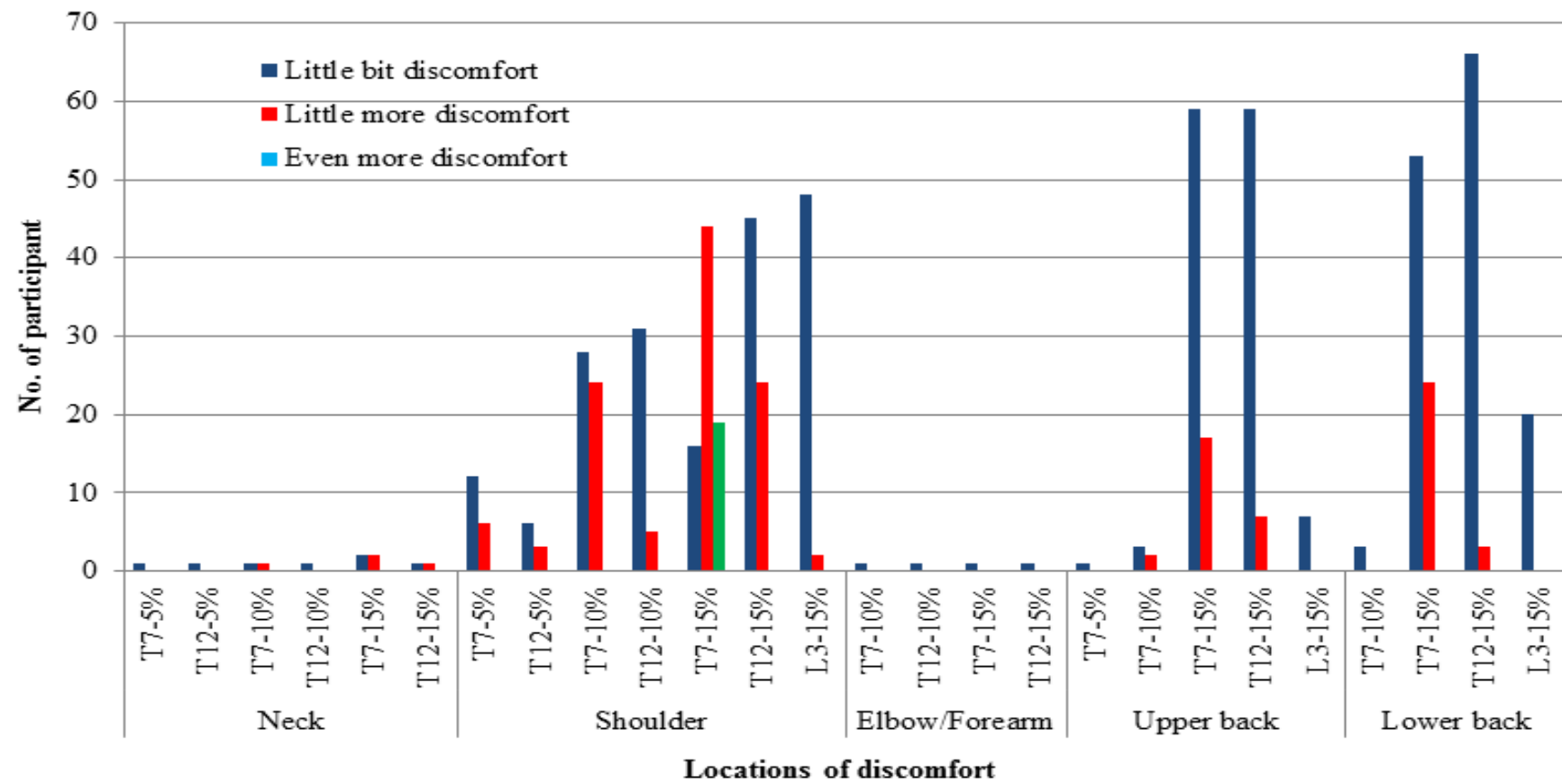


Figure 6.3: Locations and classification of discomfort

6.4 Comparison between Three Baseline Postural Angle

The baseline postural angle is defined as the body posture (standing upright) without carrying the backpack. It was measured for every participant during the experiment process, i.e. before the intervention, after the 5th intervention and after the 9th intervention (Figure 6.4).

The purpose of comparing the three postures was to determine whether there were significant differences between the three baseline angles during the course of the experiments. The implication from this test is that we can be confident about the results' robustness, rigour, and generalizability. The repeated measures ANOVA with a Greenhouse-Geisser correction determined that the mean of three baseline postural angles were not statistically and significantly different, $p > 0.05$. Post hoc tests using the Bonferroni correction revealed that all postural angles were also not statistically significant, $p > 0.05$.

These results suggested that there were no significant differences between the three baselines postural angles for all measured angles (Table 6.2).

Table 6.1: Comparisons between three baseline angles for all measured postures

Angles	Mean \pm SD			F	Sig.	Partial Eta Squared
	Baseline1	Baseline2	Baseline3			
Trunk	9.35 \pm 1.70	9.61 \pm 1.71	9.83 \pm 1.91	2.64	.075	.038
Neck	54.65 \pm 3.25	55.20 \pm 3.85	55.55 \pm 3.94	2.69	.071	.039
Gaze	21.54 \pm 4.27	21.10 \pm 4.14	20.82 \pm 4.24	2.18	.118	.031
Head on neck	19.29 \pm 3.66	18.69 \pm 3.88	18.60 \pm 3.81	1.90	.154	.028
Lower limb	6.09 \pm 1.00	5.88 \pm .91	5.86 \pm .89	3.00	.053	.043
Tragus	1.52 \pm .41	1.63 \pm .48	1.62 \pm .45	2.59	.078	.037
Acromion	1.87 \pm .44	1.98 \pm .48	1.92 \pm .45	2.00	.140	.029
Pelvic	1.78 \pm .48	1.86 \pm .44	1.85 \pm .42	1.25	.291	.018

6.5 Effects of Backpack Loads and Placements on Postural Deviation

Eight postural angles were used to determine the effects of load and placement on postural deviation, five in the sagittal and three in the frontal plane (Figure 4.6 and 4.7). Nine conditions were tested for each angle, which is a combination of three loads and three placements namely T7-5% BW, T12-5% BW, L3-5% BW, T7-10% BW, T12-10% BW, L3-10% BW, T7-15% BW, T12-15% BW, and L3-15% BW. There were no outliers and the data was normally distributed, as assessed by Shapiro-Wilk, $p > .05$.

A repeated measures ANOVA was performed to determine whether there were statistically significant changes in the eight postural angles when loading three different loads in the backpack and placing them at three different areas on the back. A Greenhouse-Geisser correction was used to assess if the assumption of sphericity (assessed by Mauchly's Test) was violated. The mean values and standard deviations for all postural angles are shown in Table 6.3.

Table 6.2: Mean value (SD) of postural angles for experiment conditions

Postural Angles	Mean (SD)									
	Baseline	T7-5%	T12-5%	L3-5%	T7-10%	T12-10%	L3-10%	T7-15%	T12-15%	L3-15%
Trunk	9.35 (0.15)	10.07 (0.15)	10.03 (0.15)	9.62 (0.18)	10.47 (0.14)	10.29 (0.16)	10.28 (0.14)	11.41 (0.14)	11.25 (0.14)	10.91 (0.16)
Neck	51.01 (0.25)	53.65 (0.67)	52.31 (0.26)	51.78 (0.21)	54.23 (0.24)	54.04 (0.29)	52.06 (0.25)	54.65 (0.28)	54.24 (0.24)	52.65 (0.32)
Gaze	18.28 (3.68)	20.23 (4.64)	19.44 (4.04)	19.10 (3.81)	20.51 (4.55)	19.64 (4.70)	19.45 (3.64)	21.64 (4.28)	20.90 (4.52)	19.66 (4.35)
Head on neck	19.29 (3.66)	17.83 (4.36)	18.69 (4.48)	19.18 (4.01)	17.64 (4.29)	17.73 (4.41)	17.83 (4.60)	17.34 (4.28)	17.51 (4.14)	17.53 (4.58)
Lower limb	3.71 (0.89)	4.20 (0.95)	3.79 (0.87)	3.75 (0.86)	4.77 (1.11)	4.58 (1.27)	4.52 (0.89)	6.11 (1.03)	5.50 (1.12)	4.83 (1.26)
Tragus	1.53 (0.41)	1.78 (0.47)	1.74 (0.46)	1.71 (0.42)	1.88 (0.46)	1.83 (0.53)	1.78 (0.52)	1.95 (0.46)	1.93 (0.56)	1.90 (0.56)
Acromion	1.87 (0.44)	2.00 (0.43)	1.99 (0.44)	1.92 (0.43)	2.11 (0.44)	2.04 (0.48)	2.02 (0.48)	2.16 (0.43)	2.15 (0.43)	2.13 (0.48)
Pelvic	1.78 (0.48)	1.79 (0.47)	1.78 (0.45)	1.78 (0.46)	1.92 (0.41)	1.91 (0.38)	1.79 (0.41)	1.97 (0.37)	1.96 (0.38)	1.94 (0.43)

Legend: 5%: five per cent of body weight, 10%: ten percent of body weight. 15%: fifteen percent of body weight. T7: backpack positioned at the seventh thoracic vertebra. T12: backpack positioned at the twelfth thoracic vertebra. L3: backpack positioned at the third lumbar vertebra.

6.5.1 Trunk angle

There was a significant effect on the participants' trunk angles, Wilks' Lambda = 0.03, $F(9,127) = 435.83$, $p < 0.001$. The assumption of sphericity was violated, as assessed by Mauchly's Test of Sphericity; $\chi^2(44) = 1317.30$, $p < 0.01$. Therefore, a Greenhouse-Geisser correction was applied ($\epsilon = 0.374$). The trunk angles for all intervention conditions had changed compared to the baseline posture ($M = 9.35$, $SD = 0.15$). The largest change was detected when carrying the load of 15% BW with placement at T7 ($M = 11.25$, $SD = 0.14$). Post-hoc analysis with Bonferroni adjustment revealed that the trunk angles had significantly changed ($p < 0.005$) for most intervention conditions except T7-5%, T12-5%, L3-5% BW ($p > 0.99$). The changes in the trunk angles from the baseline as a result of the nine intervention conditions are depicted in Figure 6.4.

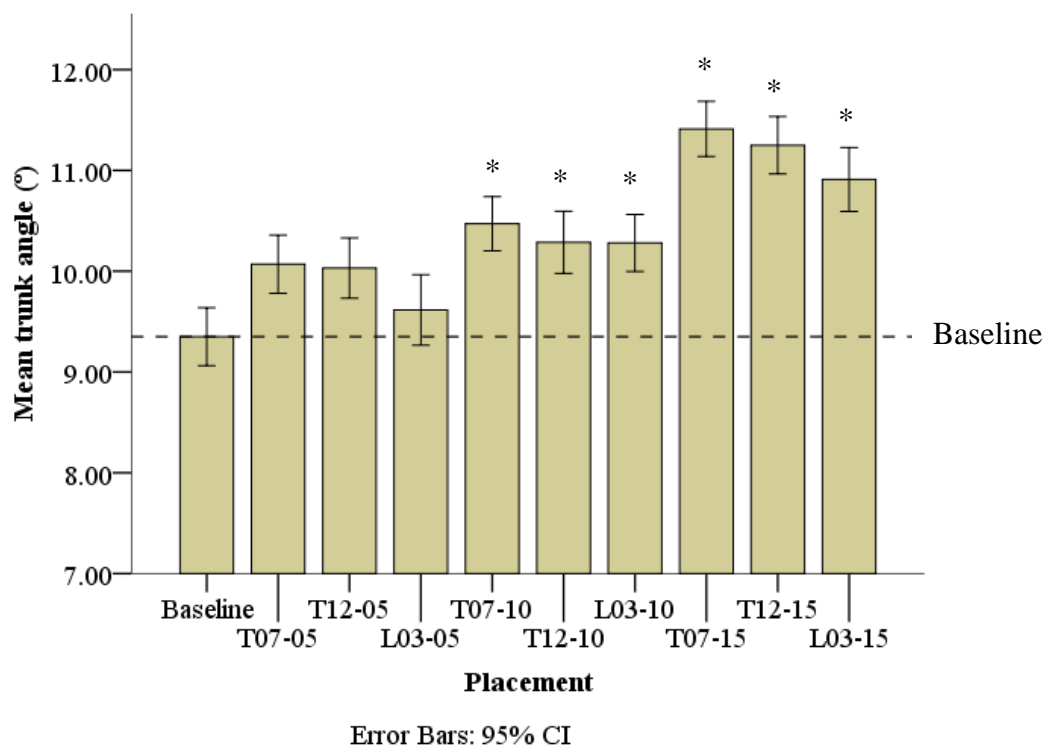


Figure 6.4: Comparison of the trunk angles between the baseline and the nine conditions of intervention, (*) $p < 0.005$

6.5.2 Neck angle

There was a significant effect on the participants' neck angles, Wilks' Lambda = 0.24, $F(9,127) = 43.66$, $p < 0.001$. The assumption of sphericity was violated, as assessed by Mauchly's Test of Sphericity; $\chi^2(44) = 402.18$, $p < 0.001$. Therefore, a Greenhouse-Geisser correction was applied ($\epsilon = 0.628$). The neck angles for all intervention conditions had changed compared to the baseline posture ($M = 51.01$, $SD = 0.25$). The largest change was detected when carrying the load of 15% BW with placement at T7 ($M = 54.65$, $SD = 0.28$). Post-hoc analysis with Bonferroni adjustment revealed that the neck angles had significantly changed ($p < 0.005$) for most intervention conditions except T12-5%, L3-5% and L3-10% BW ($p > 0.07$). The changes in the neck angles from the baseline as a result of the nine intervention conditions are depicted in Figure 6.5.

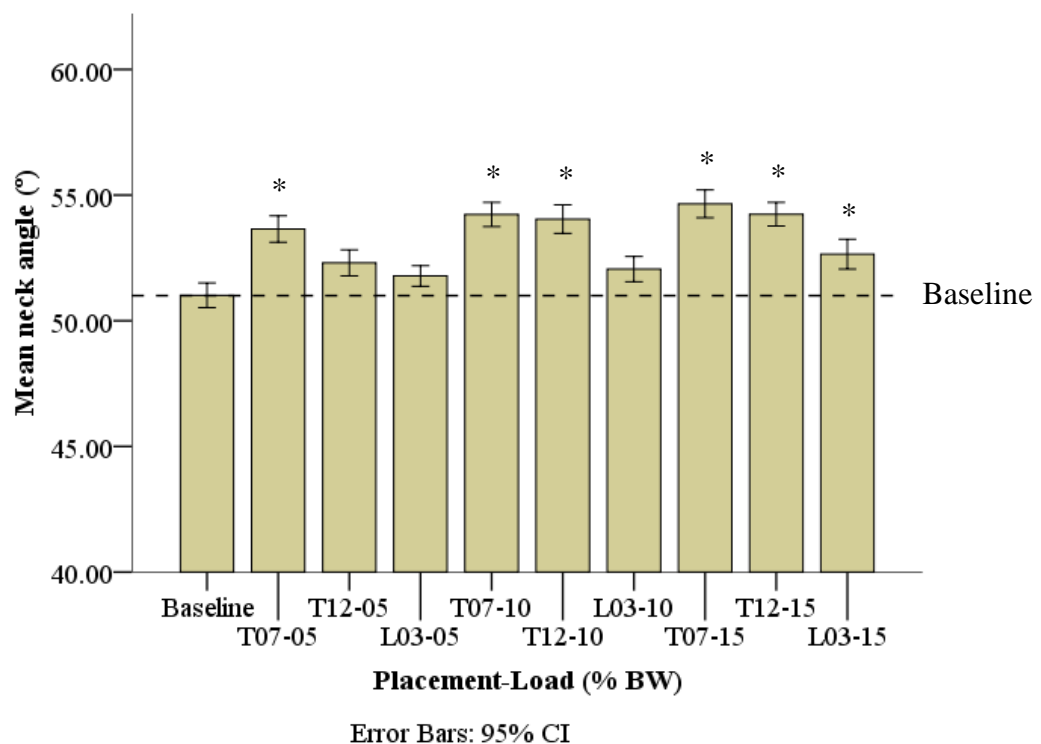


Figure 6.5: Comparison of the neck angles between the baseline and the nine conditions of intervention, (*) $p < 0.005$

6.5.3 Gaze angle

There was a significant effect on participants' gaze angles Wilks' Lambda = 0.46, $F(9,127) = 16.49$, $p < 0.001$. The assumption of sphericity was violated; $\chi^2(44) = 463.37$, $p < 0.001$. A Greenhouse-Geisser correction was applied ($\epsilon = 0.616$). The gaze angles for all intervention conditions had changed compared to the baseline posture ($M = 18.28$, $SD = 3.68$). The largest change was detected when carrying the load of 15% BW with placement at T7 ($M = 21.64$, $SD = 4.28$). Post-hoc analysis with Bonferroni adjustment revealed that the gaze angles had significantly changed ($p < 0.005$) for most intervention conditions except T12-5%, L3-5%, T12-10%, L3-10% BW ($p > 0.07$). The changes in the gaze angles from the baseline as a result of the conditions of intervention conditions are depicted in Figure 6.6.

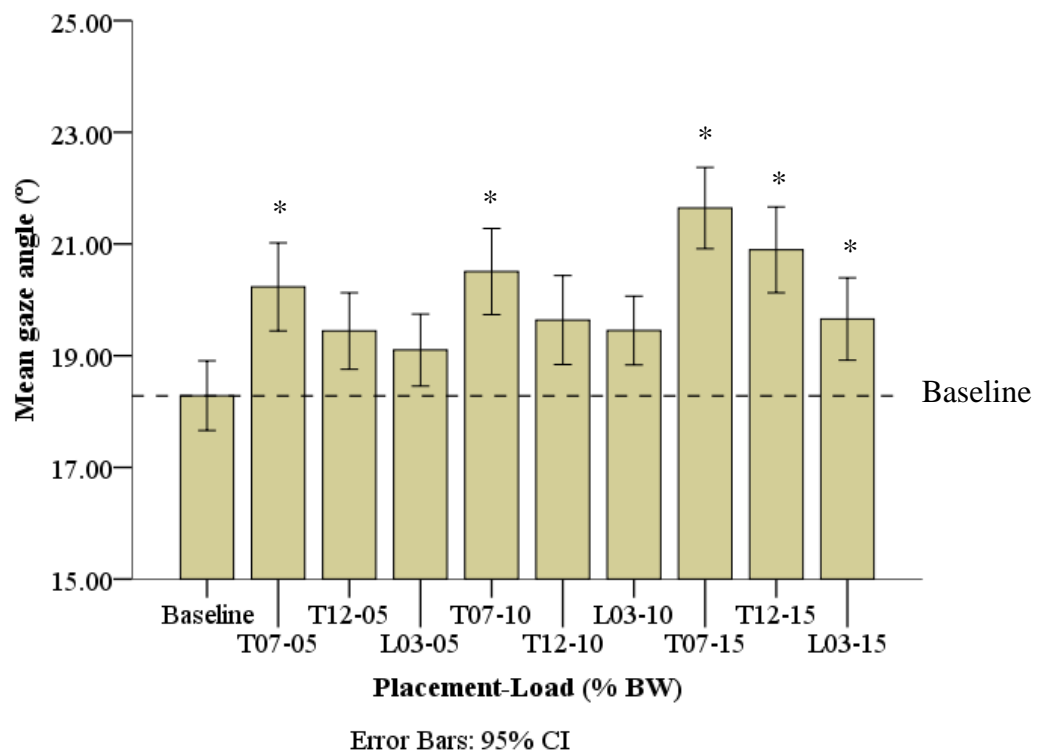


Figure 6.6: Comparison of the gaze angles between the baseline and the nine conditions of intervention, (*) $p < 0.005$

6.5.4 Head on neck angle

There was a significant effect on the participants' neck angles; Wilks' Lambda = 0.67, $F(9,127) = 6.99$, $p < 0.001$. The assumption of sphericity was violated; $\chi^2(44) = 185.37$, $p < 0.001$. Therefore, a Greenhouse-Geisser correction was applied ($\epsilon = 0.749$). The head on neck angle for all intervention conditions had changed compared to the baseline posture ($M = 19.29$, $SD = 3.66$). The largest change was detected when carrying the load of 15% BW with placement at T7 ($M = 17.34$, $SD = 4.28$). Post-hoc analysis with Bonferroni adjustment revealed that the head on neck angles had significantly changed for interventions T7-10%, T7-15%, T12-15% and L3-15% BW ($p < 0.005$). The changes in the head on neck angles from the baseline as a result of the nine intervention conditions are depicted in Figure 6.7.

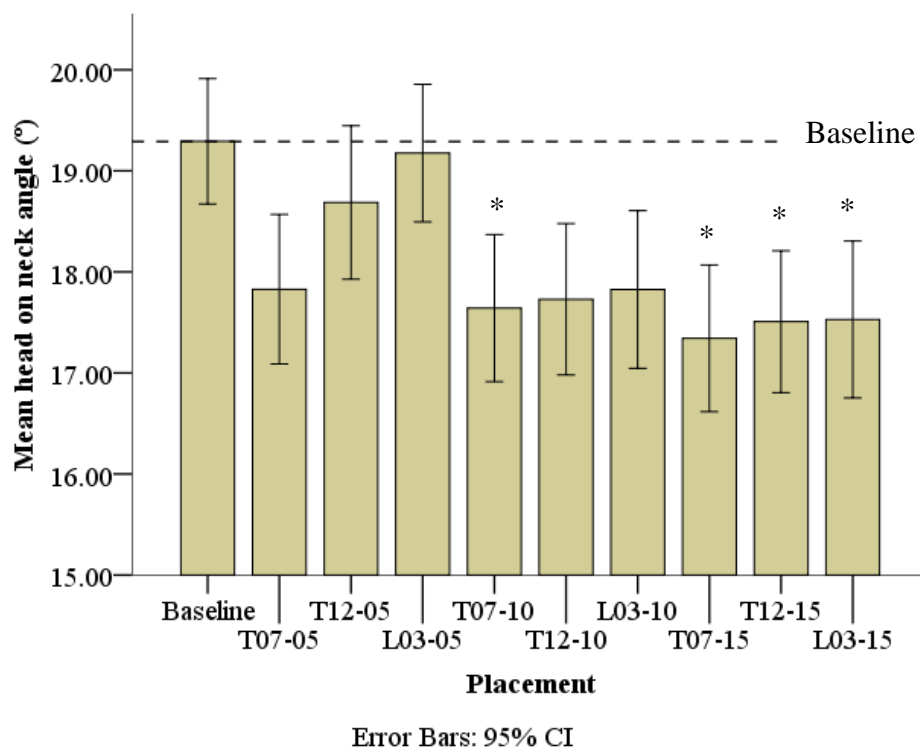


Figure 6.7: Comparison of the head on neck angles between the baseline and the nine conditions of intervention, (*) $p < 0.005$

6.5.5 Lower limb angle

There was a significant effect on the participants' lower limb angles; Wilks' Lambda = 0.04, $F(9,127) = 152.07$, $p < 0.001$. The assumption of sphericity was violated; $\chi^2(44) = 351.53$, $p < 0.001$, a Greenhouse-Geisser correction was applied ($\epsilon = 0.572$). The lower limb angles for all intervention conditions had changed compared to the baseline posture ($M = 6.11$, $SD = 1.03$). The largest change was detected when carrying the load of 15% BW with placement at T7 ($M = 6.11$, $SD = 1.03$). Post-hoc analysis with Bonferroni adjustment revealed that the lower limb angles had significantly changed ($p < 0.005$) when carrying loads of 10% and 15% BW regardless of placements (T7, T12 or L3). The changes in the lower limb angles from the baseline under the nine conditions of intervention are depicted in Figure 6.8.

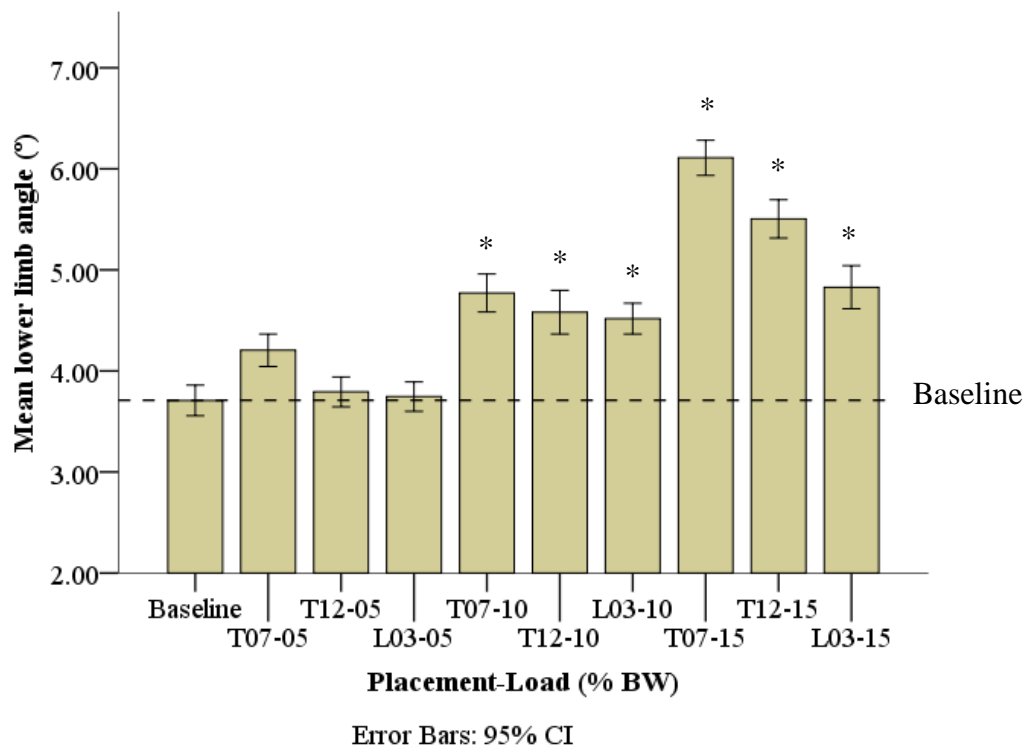


Figure 6.8: Comparison of the lower limb angles between the baseline and the nine conditions of intervention, (*) $p < 0.005$

6.5.6 Tragus angle

There was a significant effect on the participants' tragus angles, Wilks' Lambda = 0.54, $F(9,127) = 9.97$, $p < 0.001$. The assumption of sphericity was violated; $\chi^2(44) = 91.68$, $p < 0.001$, a Greenhouse-Geisser correction was applied ($\epsilon = 0.872$). The tragus angle for all intervention conditions had changed compared to the baseline posture ($M = 1.53$, $SD = 3.68$). The largest change was detected when carrying loads of 15% BW with placement at T7 ($M = 1.95$, $SD = 0.46$). Post-hoc analysis with Bonferroni adjustment revealed that the tragus angles had significantly changed ($p < 0.005$) when carrying the load of 15% regardless of placements (T7, T12, and L3). The changes in the tragus angles from the baseline as a result of the nine intervention conditions are depicted in Figure 6.9.

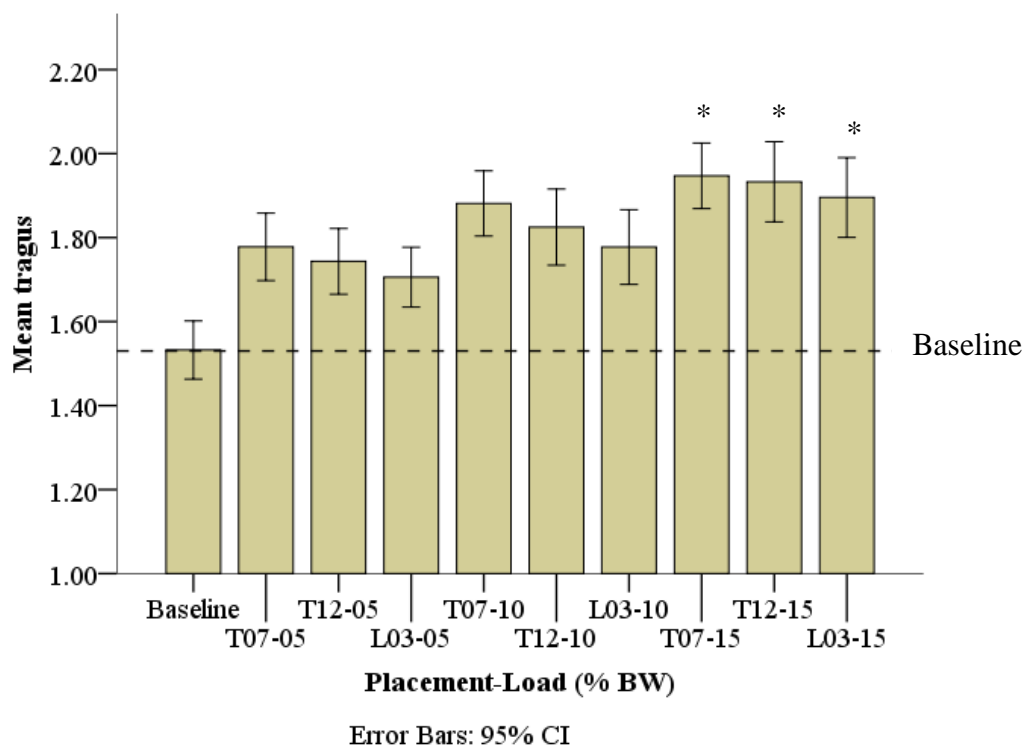


Figure 6.9: Comparison of the tragus angles between the baseline and the nine conditions of intervention, (*) $p < 0.005$

6.5.7 Acromion angle

There was a significant effect on the participants' acromion angles; Wilks' Lambda = 0.56, $F(9,127) = 10.95$, $p < 0.001$. The assumption of sphericity was violated; $\chi^2(44) = 240.57$, $p < 0.001$. Therefore, a Greenhouse-Geisser correction was applied ($\epsilon = 0.736$). The acromion angles for all intervention conditions had changed compared to the baseline posture ($M = 1.87$, $SD = 0.44$). The largest change was detected when carrying the load of 15% BW with placement at T7 ($M = 2.16$, $SD = 0.43$). Post-hoc analysis with Bonferroni adjustment revealed that the acromion angles were significantly changed when carrying the load of 10% BW with placement at T7 and carrying the load of 15% BW regardless of placements ($p < 0.005$). The changes in the acromion angles from the baseline as a result of the nine intervention conditions are depicted in Figure 6.10.

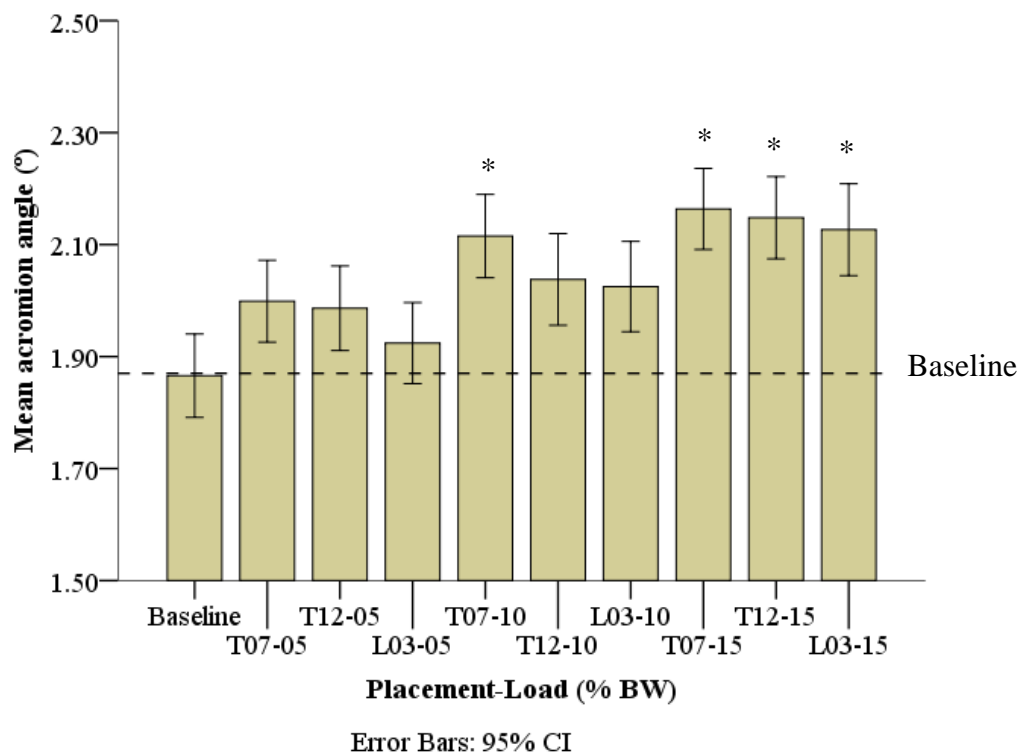


Figure 6.10: Comparison of the acromion angles between the baseline and the nine conditions of intervention, (*) $p < 0.005$

6.5.8 Pelvic angle

There was a significant effect on the participants' pelvic, Wilks' Lambda = 0.79, $F(9,127) = 3.74$, $p < 0.001$. The assumption of sphericity was violated; $\chi^2(44) = 66.04$, $p = 0.017$, a Greenhouse-Geisser correction was applied ($\epsilon = 0.895$). The pelvic angles for all intervention conditions had changed compared to the baseline posture ($M = 1.78$, $SD = 0.48$). The largest change was detected when carrying the load of 15% BW with placement at T7 ($M = 1.97$, $SD = 0.37$). Post-hoc analysis with Bonferroni adjustment revealed that the pelvic angles had significantly changed when carrying the load of 15% regardless where the backpack was placed on the back ($p < 0.005$). The changes in the pelvic angles from the baseline as a result of the nine intervention conditions are depicted in Figure 6.11.

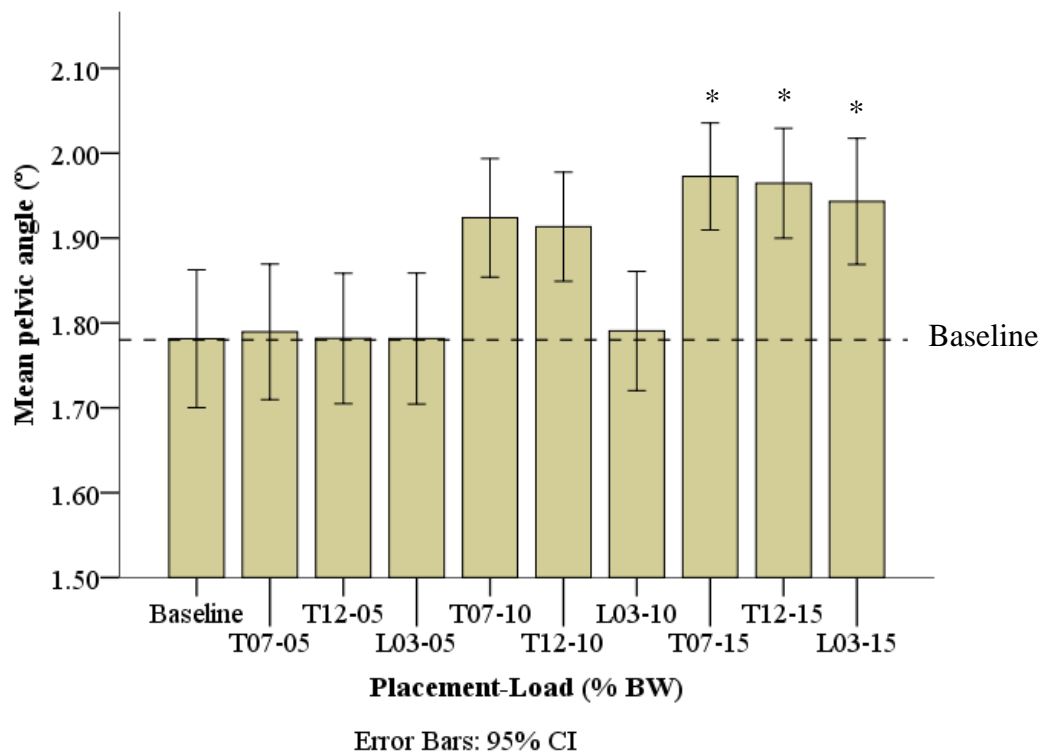


Figure 6.11: Comparison of pelvic angles between the baseline and the nine conditions of intervention, (*) $p < 0.005$

As a conclusion, we can conclude that there were statistically significant changes for postural angles when carrying the backpack at different loads and placements compared to the baseline conditions.

6.6 Relationship between Gender, Age and BMI with Postural Deviation

The relationship between gender, age and BMI was investigated using Pearson's correlation test. Preliminary analysis was performed to ensure all the assumptions (outliers, normality, linearity, and homoscedasticity) were fulfilled. The results showed all postural angles were normally distributed (Shapiro-Wilk > 0.05), linear relationship (scatter plot) and no significant outliers.

6.6.1 Relationship between gender and postural deviation

The results revealed that there were statistically significant relationships between genders with the trunk, gaze, the head on neck and lower limb angles as shown in Table 6.4. The direction of the relationship was negative, meaning that girls had more deviation compared to boys. However, the strength of the relationship was classified as weak (Cohen, 1988)

6.6.2 Relationship between age and postural deviation

The results showed there were statistically significant relationships between age with the trunk, neck and lower limb angles as shown in Table 6.4. The direction of the relationship was negative, meaning that the higher the age the less deviation occurred in the trunk, neck, and lower limb angles. The strength of the relationship was classified as weak (Cohen, 1988). When the age was categorized into two groups

(aged 7-9 and 10-12), the relationship was only significant for the trunk angle, specifically, when carrying loads 10% and 15% BW and placed it at T7 and T12.

6.6.3 Relationship between BMI and postural deviation

The results showed there were statistically significant relationships between BMI with the trunk and neck angles as shown in Table 6.4. The direction of the relationship was negative, meaning the higher the BMI the less deviation in the trunk and neck angles. The strength of the relationship was classified as weak (Cohen, 1988).

Table 6.3: The relationships between gender, age, and BMI with postural deviations

Independent variables	Postural angles	r	Sig. (p-value)	Strength
Gender	Trunk	-0.05*	0.04	Small
	Gaze	-0.06*	0.02	Small
	Head on neck	-0.06*	0.03	Small
	Lower limb	-0.10*	< 0.01	Small
Age	Trunk	-0.17*	< 0.01	Small
	Neck	-0.18*	< 0.01	Small
	Lower limb	-0.08*	< 0.01	Small
BMI	Trunk	0.07*	0.01	Small
	Neck	0.21*	< 0.01	Small

N = 136, (*) $p < 0.05$, $r < 0.29$ weak relationship (Cohen 1988, pp. 78-81)

6.7 Comparison of Postural Deviations between Gender, Age and BMI

The purpose of comparing the changes in postural deviation (the trunk, neck, gaze, head on neck, lower limb, tragus, acromion and pelvic angles) while carrying the backpack between gender, age and BMI was to propose the appropriate loads and placement for healthy primary school children in Malaysia.

6.7.1 Comparison of postural deviations between gender

The results showed that there were no significant differences in postural deviations (the trunk, neck, gaze, head on neck, lower limb, tragus, acromion and pelvic angles) between gender. These results were due to no significant differences in height, weight and BMI between boys and girls.

6.7.2 Comparison of postural deviations between age groups

The results showed there were significant differences in postural deviations (the trunk, neck, gaze, head on neck, lower limb, tragus, acromion and pelvic angles) between age groups. The results may be due to differences in height, weight and BMI between ages. The comparison of postural deviations between age groups is shown in Table 6.4.

Table 6.4: Comparison of postural deviations between age groups

Age groups	Postural angles	Loads (BW)	Placements	Sig.
Group 1: (aged 7-9) vs. Group 2: (aged 10-12)	Trunk, neck, gaze, head on neck and lower limb	10% and 15% 15%	T7 and T12	< 0.05
BW – body weight, T7 – 7 th thoracic, T12 – 12 th thoracic				

6.7.3 Comparison of postural deviations between BMI groups

The results showed there were significant differences in postural deviations (the trunk and neck angles) between BMI groups. This is because there were differences in BMI between Group 1 (aged 7-9) and Group 2 (aged 10-12) as stated in 6.2.

6.8 Association between Gender, Age and BMI with Perception of Discomfort

The relationships between gender, age, and BMI with perceptions of discomfort were investigated using the Pearson's chi-square tests. In order to perform this test, the BMI was classified into four categories namely underweight, normal, obese and overweight. Nine parts of the body were chosen to assess the perceptions of discomfort when loading the backpack namely the neck, shoulders, elbow/forearm, hand/wrist, hip/thigh, upper back, lower back, knee, and ankle/foot.

6.8.1 Association between gender and perception of discomfort

Although the participants complained that they had discomfort at the neck, shoulder, elbow/forearm, upper back, and, lower back when carrying the loaded backpacks, the chi-square did not show any significant relationships between gender and discomfort scores; $p > 0.05$.

6.8.2 Association between age and perception of discomfort

Although the participants complained that they had discomfort at the neck, shoulder, elbow/forearm, upper back, and, lower back when carrying the loaded backpacks, the chi-square did not show any significant relationships between age and discomfort scores; $p > 0.05$.

6.8.3 Association between BMI and perception of discomfort

Although the participants complained that they had discomfort at the neck, shoulder, elbow/forearm, upper back, and, lower back when carrying the loaded backpacks, the chi-square did not show any significant relationships between BMI and discomfort scores; $p > 0.05$.

6.9 Proposed Backpack Loads and Placements

The present study showed that carrying 15% BW backpack load may change all postural angles (the trunk, neck, gaze, head on neck, lower limb, tragus, acromion and pelvic). Hence, we recommend a healthy primary school students should avoid carrying backpack load exceeding 15% BW. In addition, the appropriate location to place the centre of gravity of the backpack was at L3. However, when the participants were divided into two groups, the appropriate location for the Group 1 (aged 7-9) is between T12 and L3 while Group 2 (aged 10-12) is at L3. This may be due to the fact that the body's centre of gravity of participants in Group 1 is higher compared to Group 2. However, the proposed loads and placements may change when considering the dynamic conditions' results.

6.10 Summary

The above results were based on the modernized protocol adapted from Grimmer et al. (2002). Further elaborations on the results are presented in Chapter 7 that also compares the present findings with prior studies in this area. In conclusion, it can be surmised that there were statistically significant changes for all postural angles except for the pelvic angle when carrying backpacks with different loads and placements, as compared to the baseline angles.

CHAPTER 7

DISCUSSION

7.1 Introduction

The issue of heavy school bags in Malaysia has been the subject of some research and investigation over the past few years (Fazrolrozi & Rambely, 2008; Mohd Tamrin et al., 2005; Rambely, Tan, Hasan, & Ganason, 2007). A critical view of this study revealed that most of the researches were outdated and used methodologies that were unable to be generalised. Meanwhile, there have been some national governmental initiatives to address the issue, for instance, the Terengganu State Government has provided e-books for primary school children, so that they no longer need to bring textbooks to schools once they are equipped with the special software as an alternative. This alternative was not only seen as a solution to the problem of heavy school bags but also, may help in creating an inspirational learning environment that may be sustainable in the long term. However, the pilot project was terminated in 2015 by the state government due to technical problems.

The issue of school backpacks and their effects on the posture of school-aged children in Malaysian is the subject of this thesis. The purpose of the present study was to investigate the effects of various backpack loads and placements on postural

deviation. Additionally, the relationships between age, gender and BMI with postural deviation and discomfort scores were examined. Although similar studies have been conducted in various countries, no consensus has been reached particularly in determining the universal load limits for school children and the best placement for the backpack to reduce postural deviation (Brackley et al., 2009; Devroey et al., 2007) as discussed in the systematic review. In essence, this study provides new and comprehensive information on postural deviations caused by heavy backpacks. The value of this is that in communicating the information to the related organizations, we can enable them to develop effective solutions, policies, practices and procedures in the future.

7.2 Participants' Background

Initially, it was planned to recruit participants based on a 50:50 ratio of males and females. However, until the end of the study, the boys outnumbered the girls especially for the 10-12 year age group. This may be attributed to religious and cultural factors (Islam forbids females from wearing tight attires especially after puberty and their reluctance for their body shapes to be photographed and recorded). This represents an important consideration when undertaking research in countries with a predominantly Muslim population – consideration may need to be given to different ways of collecting information.

The number of 'underweight' participants in the present study was slightly higher compared to the national prevalence, i.e. 13.6% in urban areas and nearly double in rural areas (Ahmad Ali et al., 2013). What this means, is that the effect of carrying

backpacks in this group may have been slightly exaggerated due to their body weight ratio.

7.3 Discomfort Scores

Various outcome measures have been used to assess pain or discomfort (Table 2.20 and 2.21) but in the present study, perceptions of discomfort were used because the range of tested load was within the recommended load limits and none of the participants in the feasibility study experienced pain while carrying the backpack (section 4.5.4). Twelve body parts were selected to assess discomfort, i.e. the neck, shoulders, upper back, upper arm, lower back, forearm, wrist, hip/buttock, thigh, knee, lower leg, and foot. None of the participants gave discomfort scores at level 8 (huge discomfort) and 10 (pain) when the backpack was placed on their backs regardless of loads (5%, 10%, 15% BW) and placements (T, T12, L3).

The issue of discomfort when carrying backpacks has been inconsistently reported in the literature. Some authors reported that there was a significant relationship between discomfort and backpack carriage (Chiang et al., 2006; Negrini & Carabalona, 2002) while more recent literature refutes such associations (Dockrell et al., 2015; Rai & Agarwal, 2014). The different findings might be due to the different physical characteristics of the respondents (height, weight and BMI) because these studies were conducted in diverse locations, i.e. in Europe (height, weight and BMI) because the locations of the studies were in Europe (Chiang et al., 2006; Dockrell et al., 2015; Negrini & Carabalona, 2002) and in Asia (Rai & Agarwal, 2014).

In the present study, the most complaints discomfort was identified most frequently at the shoulders, upper back and lower back of the participants'. Although the study by Chiang et al. (2006) and Negrini & Carabalona (2002) claimed there was a significant association between discomfort and backpack carriage, they did not specify the most frequent location of discomfort experienced by the respondents. Another study in Malaysia reported that the most frequent complaints of discomfort related to backpack carriage involved the neck, followed by the upper back and lower back (Mohd Azuan et al., 2010). Prior studies in this area focused largely on back pain because other studies have associated low back pain in childhood with adult back pain (Lise Hestbaek, Leboeuf-Yde, & Kyvik, 2006). However, the evidence is still controversial because there is no clear objective evidence to support the relationship between poor school posture and the development of neck and/or low back pain in adult life (Grimes & Legg, 2004). This has implications for further research – and ideally, children should be followed throughout their adolescence to identify whether this is the case.

7.4 Comparison between Three Baseline Postural Angles

The purpose of comparing the three baseline posture angles or baseline angles was to ensure that changes in the angles during measurements were the spontaneous bodily reactions to maintain stability and not due to fatigue. In the present study, postural deviations were determined by comparing the postural angles during interventions (carrying the backpack) with the baseline (without carrying the backpack). The intervention in this study involves nine experimental conditions of backpack carriage

(Table 4.1) that were carried out consecutively. This situation may cause participants to experience fatigue, and ultimately affect the results of the experiment.

Comparisons between baseline angles were performed using one-way repeated measures ANOVA. The results showed no significant differences between the angles taken before the 1st intervention as well as after the 5th and 9th intervention. This means that the postural changes that occurred during measurements were the spontaneous reaction of the body to maintain stability and not due to postural fatigue, and we can be confident that our results were accurate. This technique was also used by Grimmer et al. (2002) to indicate consistency in postural positioning in unloaded conditions (Karen Grimmer, Leah, & Steve, 2006).

7.5 The Effects of Backpack Loads and Placements on Postural Deviation

The effects of backpack loads and placements varied between postural angles. Some angles change proportionally to the increasing of loads carried while some angles were inversely proportional.

7.5.1 Trunk angle

The trunk angle is defined as the angle formed by a line drawn from the anatomical markers in C7 to the greater trochanter and vertical lines through the greater trochanter. The deviation of the trunk angle is crucial because it indicates the occurrence of spinal curvature.

The peer-reviewed literature consistently reported that carrying the backpack loads of 10% BW and above had significantly changed the trunk angle compared to the baseline condition (Brackley et al., 2009; Hong & Brueggemann, 2000; Li & Hong, 2001, 2004; Talbott, 2005). To avoid extreme postural deviation, some literature suggested avoiding loads exceeding 20% BW to reduce the risk of awkward postures, imbalance and falls (Li & Hong, 2001; Singh & Koh, 2009a; Talbott, 2005).

In the present study, the trunk angle was changed compared to the baseline condition when carrying backpack loads of 5%, 10% and 15% BW regardless of placement (T7, T12 or L3). However, the angle of the trunk significantly changed compared to the baseline conditions when carrying a load of 10% and 15% BW regardless of placement. This study was consistent with another study in Singapore that found the trunk angle changed significantly from the baseline condition when carrying the loads of 10%, 15% and 20% BW placed between T8-T9 (Singh & Koh, 2009a). Another study in India found a significant change in the trunk angle when carrying the load of 5% BW compared to baseline condition but did not specify the placement of the backpack (Ramprasad et al., 2010).

In other studies, the changes of trunk angles were measured using the TFL. Several studies reported the TFL changed significantly when carrying a load of 15% BW (Brackley et al., 2009; Li & Hong, 2004). This finding does not conflict with the present study results because the variable tested was different. For example, the study by Brackley (2009) only tested the effects of carrying loads of 15% BW on TFL and not any other loads. Although the study by Li & Hong (2004) involved participants aged 6-12 years carrying loads of 10%, 15%, 20% BW, it was performed in a

dynamic condition where participants were required to walk on a treadmill for 20 minutes. In an earlier study, it was suggested that a backpack load of 15% BW appeared to be too heavy to maintain standing posture for adolescents (Chansirinukor, Wilson, et al., 2001). In this study, loads of both 10% and 15% BW were shown to have an effect on the trunk.

7.5.2 Neck angle

The neck angle is defined as the angle formed by a line drawn from the anatomical markers in C7 to the tragus of the ear, and a line from anatomical markers in C7 until the greater trochanter. In another study, it is also called the head on neck on trunk angle (HNTA) (Ramprasad et al., 2010). However, most studies prefer to use the cranio-vertebral angle (CVA) to determine the deviation of the neck angle while carrying the backpack (Brackley et al., 2009; Chansirinukor, Ilson, et al., 2001; Kistner et al., 2012; Moa, Xua, Lia, & Liua, 2013; Mohan et al., 2007; Ramprasad et al., 2010). The CVA is defined as the angle formed by the intersection of a horizontal line through the spinous process of C7 and line of the tragus of the ear. The deviation of the neck angle may result in abnormal stress to the nerves of the neck, shoulders and lower back regions (Chansirinukor, Ilson, et al., 2001).

In the present study, the neck angle has significantly changed compared to the baseline condition when carrying all loads above baseline - of 5%, 10% and 15% BW but this depended on where it was placed on the back. The neck angle significantly changed when carrying the load of 5% BW placed at T7. In addition, it also changed significantly when carrying a load of 10% BW placed at T7 and T12. However, the

trunk angle changed significantly when carrying a load of 15% BW regardless of placement (T7, T12 and L3). The results are consistent with another study among boys aged 12 years in India although it did not specify the placement of the backpack being tested (Ramprasad et al., 2010). Another study in Belgium also found that the neck angle significantly changed when carrying loads of 10% and 15% BW placed on the thoracic and lumbar region (Devroey et al., 2007). The study concluded that most postural deviation occurred in the higher position (thoracic compared to lumbar region).

In other studies, the change of neck angle while carrying the backpack was measured using CVA. It was suggested when the backpack was placed on the back, the CVA is decreased by poking the head forward (Brackley & Stevenson, 2004). Some studies found that carrying a backpack load of 10% BW significantly changed the CVA (Moa et al., 2013; Mohan et al., 2007) while some studies reported changes with 15% BW (Brackley et al., 2009; Chansirinukor, Ilson, et al., 2001; Ramprasad et al., 2010).

Despite the suggestion by the literature indicating that the neck angle changed while carrying loads of 10% BW and above, the recent study has interesting results in terms of time response (Kistner et al., 2012). The study claimed that carrying the backpack at 10% BW load does not cause an immediate change in the CVA compared to the 15% and 20% BW. Therefore, they recommended the load carried by school children should be limited to 10% BW.

7.5.3 Gaze angle

The gaze angle is defined as the angle formed by a line drawn from the anatomical markers at the cantus of the eye to the tragus of the ear and a horizontal line through the tragus of the ear. In another study, it also called the cranio-horizontal angle (CHA) (Moa et al., 2013; Mohan et al., 2007). The change in the gaze angle is dependent on the head movement.

In the present study, the gaze angles significantly changed compared to the baseline when the participants were carrying loads of 5%, 10% and 15% BW depending on where it placed on the back. All experimental conditions led to significant changes in the gaze angle except when carrying loads of 5% and 10% BW and placed at T7. However, the gaze angle changed significantly when carrying a load of 15% BW regardless of placement (T7, T12 and L3). Another study in India found the CHA changed significantly compared to the baseline condition when carrying the load of 10% BW in static and dynamic conditions (Mohan et al., 2007). However, the study did not specify where the backpack was placed on the back. Furthermore, the recent study also reported the gaze angle had changed significantly compared to the baseline condition when the children aged 10 years old carried loads of 10% and 15% BW in dynamic condition but also did not specify the placement of the backpack (Moa et al., 2013).

7.5.4 Head on neck angle

The head on neck angle is defined as the angle formed by a line drawn from anatomical markers at C7 to the tragus of the ear and a line drawn through the canthus of the eye and the tragus of the ear. The change of head on neck angle is also dependent on the movement of the head.

In the present study, the head on neck angles significantly changed compared to the baseline condition when carrying a load of 10% BW placed at T7. However, the head on neck angle changed significantly when carrying a load of 15% BW regardless of placement (T7, T12 and L3). This result is consistent with another study involving school children aged 12 years old in India but did not specify the back placement during the experiment (Ramprasad et al., 2010). In a recent study, the gaze angle also was reported to have significantly changed compared to the baseline condition when the children aged 10 years old carried backpack load of 10% and 15% BW in dynamic condition (Moa et al., 2013). Backpack loads carried by schoolchildren should be limited to 10% body weight due to increased forward head positions compared to the 15% and 20% BW load (Kistner et al., 2012).

7.5.5 Lower limb angle

The lower limb angle is defined as the angle formed by a line drawn from the greater trochanter to the ankle, and the vertical line through the greater trochanter. Several studies were conducted to investigate the effect of lower limb angles while carrying backpack among students aged 10 and 12 years old (Ramprasad et al., 2010; Singh & Koh, 2009b).

The present study revealed that carrying the load of 10% and 15% BW caused significant change to the lower limb angle compared to the baseline condition regardless where the backpack was placed on the back. This result was contradicted by another study involving school children aged 12 years old in India which reported the lower limb angle changed significantly when carrying the load of 5% BW but did not specify the placement of the backpack during the experiment (Ramprasad et al., 2010).

In other studies, the deviation of the lower limb due to backpack carriage was assessed by looking at the movement of the body markers at the knee and ankle (Karen Grimmer et al., 2002; Talbott, 2005). A study by Grimmer et al. (2002) did not find any significant changes at mid joint knee compared to baseline condition when carrying the load of 3%, 5% and 10% BW regardless of where the backpack was placed (T7, T12 and L3). Although Talbott (2005) had used the loads of 10% and 20% BW, the result also found no significant differences at knees and ankles.

7.5.6 Tragus angle

The tragus angle is defined as the angle formed by a line drawn from the tragus of the ears (left to right) and a horizontal line through the tragus of the ear. The purpose of measuring tragus angles was to determine the tendency of the head to lean right or left while carrying different backpack loads and placement. Based on a literature search using google scholar search engine, only one study was performed to determine the tendency of head to lean right or left from the frontal plan (Talbott, 2005).

The present study revealed that the tragus angle significantly changed compared to the baseline condition when carrying a load of 15% BW regardless where the backpack was placed on the back (T7, T12 and L3). The tendency of lean for tragus angle was more to left especially when placing the backpack at T7. A study by Tablott (2005) used the right and left temporal angles to determine the changes of the head while carrying the load of 10% and 20% BW and placed at T7 and scapula region. The study found no statistical changes at the temporal angle when carrying loads of 10% and 20% BW between placements. Although there was a study measuring the tragus angle, no specific conclusion was mentioned about it (Moa et al., 2013).

7.5.7 Acromion angle

The acromion angle is defined as the angle formed by a line drawn from the acromion (left to right) and a horizontal line through the acromion. Studies on the determination of the effect on the acromion while carrying various backpack load were conducted in sagittal plane by using body markers (Chansirinukor, Wilson, et al., 2001; Fiolkowski et al., 2006).

The present study revealed the acromion angle was significantly changed from the baseline angle when loading the backpack with load of 10% BW placed at T7. However, the acromion angle changed significantly when carrying a load of 15% BW regardless of placement (T7, T12 and L3). The tendency of lean for acromion angle was in equal range between left and right irrespective of the load carried and placement of the backpack on the back. In another study, Talbott (2005) compared the changes of the right and left shoulder using the shoulder angle. However, no

significant change was found between the shoulders when carrying the load of 10% and 20% regardless of placement. It is difficult to compare the present study results with the other studies as the study in this area is very limited. The effect on the acromion angle requires more investigation particularly to compare between symmetrical and asymmetrical backpack carriage.

7.5.8 Pelvic angle

The pelvic angle is defined as the angle formed by a line drawn through the canthus of the pelvic (left to right) and a horizontal line through the pelvic. Studies on the effects on the pelvic while carrying the backpack were performed in the sagittal plane (Chow et al., 2010; Devroey et al., 2007). In the present study, the pelvic angle was significantly changed when carrying a load of 15% BW regardless where the backpack was placed. The tendency to lean for acromion angle ranged equally between the left and right irrespective of the load carried.

A study by Chow et al. (2010) used the pelvic tilt angle as one of the indicators to determine spinal displacement while carrying a backpack load of 15% BW placed at T7, T12 and L3. The results revealed that there was no significant difference in pelvic tilt angle compared to baseline condition regardless of placements. In another study, Devroey et al. (2009) found significant changes at the pelvic while carrying backpack loads of 10% and 15% BW placed at the thoracic and lumbar region. Most of the changes occurred at higher placements (thoracic region).

Based on the above discussion, a solution for the backpack load and placement must be given a priority because until now, primary school children still need to carry heavy backpacks in accordance with the curriculum developed by the MOE and the timetable set by the school. If the issue is not addressed early, it may affect the government's aspiration to develop human capital that will help turn this country into a developed nation by 2020. Guidelines on healthy backpacks must be established not only to prevent the occurrence of musculoskeletal problems among students but also to reduce the medical costs to treat such musculoskeletal problems and to prevent frequent sick leave in their future working life.

In summary, children should carry backpacks placed on their lower back position, but regardless of where they place their backpack, never at 15% BW or higher. In some children, 10% BW may be too heavy, and alternatives must be found.

The second null hypothesis (H_0) stated that there will be no significant changes in the postural angles (the trunk, neck, gaze, head on neck, lower limb, tragus, acromion and pelvic angles) compared to the baseline conditions when carrying different backpack loads (5%, 10%, 15% BW) and placing the backpack at different locations (T7, T12 and L3) should be rejected because all postural angles statistically significantly changed when carrying loads of 15% BW regardless of its placement on the back.

7.6 Relationship between Gender, Age, and BMI with Postural Deviation

The occurrence of postural deviation in school-aged children may reflect the normal postural development and can result in negative impacts on the quality of life during childhood and adulthood (Penha et al., 2005). Studies on the relationship between personal characteristics (age, gender and BMI) and postural deviation are very limited (Rodríguez-Oviedo et al., 2012; Sheir-Neiss et al., 2003).

7.6.1 Relationship between gender and postural deviation

The present study, the statistically significant relationships were found between gender and the deviation of the trunk, gaze, head on neck, lower limb angles (Table 6.4). This result was consistent with another study conducted in the USA that reported significant correlations between gender and postural deviations while carrying backpacks (Talbot, 2005). In contrast, other studies have found no significant relationship between gender and postural deviations while carrying backpack (Danik, Martin, Martin, & Deed, 2007; Karen Grimmer et al., 2002).

The third null hypothesis (H_0) stated that there will be no significant relationship between gender, age, and BMI with the deviations of the trunk, neck, gaze, head on neck, lower limb, tragus, acromion and pelvic angles should be rejected.

7.6.2 Relationship between age and postural deviation

The present study, the significant relationships were found between age with the deviation of the trunk and neck angles especially when carrying loads of 10% and 15% BW placed at T7 and T12 (Table 6.4). When the age was categorized into two

groups (7-9 and 10-12-year-old), the relationship was only significant for the trunk angle, specifically, when carrying loads 10% and 15% BW and placed it at T7 and T12. However, both relationships were small ($r < 0.30$). These findings concur with a study in the USA that found a significant correlation between age and postural changes while carrying backpack (Talbot, 2005). However, there were also studies that did not find any correlation between age and postural deviation while carrying backpack (Danik et al., 2007; Karen Grimmer et al., 2002).

The third null hypothesis (H_0) stated that there will be no significant relationship between age and the deviations of the trunk, neck, gaze, head on neck, lower limb, tragus, acromion and pelvic angles should be rejected. The difference in results from the literature demonstrates that this issue should be examined longitudinally where possible, to determine when are the crucial times for this to matter, and the long term outcomes of backpack carriage on young and vulnerable bodies.

7.6.3 Relationship between BMI and postural deviation

The present study, the significant relationships were found between BMI with the deviation of the neck and lower limb angles especially when carrying the loads of 10% and 15% BW placed at T7 and T12 (Table 6.4). However, most of the relationships were small ($r < 0.30$). These findings concur with a study in the USA that found significant correlations between BMI and postural deviations while carrying the backpack (Talbot, 2005). On the other hand, there were also studies that did not find any correlation between BMI with postural deviation while carrying the backpacks (Danik et al., 2007; Karen Grimmer et al., 2002).

This is an area that warrants further investigation – it may be that as the current sample was smaller than average, then the result is exaggerated. With the current concerns about obesity, it would also be worth looking at over as well as under BMI to see the effect of this.

The third null hypothesis (H_0) stated that there will be no significant relationship between BMI and the deviations of the trunk, neck, gaze, head on neck, lower limb, tragus, acromion and pelvic angles should be rejected because there were statistically significant relationships between BMI with the neck and trunk angles.

7.7 Comparison of Postural Deviations between Gender, Age and BMI

7.7.1 Between gender comparison of postural deviations

The between gender comparison of postural deviations while carrying backpack was reported in biomechanics literature (Karen Grimmer et al., 2002; Talbott, 2005). According to Grimmer et al. (2002), there was no significant difference in postural deviations between gender while carrying the backpack. In contrast, Talbott (2005) reported that gender has an influence on postural deviation while carrying the backpack. The contradiction in findings was due to several differences between the studies. Grimmer et al. (2002) conducted the study on participants aged between 12-16 years and the measurements were performed in a static condition. Conversely, Talbott (2005) involved participants about 12 years old, with measurements performed in static and dynamic conditions. Secondly, Grimmer et al. (2002) measured the deviation based on changes in the body marker coordinates (x and y-axis) while Talbott (2005) was based on the changes in the angle of the selected

posture. In this study, there were significant differences in postural deviations between men and women, concurring with Talbott (2005). Additionally, there were significant differences for postural deviations (the trunk, neck, gaze, head on neck, lower limb, tragus, acromion and pelvic angles) between boys and girls and this is consistent with a study conducted Talbott (2005).

7.7.2 Between age comparison of postural deviations

The influence of age on postural deviation while carrying backpacks was reported in several peer-reviewed journals. A study in Australia revealed that there was no significant difference for postural angles between ages when carrying backpacks (Karen Grimmer et al., 2002). By contrast, another study in the USA reported that age may influence postural deviations while carrying the backpack (Talbott, 2005). The differences between studies are described in section 7.8.1. Another study in Australia suggests that postural deviation was more likely in younger students (K Grimmer, Williams, & Gill, 1999). In the present study, there were significant differences for postural deviation (the trunk, neck, gaze, head on neck, lower limb and tragus) between all ages and more prone to younger participants. When divided into two age categories (aged 7-9 and 10-12), a significant difference was only seen at the trunk angle. This indicates that analysis for all ages was more appropriate to determine the postural deviation. This result was consistent with a study conducted Grimmer et al. (1999).

7.7.3 Between BMI comparison of postural deviations

There is limited evidence on the comparison of postural deviation while carrying the backpack between BMI. According to Talbott (2005), BMI may influence the postural deviation while carrying the backpack (Talbott, 2005). In the present study, there was no significant difference for postural deviation (the trunk, neck, gaze, head on neck, lower limb, tragus, acromion and pelvic angles) between BMI. There was also no significant difference when the participants were divided into four groups (underweight, normal, overweight and obese), $p < 0.05$. The difference between the present study and Talbott (2005) was the age of the participants. The participants of the present study aged between 7 and 12 while Talbott (2005) are within 2 years. This factor may lead to discrepancies between the findings of the study.

7.8 The Association between Gender, Age and BMI with Perceptions of Discomfort

The relationship between backpack carriage with pain, perceived exertion and discomfort have been frequently reported (Golriz & Walker, 2011). In the present study, of the twelve body parts measured only five were reported to experience discomfort, i.e. the neck, shoulder, elbow/ forearm, upper back, and, lower back. However, no significant relationship was found between age, gender and BMI with discomfort scores ($P > 0.05$). Previous studies have inconsistent findings on the relationship between gender, age and BMI with discomfort, pain and fatigue.

7.8.1 The association between gender and perceptions of discomfort

An epidemiology study in Malaysia reported that lifetime prevalence of neck and lower back pain was more likely in boys compared with girls (Mohd Azuan et al., 2010). However, most studies reported that girls are at higher risk of back pain and discomfort compared to boys (Karen Grimmer & Williams, 2000; Kellis & Emmanouilidou, 2010; Rodríguez-Oviedo et al., 2012). Girls are more likely to experience pain or discomfort because they carried heavier loads than boys. However, no reasons were given by Mohd Azuan et al. (2000) to support their findings. In the present study, a significant association was found between gender and perceptions of discomfort scores but cannot be used to support the association between gender and musculoskeletal pain because the strength of the association was weak ($r < 0.02$).

7.8.2 The association between age and perceptions of discomfort

The association between age with pain and discomfort is a controversial issue among researchers. A study in Malaysia reported that the younger age group experiences more lifetime prevalence of neck, upper and lower back pain compared to the elder (Mohd Azuan et al., 2010). In contrast, most studies found that the lifetime prevalence of spinal pain increased steadily with age (Burton et al., 1996; Karen Grimmer, Leah, et al., 2006; Jeffries, Milanese, & Grimmer-Somers, 2007). However, a study reported an association of pain in childhood with pain in early adulthood (Brattberg, 2004). The present study found there was a significant association between age and perceptions of discomfort scores but cannot be used to

support the lifetime prevalence of musculoskeletal pain because this result was only based on a short duration of backpack carriage.

7.8.3 The association between BMI and perceptions of discomfort

Scientific evidence about the association between BMI and discomfort is very limited. A study on Danish students found that discomfort or pain tended to occur for those with BMI of more than 25 compared to the normal BMI (Harreby et al., 1999). Another study in Australia suggests that there was no association between BMI and musculoskeletal pain (Karen Grimmer & Williams, 2000). In the present study, there was no significant association between BMI and discomfort. Another study among college students also refuted the association between BMI and perceptions of discomfort (Devroey et al., 2007). Results of perceptions of discomfort from this study cannot be used to justify the appropriate load and placement for Malaysian primary school children.

The fourth hypothesis stated that there will be no significant relationships between backpack carriage and discomfort score failed to be rejected because there were no significant associations between age, gender and BMI with discomfort scores.

7.9 The Importance of Study Results to Current Practices and Future Procedures in Malaysia

The findings of this study contribute valuable information to Malaysia especially with regard to future policies, practices and procedure in Malaysia. The two major findings relate to the determination of load limits for primary school students and the best location for placing backpacks on the back.

7.9.1 Current practices

Despite heavy school bags in public schools has become controversial in Malaysia, not many researchers have explored this area of concern. To date, only four articles were published related to the determination of backpack loads in public schools (Rambely et al., 2007; Sharifah & Azmin, 2011; Sharifah Alwiah et al., 2009; Shasmin et al., 2006). The preliminary study reported that the mean of schoolbag weight carried by Malaysian primary school children exceeds 15% BW (Mohd Tamrin et al., 2005). More alarming, after a few years, the load carried is said to reach 25% BW (Fazrolrozi & Rambely, 2008). After the implementation of the new curriculum, another study reported that students still have to carry backpacks with more than 15% BW (Mohd Azuan et al., 2010). However, this load carriage is not representative of all students in Malaysia because these studies were conducted in sub-urban and rural schools. In order to get a generalizable mean load carriage, more comprehensive studies should be conducted involving schools in urban, suburban and rural areas.

7.9.2 Procedure for the future

Children's health is of prime importance because it also acts as an indicator of the quality of the country's future generations. Some childhood diseases not only affect the current health conditions but also have the potential to affect future adult life. Several studies have reported that back pain in childhood can recur during adulthood (Harreby, Nygaard, & Jessen et al., 1999; Hestbaek et al., 2006). These findings demand greater consideration as they involve the country's future human capital. If no action is taken to tackle this problem, either sooner or later, it will expose children to muscular problems and injuries due to falls resulting from failure to balance the body. Therefore, the Malaysian government, particularly the Ministry of Education has taken the first step by appointing a steering committee to look at the root-cause of the problem. The solution steps should start from the most to the least important and should include the immediate and the long terms effects.

7.10 Summary

The MOE has acknowledged that carrying excessive loads contributes to negative health effects on primary school students, especially those in Year 1 and Year 2 (Malaysian Ministry of Education, 2010). Several initiatives have been undertaken by the Ministry of Education to address this problem including directives to textbook publishers to limit the thickness of textbooks to 128 pages. The MOE has also conducted a study on primary school children to measure the load carried by the students and to investigate the association between carrying heavy school bags with scoliosis (Utusan Malaysia Online, 2010). In order to overcome the issue, the MOE has urged parents to check their children's timetable every day to ensure that only

books and related items are brought to school. In addition, teachers are also asked to provide a place to store workbooks that are only used in school and not used for homework in their respective classes.

Yet, such initiatives by the school management, PTAs and NGOs have not helped to resolve the issue of heavy school bags. Teachers are still unable to provide smart timetables to reduce the quantity of books carried by the students. Awareness programs conducted by the NGOs and PTA to parents and guardians have also not improved the situation much. As a result, until today, students in public primary schools in Malaysia still have to carry school bags with more than 15% BW on each school day.

Based on the above discussion, there are several interesting findings, especially on the load limits and the appropriate location to place the backpack on the back. Several recommendations have been given to address the problem of heavy school bags in Malaysia as listed in Chapter 8. Findings from this study will contribute to scientific evidence and literature, especially on the effects of heavy school backpacks.

CHAPTER 8

CONCLUSION

8.1 Conclusion

The overall objective of this study was to investigate the effects of backpack load and placement on the postural deviation in healthy Malaysian primary school children. We further investigated whether there were relationships between postural deviation due to backpack load and placement with gender, age, and BMI, and also measured the children's comfort whilst wearing a backpack.

8.1.1 The effects of backpack loads and placements on postural deviation

The present study revealed that carrying a backpack load of 5% and 10% BW resulted in significant changes to the angles in the trunk, neck, gaze, head on neck and lower limb and acromion depending on placement. When the backpack load was increased to 15% BW, all the postural angles (the trunk, neck, gaze, head on neck, lower limb, tragus, acromion and pelvic) changed significantly compared to the baseline condition regardless where the backpack was placed on the back (T7, T12 or L3). The present study also revealed that placing the centre of gravity of the backpack at a lower location (L3) resulted in smaller postural deviation compared to the higher placement (T7 and T12). These findings were consistent with previous studies that suggested

load limits for school children are between 10% and 15% BW and the appropriate location to place the backpack is lower on the back due to less postural deviation. Primary school students should avoid carrying backpack loads beyond 15% BW regardless of the location of its placement because it caused significant changes to all postural angles compared to the baseline condition.

8.1.2 The relationship between gender, age and BMI with postural deviation

In general, the present study showed that there were negative relationships between gender with the trunk, gaze, head on neck and lower limb angles but all relationship were classified as small (weak).

In addition, negative relationships were also found between age with the trunk, neck and lower limb angles and the relationship were also small. This indicates that the higher the age, the less deviation of the trunk, gaze and neck angles. However, when the participants were divided into two groups (Group 1; 7-9-year-old and Group 2; 10-12 year old), negative correlation only seen at trunk angle. Therefore, the assessment of all ages was better than divided them into groups to investigate the actual effect on measured angles.

Interestingly, a negative relationship was also found between BMI and the deviation of the neck and lower limb angles. The underweight participants showed greater deviation compared to obese and overweight participants that carried the same backpack loads.

8.1.3 The association between gender, age and BMI with perception of discomfort

Results from this study showed that out of the twelve parts of the body evaluated; only six locations reported discomfort while carrying the backpack. The most cited location that caused discomfort was the shoulders and followed by the neck, upper back, lower back, arms and knees. The feedbacks about discomfort ranged from the categories of 'a little bit discomfort' up to 'a lot of discomfort'. The relationship between age and perception of discomfort score was weak and negative direction, illustrating that the higher the age, less discomfort reported. There was also a weak relationship between gender and perception of discomfort scores. Girls participants complained of more discomfort compared to boys. However, there was no significant relationship between BMI and perception of discomfort scores.

8.2 Recommendations

8.2.1 Establishment of specific guidelines for backpack load and placement

Based on the scientific evidence, carrying heavy backpacks and inappropriate placement on the back may cause postural deviation and ultimately contribute to musculoskeletal problems among school children. In the long run, these health risks may also affect their potential productivity, independent living and future health conditions. Therefore, it is timely for the Ministry of Education Malaysia (MOE) to set up a committee to develop guidelines on backpack safety among school children. This is crucial because several studies have highlighted the relationship between musculoskeletal problems in childhood and the likelihood of chronic back pain in later stages of their life. Such guidelines shall include a safe load limit and the appropriate location for backpack placement.

The implementation of this guideline may be exercised through the cooperation of the Parents and Teachers Association's (PTA's), NGOs and the backpack manufacturers. Implementing the guidelines will not only reduce the risk of musculoskeletal pain related to backpack use but may also reduce the risk of injuries related to carrying heavy backpacks in school children. The results of this study and other local research can be used as a guide for developing the aforementioned guidelines.

8.2.2 Proposed backpack load and placement

The proposed loads vary between students based on their age, gender and BMI. The range of the recommended loads for the Malaysian healthy school children is shown in Table 8.1.

Table 8.1: Recommended backpack load based on age and gender

Age (years)	Boys	Girls
	Load (kg.)	Load (kg.)
7	2.3 - 3.2	2.3 - 3.2
8	2.4 - 3.6	2.5 - 3.5
9	3.0 - 4.2	2.8 - 3.9
10	3.4 - 4.8	3.3 - 4.6
11	3.8 - 5.3	3.8 - 5.3
12	4.2 - 5.8	4.0 - 5.6

The locations for placing the backpack are depending on the gender, age and BMI. Generally, the proposed placements are between T12 and L3 for children aged 7-9 and around L3 for children aged 10-12 years.

8.2.3 Education Department Policy

School backpacks become heavy because they are filled with all kinds of loads such as textbooks, exercise books, stationery and students' necessities such as food and clothes for extra-curricular activities. Although the government has instructed publishers not to print thick textbooks, the considerable numbers of books in the backpack does not help to reduce the load. This problem is particularly noticeable in urban schools as opposed to suburban and rural areas because such schools encourage students to buy exercise books in addition to textbooks provided by the government. The MOE should instruct the school management team to investigate this issue and reduce the number of books carried by students. Additionally, planning the school timetable for the most efficient use of the smallest number of textbooks every day may provide an effective and complementary solution.

8.2.4 Integrated involvement

Integrated involvement is also required from the MOE, school management, teachers, and PTAs to create awareness among the parents about the importance of complying with the recommended load limit. Online resources, talks, and demonstrations on how to carry the right backpacks must be comprehensive and not only conducted in the cities but involve schools in the outlying and rural areas. Assessment should also be conducted on a periodic basis so that the effectiveness of the program can be evaluated.

8.2.5 Monitor the children's backpack load

Parents and guardians should monitor the weight of the backpacks carried by their children. Additionally, parents have a valuable voice in their children's education, and they will be able to influence the various educational providers.

8.3 Direction for Future Research

The results of this study meaningfully contribute to the literature on the problem of carrying heavy, burdensome backpacks by primary school students, especially in Malaysia. This study has raised several questions in need of further investigation particularly in the following areas:

8.3.1 Dynamic condition

The purpose of backpacks is to transfer loads from one location to another. Hence, a dynamic study is essential in order to identify the comprehensive response of body postures prior to establishing the appropriate loads and placement for primary school children carrying backpacks.

8.3.2 Study on double pack

The use of double packs (front and backpack) has been reported and may reduce forward head angles and maintain a more upright posture particularly in dynamic conditions compared to backpacks with the same load. This study will not only enhance knowledge to be used in designing ergonomic backpacks but will also ultimately reduce the likelihood of postural deviation whilst carrying backpacks.

8.3.3 Study on the awareness of healthy school backpack

To date, awareness studies about healthy school backpacks among teachers and parents are very limited. Based on the literature search, there is no article related to this area, thus making this a significant area to explore in order to plan awareness programs for the relevant groups. Specifically, (PTAs) can play an important role in conducting awareness activities involving parents and guardians.

8.3.4 Further investigation on load limits and placements

Most of the previous studies used backpack loads of 5%, 10%, 15% and 20% BW to determine the load limit. It is suggested that future studies will compare the effects of loads between 10%, 11%, 12%, 13%, 14% and 15% BW as this represents the range of load limits suggested by previous studies. Future studies concerning load placement need to compare the effects of placing the backpack at L3, L4 and L5 because current evidence suggests that placing the backpack between L3-L5 may reduce postural deviation.

8.3.5 The effect of distance and pathway, environmental, psychological, curriculum and backpack characteristics

Studies on the effects of distance and routes, environmental, psychological characteristics and its relationship to backpack carriage have never been carried out in Malaysia. Therefore, research in this area is urgently required to solve the problem of heavy backpacks among students in Malaysia.

8.3.6 Other method of measuring postural deviation

Various methods have been used to investigate the changes in posture whilst carrying the backpack. One of the latest methods introduced by Professor Quinette Louw uses 3-D technology. This technique can produce more accurate results on postural deviation. However, it is only suitable for study in the laboratory because it is difficult to carry to the field.

8.4 Study Limitations

8.4.1 Healthy children

The study involved healthy children only. The results of this study cannot be applied to children who suffer from spinal abnormalities such as scoliosis, lordosis and kyphosis.

8.4.2 Static condition

This study investigated the effects of backpack loads and placement on the postural deviations in static conditions only. In order to obtain more realistic results, further investigation is required especially under more dynamic conditions. This is crucial because the purpose of the backpack is to transfer the load from one place to another. By considering the static and dynamic effects, then the proposed load limits and placement will be more comprehensive and robust.

8.4.3 Primary school children

The present study only investigated school children aged between 7-12 years only. Therefore, the results cannot be applied to secondary school children.

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LIST OF APPENDICES

Appendix 1: Appraisal Tool for Descriptive/ Cross-Sectional Study

1. Did the study address a clearly focused issue?

☐ Yes ☐ Can't tell ☐ No

HINT: A question can be focused in terms of:

- The population(s) studied
- The health measure(s) studied (e.g. risk factor, preventive behaviour, outcome)

2. Did the authors use an appropriate method to answer their question? ☐ Yes ☐ Can't tell ☐ No

HINT: Consider

- Is a descriptive/cross-sectional study an appropriate way of answering the question?
- Did it address the study question?

3. Were the subjects recruited in an acceptable way?

☐ Yes ☐ Can't tell ☐ No

HINT: We are looking for selection bias which might compromise the generalizability of the findings:

- Was the sample representative of a defined population?
- Was everybody included who should have been included?

4. Were the measures accurately measured to reduce bias?

☐ Yes ☐ Can't tell ☐ No

HINT: We are looking for measurement or classification bias:

- Did they use subjective or objective measurements?
- Do the measures truly reflect what you want them to (have they been validated)?

5. Were the data collected in a way that addressed the research issue? ☐ Yes ☐ Can't tell ☐ No

Consider:

- if the setting for data collection was justified
- if it is clear how data were collected (e.g., interview, questionnaire, chart review)
- if the researcher has justified the methods chosen
- if the researcher has made the methods explicit (e.g. for interview method, is there an indication of how interviews were conducted?)

6. Did the study have enough participants to minimize the play of chance? ☐ Yes ☐ Can't tell ☐ No

Consider:

- if the result is precise enough to make a decision
- if there is a power calculation. This will estimate how many subjects are needed to produce a reliable estimate of the measure(s) of interest.

7. How the results presented and what is the main result?
☐ Yes ☐ Can't tell ☐ No

Consider:

- if the if, for example, the results are presented as a proportion of people experiencing an outcome, such as risks, or as a measurement, such as mean or median differences, or as survival curves and hazards
- how large this size of result is and how meaningful it is
- how you would sum up the bottom-line result of the trial in one sentence

8. Was the data analysis sufficiently rigorous?
☐ Yes ☐ Can't tell ☐ No

Consider:

- if there is an in-depth description of the analysis process
- if sufficient data are presented to support the findings.

9. Is there a clear statement of findings?
☐ Yes ☐ Can't tell ☐ No

Consider:

- if the findings are explicit
- if there is adequate discussion of the evidence both for and against the researchers' arguments
- if the researcher have discussed the credibility of their findings
- if the findings are discussed in relation to the original research questions

10. Can the results be applied to the local population?

☐ Yes ☐ Can't tell ☐ No

HINT: Consider whether

- The subjects covered in the study could be sufficiently different from your population to cause concern.
- Your local setting is likely to differ much from that of the study

11. Can the results be applied to the local population?

☐ Yes ☐ Can't tell ☐ No

Consider:

- if the researcher discusses the contribution the study makes to existing knowledge (e.g. do they consider the findings in relation to current practice or policy, or relevant research-based literature?)
- if the researchers have discussed whether or how the findings can be transferred to other populations

Appendix 2: Appraisal Tool for Review Article

1. Did the review address a clearly focused question?

☐ Yes ☐ Can't tell ☐ No

HINT: An issue can be 'focused' In terms of

- The population studied
- The intervention given
- The outcome considered

2. Did the authors look for the right type of papers?

☐ Yes ☐ Can't tell ☐ No

HINT: 'The best sort of studies' would

- Address the reviews question
- Have an appropriate study design (usually RCTs for papers evaluating interventions)

3. Do you think all the important, relevant studies were included? ☐ Yes ☐ Can't tell ☐ No

HINT: Look for

- Which bibliographic databases were used
- Follow up from reference lists
- Personal contact with experts
- Search for unpublished as well as published studies
- Search for non-English language studies

4. Did the review's authors do enough to assess the quality of the included studies? ☐ Yes ☐ Can't tell ☐ No

HINT: The authors need to consider the rigour of the studies they have identified. Lack of rigour may affect the studies' results. ("All that glitters is not gold" Merchant of Venice – Act II Scene 7)

5. If the results of the review have been combined, was it reasonable to do so? ☐ Yes ☐ Can't tell ☐ No

HINT: Consider whether

- The results were similar from study to study
- The results of all the included studies are clearly displayed
- The results of the different studies are similar
- The reasons for any variations in results are discussed

6. What are the overall results of the review?

HINT: Consider

- If you are clear about the review's 'bottom line' results
- What these are (numerically if appropriate)
- How were the results expressed (NNT, odds ratio etc.)

7. How precise are the results?

HINT: Look at the confidence intervals, if given.

8. Can the results be applied to the local population?

☐ Yes ☐ Can't tell ☐ No

HINT: Consider whether

- The patients covered by the review could be sufficiently different to your population to cause concern
- Your local setting is likely to differ much from that of the review.

9. Were all important outcomes considered?

☐ Yes ☐ Can't tell ☐ No

HINT: Consider whether

- Is there other information you would like to have seen

10. Are the benefits worth the harms and costs?

☐ Yes ☐ Can't tell ☐ No

HINT: Consider

- Even if this is not addressed by the review, what do you think?

Appendix 3: Appraisal Tool for Case-Control Study

1. Did the study address a clearly focused issue?

☐ Yes ☐ Can't tell ☐ No

HINT: A question can be focused in terms of

- The population studied
- The risk factors studied
- Whether the study tried to detect a beneficial or harmful effect?

2. Did the authors use an appropriate method to answer their question? ☐ Yes ☐ Can't tell ☐ No

HINT: Consider

- Is a case control study an appropriate way of
- Answering the question under the circumstances? (Is the outcome rare or harmful)
- Did it address the study question?

3. Were the cases recruited in an acceptable way?

☐ Yes ☐ Can't tell ☐ No

HINT: We are looking for selection bias which might compromise validity of the findings

- Are the cases defined precisely?
- Were the cases representatives of a defined population? (Geographically and/or temporally?)
- Was there an established reliable system for selecting all the cases
- Are they incident or prevalent?
- Is there something special about the cases?
- Is the time frame of the study relevant to disease/exposure?
- Were there a sufficient number of cases selected?
- Was there a power calculation?

4. Were the controls selected in an acceptable way?

☐ Yes ☐ Can't tell ☐ No

HINT: We are looking for selection bias which might compromise The generalizability of the findings

- Were the controls representative of defined population (geographically and/or temporally)
- Was there something special about the controls?
- Was the non-response high? Could non-respondents be different in any way?
- Are they matched, population based or randomly selected?
- Was there a sufficient number of controls selected?

5. Was the exposure accurately measured to minimise bias?
☐ Yes ☐ Can't tell ☐ No

HINT: We are looking for measurement, recall or classification bias

- Was the exposure clearly defined and accurately measured?
- Did the authors use subjective or objective measurements?
- Do the measures truly reflect what they are supposed to measure? (Have they been validated?)
- Were the measurement methods similar in the cases and controls?
- Did the study incorporate blinding where feasible?
- Is the temporal relation correct? (Does the exposure of interest precede the outcome?)

6. (a) What confounding factors have the List: authors accounted for?

HINT: List the ones you think might be important, that The author missed.

- Genetic
- Environmental
- Socio-economic

(b) Have the authors taken account of the potential confounding factors in the design and/or in their analysis?

☐ Yes ☐ Can't tell ☐ No

HINT: Look for

- Restriction in design, and techniques e.g. modelling stratified-, regression-, or sensitivity analysis to correct, control or adjust for confounding factors

7. What are the results of this study?

HINT: Consider

- What are the bottom line results?
- Is the analysis appropriate to the design?
- How strong is the association between exposure and outcome (look at the odds ratio)?
- Are the results adjusted for confounding, and might confounding still explain the association?
- Has adjustment made a big difference to the OR?

8. How precise are the results? How precise is the estimate of risk?

HINT: Consider

- Size of the P-value
- Size of the confidence intervals
- Have the authors considered all the important variables?
- How was the effect of subjects refusing to participate evaluated?

9. Do you believe the results? ☐ Yes ☐ Can't tell ☐ No

HINT: Consider

- Big effect is hard to ignore!
- Can it be due to chance, bias or confounding?
- Are the design and methods of this study sufficiently flawed to make the results unreliable?
- Consider Bradford Hills criteria (e.g. time sequence, dose-response gradient, strength, biological plausibility)

10. Can the results be applied to the local population?

☐ Yes ☐ Can't tell ☐ No

HINT: Consider whether

- The subjects covered in the study could be sufficiently different from your population to cause concern
- Your local setting is likely to differ much from that of the study
- Can you quantify the local benefits and harms?

11. Do the results of this study fit with other available evidence?

☐ Yes ☐ Can't tell ☐ No

HINT: Consider all the available evidence from RCT's, systematic reviews, cohort studies and case-control studies as well for consistency.

Appendix 4: Appraisal Tool for RCT Study

1. Did the trial address a clearly focused issue?

☐ Yes ☐ Can't tell ☐ No

Consider: An issue can be 'focused' in terms of

- The population studied
- The intervention given
- The comparator given
- The outcomes considered

2. Was the assignment of patients to treatments randomised?

☐ Yes ☐ Can't tell ☐ No

Consider:

- How was this carried out, some methods may produce broken allocation concealment
- Was the allocation concealed from researchers?

3. Were patients, health workers and study personnel blinded?

☐ Yes ☐ Can't tell ☐ No

Consider:

- Health workers could be; clinicians, nurses etc
- Study personnel – especially outcome assessors

4. Were the groups similar at the start of the trial?

☐ Yes ☐ Can't tell ☐ No

Consider: Look at

- Other factors that might affect the outcome such as age,
- sex, social class, these may be called baseline characteristics

5. Aside from the experimental intervention, were the groups treated equally? ☐ Yes ☐ Can't tell ☐ No

6. Were all of the patients who entered the trial properly accounted for at its conclusion? ☐ Yes ☐ Can't tell ☐ No

Consider:

- Was the trial stopped early?
- Were patients analysed in the groups to which they were randomised?

7. How large was the treatment effect?

Consider:

- What outcomes were measured?
- Is the primary outcome clearly specified?
- What results were found for each outcome?
- Is there evidence of selective reporting of outcomes?

8. How precise was the estimate of the treatment effect?

Consider:

- What are the confidence limits?
- Were they statistically significant?

9. Can the results be applied in your context? (Or to the local population?) ☐ Yes ☐ Can't tell ☐ No

Consider:

- Do you have reason to believe that your population of interest is different to that in the trial
- If so, in what way?

10. Were all clinically important outcomes considered?

☐ Yes ☐ Can't tell ☐ No

Consider:

- Is there other information you would like to have seen?
- Was the need for this trial clearly described?

11. Are the benefits worth the harms and costs?

☐ Yes ☐ Can't tell ☐ No

Consider:

- Even if this is not addressed by the trial, what do you think?

Appendix 5: Appraisal Tool for Cohort Study

1. Did the study address a clearly focused issue?

☐ Yes ☐ Can't tell ☐ No

HINT: A question can be 'focused' In terms of

- The population studied
- The risk factors studied
- The outcomes considered
- Is it clear whether the study tried to detect a beneficial or harmful effect?

2. Was the cohort recruited in an acceptable way?

☐ Yes ☐ Can't tell ☐ No

HINT: Look for selection bias which might compromise the generalisability of the findings:

- Was the cohort representative of a defined population?
- Was there something special about the cohort?
- Was everybody included who should have been included?

3. Was the exposure accurately measured to minimise bias?

☐ Yes ☐ Can't tell ☐ No

HINT: Look for measurement or classification bias:

- Did they use subjective or objective measurements?
- Do the measurements truly reflect what you want them to (have they been validated)?
- Were all the subjects classified into exposure groups using the same procedure

4. Was the outcome accurately measured to minimise bias?

☐ Yes ☐ Can't tell ☐ No

HINT: Look for measurement or classification bias:

- Did they use subjective or objective measurements?
- Do the measures truly reflect what you want them to (have they been validated)?
- Has a reliable system been established for detecting all the cases (for measuring disease occurrence)?
- Were the measurement methods similar in the different groups?
- Were the subjects and/or the outcome assessor blinded to exposure (does this matter)?

5. (a) Have the authors identified all important confounding factors? ☐ Yes ☐ Can't tell ☐ No

List the ones you think might be important, that the author missed.

- (b) Have they taken account of the confounding factors in the design and/or analysis? ☐ Yes ☐ Can't tell ☐ No

List:

HINT: Look for restriction in design, and techniques e.g. Modelling, stratified-, regression-, or sensitivity analysis to correct, control or adjust for confounding factors.

6. (a) Was the follow up of subjects complete enough?
☐ Yes ☐ Can't tell ☐ No

- (b) Was the follow up of subjects long enough?
☐ Yes ☐ Can't tell ☐ No

HINT: Consider

- The good or bad effects should have had long enough to reveal themselves
- The persons that are lost to follow-up may have different outcomes than those available for assessment
- In an open or dynamic cohort, was there anything special about the outcome of the people leaving, or the
- Exposure of the people entering the cohort?

7. What are the results of this study?

HINT: Consider

- What are the bottom line results?
- Have they reported the rate or the proportion between the exposed/unexposed, the ratio/the rate difference?
- How strong is the association between exposure and outcome (RR_c)?
- What is the absolute risk reduction (ARR)?

8. How precise are the results?

HINT: Look for the range of the confidence intervals, if given.

9. Do you believe the results?

☐ Yes ☐ Can't tell ☐ No

HINT: Consider

- Big effect is hard to ignore!
- Can it be due to bias, chance or confounding?
- Are the design and methods of this study sufficiently flawed to make the results unreliable?
- Bradford Hills criteria (e.g. time sequence, dose-response gradient, biological plausibility, consistency)

10. Can the results be applied to the local population?

☐ Yes ☐ Can't tell ☐ No

HINT: Consider whether

- A cohort study was the appropriate method to answer this question
- The subjects covered in this study could be sufficiently different from your population to cause concern
- Your local setting is likely to differ much from that of the study
- You can quantify the local benefits and harms

11. Do the results of this study fit with other available evidence?

☐ Yes ☐ Can't tell ☐ No

12. What are the implications of this study for practice?

HINT: Consider

- One observational study rarely provides sufficiently robust evidence to recommend changes to clinical practice or within health policy decision making
- For certain questions observational studies provide the only evidence
- Recommendations from observational studies are always stronger when supported by other evidence

Appendix 6: PEDro scale: Rating scale for RCT's, non-RCTs, and Case Series

For each item, please justify scoring (for both YES and NO responses), by at least mentioning page and paragraph numbers	Rater 1	Rater 2	Rater 3	Consensus
	_____	_____	_____	_____
Eligibility score (not included in score)				
1. Eligibility criteria were specified	Yes <input type="checkbox"/> No <input type="checkbox"/> Where: _____	Yes <input type="checkbox"/> No <input type="checkbox"/> Where: _____	Yes <input type="checkbox"/> No <input type="checkbox"/> Where: _____	Yes <input type="checkbox"/> No <input type="checkbox"/> Where: _____
Internal validity criteria (2-9)				
2. Subjects were randomly allocated to interventions (in a crossover study, subjects were randomly allocated an order in which treatments were received)	Yes <input type="checkbox"/> No <input type="checkbox"/> Where: _____	Yes <input type="checkbox"/> No <input type="checkbox"/> Where: _____	Yes <input type="checkbox"/> No <input type="checkbox"/> Where: _____	Yes <input type="checkbox"/> No <input type="checkbox"/> Where: _____
3. Allocation was concealed	Yes <input type="checkbox"/> No <input type="checkbox"/> Where: _____	Yes <input type="checkbox"/> No <input type="checkbox"/> Where: _____	Yes <input type="checkbox"/> No <input type="checkbox"/> Where: _____	Yes <input type="checkbox"/> No <input type="checkbox"/> Where: _____
4. The intervention groups were similar at baseline regarding the most important prognostic indicators	Yes <input type="checkbox"/> No <input type="checkbox"/> Where: _____	Yes <input type="checkbox"/> No <input type="checkbox"/> Where: _____	Yes <input type="checkbox"/> No <input type="checkbox"/> Where: _____	Yes <input type="checkbox"/> No <input type="checkbox"/> Where: _____
5. There was blinding of all subjects	Yes <input type="checkbox"/> No <input type="checkbox"/> Where: _____	Yes <input type="checkbox"/> No <input type="checkbox"/> Where: _____	Yes <input type="checkbox"/> No <input type="checkbox"/> Where: _____	Yes <input type="checkbox"/> No <input type="checkbox"/> Where: _____
6. There was blinding of all therapists who administered the therapy	Yes <input type="checkbox"/> No <input type="checkbox"/> Where: _____	Yes <input type="checkbox"/> No <input type="checkbox"/> Where: _____	Yes <input type="checkbox"/> No <input type="checkbox"/> Where: _____	Yes <input type="checkbox"/> No <input type="checkbox"/> Where: _____
7. There was blinding of all assessors who measured at least one key outcome.	Yes <input type="checkbox"/> No <input type="checkbox"/> Where: _____	Yes <input type="checkbox"/> No <input type="checkbox"/> Where: _____	Yes <input type="checkbox"/> No <input type="checkbox"/> Where: _____	Yes <input type="checkbox"/> No <input type="checkbox"/> Where: _____

For each item, please justify scoring (for both YES and NO responses), by at least mentioning page and paragraph numbers				
	Rater 1	Rater 2	Rater 3	Consensus
8. Measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups.	Yes <input type="checkbox"/> No <input type="checkbox"/> Where: _____	Yes <input type="checkbox"/> No <input type="checkbox"/> Where: _____	Yes <input type="checkbox"/> No <input type="checkbox"/> Where: _____	Yes <input type="checkbox"/> No <input type="checkbox"/> Where: _____
9. All subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analysed by 'intention to treat'	Yes <input type="checkbox"/> No <input type="checkbox"/> Where: _____	Yes <input type="checkbox"/> No <input type="checkbox"/> Where: _____	Yes <input type="checkbox"/> No <input type="checkbox"/> Where: _____	Yes <input type="checkbox"/> No <input type="checkbox"/> Where: _____
Statistical reporting score (10-11)				
10. The results of between- intervention group statistical comparisons are reported for at least one key outcome	Yes <input type="checkbox"/> No <input type="checkbox"/> Where: _____	Yes <input type="checkbox"/> No <input type="checkbox"/> Where: _____	Yes <input type="checkbox"/> No <input type="checkbox"/> Where: _____	Yes <input type="checkbox"/> No <input type="checkbox"/> Where: _____
11. The study provides both point measures and measures of variability for at least one key outcome.	Yes <input type="checkbox"/> No <input type="checkbox"/> Where: _____	Yes <input type="checkbox"/> No <input type="checkbox"/> Where: _____	Yes <input type="checkbox"/> No <input type="checkbox"/> Where: _____	Yes <input type="checkbox"/> No <input type="checkbox"/> Where: _____

Appendix 7: Quality appraisal score using Downs and Black checklist (1998)

Reporting

1. Is the hypothesis/aim/objective of the study clearly described?

Yes	1
No	0

2. Are the main outcomes to be measured clearly described in the Introduction or Methods section?

If the main outcomes are first mentioned in the Results section, the question should be answered 'No'.

Yes	1
No	0

3. Are the characteristics of the patients included in the study clearly described?

In cohort studies and trials, inclusion and/or exclusion criteria should be given.

In case-control studies, a case-definition and the source for controls should be given

Yes	1
No	0

4. Are the interventions of interest clearly described?

Treatments and placebo (where relevant) that are to be compared should be clearly described.

Yes	1
No	0

5. Are the distributions of principal confounders in each group of subjects to be compared clearly described?

A list of principal confounders is provided.

Yes	2
Partial	1
No	0

6. Are the main findings of the study clearly described?

Simple outcome data (including denominators and numerators) should be reported for all major findings so that the reader can check the major analyses and conclusions. (This question does not cover statistical tests which are considered below).

Yes	1
No	0

7. Does the study provide estimates of the random variability in the data for the main outcomes?

In non-normally distributed data the inter-quartile range of results should be reported. In normally distributed data the standard error, standard deviation or confidence intervals should be reported. If the distribution of the data is not described, it must be assumed that the estimates used were appropriate and the question should be answered 'Yes'.

Yes	1
No	0

8. Have all important adverse events that may be a consequence of the intervention been reported?

This should be answered yes if the study demonstrates that there was a comprehensive attempt to measure adverse events. (A list of possible adverse events is provided).

Yes	1
No	0

9. Have the characteristics of patients lost to follow-up been described?

This should be answered yes where there were no losses to follow-up or where losses to follow-up were so small that findings would be unaffected by their inclusion. This should be answered 'No' where a study does not report the number of patients lost to follow-up.

Yes	1
No	0

10. Have actual probability values been reported (e.g. 0.035 rather than <0.05) for the main outcomes except where the probability value is less than 0.001?

Yes	1
No	0

External validity

All the following criteria attempt to address the representativeness of the findings of the study and whether they may be generalised to the population from which the study subjects were derived.

11. Were the subjects asked to participate in the study representative of the entire population from which they were recruited?

The study must identify the source population for patients and describe how the patients were selected. Patients would be representative if they comprised the entire source population, an unselected sample of consecutive patients, or a random sample. Random sampling is only feasible where a list of all members of the relevant population exists. Where a study does not report the proportion of the source population from which the patients are derived, the question should be answered as unable to determine.

Yes	1
No	0
Unable to determine	0

12. Were those subjects who were prepared to participate representative of the entire population from which they were recruited?

The proportion of those asked who agreed should be stated. Validation that the sample was representative would include demonstrating that the distribution of the main confounding factors was the same in the study sample and the source population.

Yes	1
No	0
Unable to determine	0

13. Were the staff, places, and facilities where the patients were treated, representative of the treatment the majority of patients receive?

For the question to be answered yes the study should demonstrate that the intervention was representative of that in use in the source population. The question should be answered no if, for example, the intervention was undertaken in a specialist centre unrepresentative of the hospitals most of the source population would attend.

Yes	1
No	0
Unable to determine	0

Internal validity - bias

14. Was an attempt made to blind study subjects to the intervention they have received?

For studies where the patients would have no way of knowing which intervention they received, this should be answered 'Yes'.

Yes	1
No	0
Unable to determine	0

15. Was an attempt made to blind those measuring the main outcomes of the intervention?

Yes	1
No	0
Unable to determine	0

16. If any of the results of the study were based on "data dredging", was this made clear?

Any analyses that had not been planned at the outset of the study should be clearly indicated. If no retrospective unplanned subgroup analyses were reported, then answer 'Yes'.

Yes	1
No	0
Unable to determine	0

17. In trials and cohort studies, do the analyses adjust for different lengths of follow-up of patients, or in case-control studies, is the time period between the intervention and outcome the same for cases and controls?

Where follow-up was the same for all study patients the answer should be yes. If different lengths of follow-up were adjusted for by, for example, survival analysis the answer should be yes. Studies where differences in follow-up are ignored should be answered No.

Yes	1
No	0
Unable to determine	0

18. Were the statistical tests used to assess the main outcomes appropriate?

The statistical techniques used must be appropriate to the data. For example nonparametric methods should be used for small sample sizes. Where little statistical analysis has been undertaken but where there is no evidence of bias, the question should be answered yes. If the distribution of the data (normal or not) is not described it must be assumed that the estimates used were appropriate and the question should be answered Yes.

Yes	1
No	0
Unable to determine	0

19. Was compliance with the intervention/s reliable?

Where there was non-compliance with the allocated treatment or where there was contamination of one group, the question should be answered no. For studies where the effect of any misclassification was likely to bias any association to the null, the question should be answered 'Yes'.

Yes	1
No	0
Unable to determine	0

20. Were the main outcome measures used accurate (valid and reliable)?
For studies where the outcome measures are clearly described, the question should be answered yes. For studies which refer to other work or that demonstrates the outcome measures are accurate, the question should be answered as 'Yes'.

Yes	1
No	0
Unable to determine	0

Internal validity - confounding (selection bias)

21. Were the patients in different intervention groups (trials and cohort studies) or were the cases and controls (case-control studies) recruited from the same population?
For example, patients for all comparison groups should be selected from the same hospital. The question should be answered unable to determine for cohort and case-control studies where there is no information concerning the source of patients included in the study.

Yes	1
No	0
Unable to determine	0

22. Were study subjects in different intervention groups (trials and cohort studies) or were the cases and controls (case-control studies) recruited over the same period of time?
For a study which does not specify the time period over which patients were recruited, the question should be answered as unable to determine.

Yes	1
No	0
Unable to determine	0

23. Were study subjects randomised to intervention groups?

Studies which state that subjects were randomised should be answered yes except where method of randomisation would not ensure random allocation. For example alternate allocation would score no because it is predictable.

Yes	1
No	0
Unable to determine	0

24. Was the randomised intervention assignment concealed from both patients and health care staff until recruitment was complete and irrevocable?

All non-randomised studies should be answered no. If assignment was concealed from patients but not from staff, it should be answered 'No'.

Yes	1
No	0
Unable to determine	0

25. Was there adequate adjustment for confounding in the analyses from which the main findings were drawn?

This question should be answered no for trials if: the main conclusions of the study were based on analyses of treatment rather than intention to treat; the distribution of known confounders in the different treatment groups was not described; or the distribution of known confounders differed between the treatment groups but was not taken into account in the analyses. In nonrandomised studies if the effect of the main confounders was not investigated or confounding was demonstrated but no adjustment was made in the final analyses the question should be answered as 'No'.

Yes	1
No	0
Unable to determine	0

26. Were losses of patients to follow-up taken into account?

If the numbers of patients lost to follow-up are not reported, the question should be answered as unable to determine. If the proportion lost to follow-up was too small to affect the main findings, the question should be answered 'Yes'.

Yes	1
No	0
Unable to determine	0

Power

27. Did the study have sufficient power to detect a clinically important effect where the probability value for a difference being due to chance is less than 5%?

Sample sizes have been calculated to detect a difference of x% and y%.

	Size of smallest intervention group	
A	< n1	0
B	n1- n2	1
C	n3- n4	2
D	n5- n6	3
E	n7- n8	4
F	n8+	5

Appendix 8: Quality appraisal score using modified Downs and Black checklist

#	Items	Database 1	Database 2	Database 3
1.	Is the hypothesis/aim/objective of the study clearly described?			
2.	Are the main outcomes to be measured clearly described in the Introduction or Methods section?			
3.	Are the characteristics of the patients included in the study clearly described?			
4.	Are the interventions of interest clearly described?			
5.	Are the main findings of the study clearly described?			
6.	Does the study provide estimates of the random variability in the data for the main outcomes?			
7.	Have the characteristics of patients lost to follow-up been described?			
8.	Have actual probability values been reported (e.g. 0.035 rather than <0.05) for the main outcomes except where the probability value is less than 0.001?			
9.	Were those subjects who were prepared to participate representative of the entire population from which they were recruited?			
10.	Were the staff, places, and facilities where the patients were treated, representative of the treatment the majority of patients receive?			
11.	Was an attempt made to blind study subjects to the intervention they have received?			
12.	If any of the results of the study were based on “data dredging”, was this made clear?			
13.	In trials and cohort studies, do the analyses adjust for different lengths of follow-up of patients, or in case control studies, is the time period between the intervention and outcome the same for cases and controls?			
14.	Were the statistical tests used to assess the main outcomes appropriate?			
15.	Were the main outcome measures used accurate (valid and reliable)?			
TOTAL SCORE				

Appendix 9: Human Ethics Certificate of Approval



MONASH University

Monash University Human Research Ethics Committee (MUHREC)
Research Office

Human Ethics Certificate of Approval

Date: 26 July 2010
Project Number: CF10/1178 - 2010000623
Project Title: The effects of backpack load and placement on postural deviation in healthy school children
Chief Investigator: Dr Rachael McDonald
Approved: From: 26 July 2010 to 26 July 2015

Terms of approval

1. The Chief investigator is responsible for ensuring that permission letters are obtained, if relevant, and a copy forwarded to MUHREC before any data collection can occur at the specified organisation. Failure to provide permission letters to MUHREC before data collection commences is in breach of the National Statement on Ethical Conduct in Human Research and the Australian Code for the Responsible Conduct of Research.
2. Approval is only valid whilst you hold a position at Monash University.
3. It is the responsibility of the Chief Investigator to ensure that all investigators are aware of the terms of approval and to ensure the project is conducted as approved by MUHREC.
4. You should notify MUHREC immediately of any serious or unexpected adverse effects on participants or unforeseen events affecting the ethical acceptability of the project.
5. The Explanatory Statement must be on Monash University letterhead and the Monash University complaints clause must contain your project number.
6. **Amendments to the approved project (including changes in personnel):** Requires the submission of a Request for Amendment form to MUHREC and must not begin without written approval from MUHREC. Substantial variations may require a new application.
7. **Future correspondence:** Please quote the project number and project title above in any further correspondence.
8. **Annual reports:** Continued approval of this project is dependent on the submission of an Annual Report. This is determined by the date of your letter of approval.
9. **Final report:** A Final Report should be provided at the conclusion of the project. MUHREC should be notified if the project is discontinued before the expected date of completion.
10. **Monitoring:** Projects may be subject to an audit or any other form of monitoring by MUHREC at any time.
11. **Retention and storage of data:** The Chief Investigator is responsible for the storage and retention of original data pertaining to a project for a minimum period of five years.



Professor Ben Canny
Chair, MUHREC

Cc: Dr Shapour Jaberzadeh; Mr Abdul Mujid Abdullah

Postal – Monash University, Vic 3800, Australia
Building 3E, Room 111, Clayton Campus, Wellington Road, Clayton
Telephone +61 3 9905 5490 Facsimile +61 3 9905 3831
Email muhrec@adm.monash.edu.au www.monash.edu/research/ethics/human/index/html
ABN 12 377 614 012 CRICOS Provider #00008C

Appendix 10: Study Protocol by Grimmer et al. (2002)

**PROTOCOL MANUAL FOR BACKPACK STUDY
IN PRIMARY SCHOOL CHILDREN**

This protocol manual was adopted from the Adolescents and School Bags (NH&MRC Research 1999) Protocol Manual by Grimmer, K and Milanese, S.

Tasks

1. To recruit participants.
2. To obtain the signed Consent Forms from participants and parents/guardians.
3. To measure weight and height of participants.
4. To ensure participants wear appropriate attire (bike shorts and sleeveless t-shirt).
5. To place anatomical markers accurately on participants' bodies prior to taking photographs. The markers are to be placed at:
 - a) Lateral canthus of eyes (right and left)
 - b) Tragus of right ear
 - c) Lateral part of shoulders (right and left) - mid-point between greater tuberosity of humerus and posterior of acromion process
 - d) Lateral superior border of iliac crest (right and left)
 - e) Right greater trochanter
 - f) Lateral epicondyle of femur
 - g) Lateral malleolus
 - h) Spinous process of C7
6. To ensure that the participants are accurately identified by placing their ID number so that it appears in every photograph.
7. To line participants up accurately with the camera according to the protocols.
8. To ensure that the camera is positioned appropriately on the tripod for each photograph.
9. To ensure that participants stand appropriately for each photograph.
10. To take 12 shots of sagittal view and 12 shots of frontal view using the Allocated Latin Square design.
11. To develop an Excel spreadsheet of results.

Equipment

1. Camera (1)
2. String (4 meters)
3. Plum bob (1)
4. Spirit level (2)
5. Tripod (2)
6. Board and paper (participant ID)
7. Masking tape
8. Body markers (foam balls/removable markers)
9. Set square
10. Hair clips
11. Bulldog clips
12. Marker pen and pen/pencil
13. Digital weighing scale
14. Body meter
15. Measuring tape
16. Bike shorts (Small, Medium ,Large)
17. Sleeveless t-shirt (Small, Medium, Large)
18. Body alignment grid
19. Velcro
20. Double sided tape
21. Posture Recording Sheet
22. Discomfort Assessment Scale

Posture Protocol for Camera Setup

1. At participant end:

Using a 4-meter string, make a straight line on the floor from the centre of the body alignment grid towards the camera. This is to enable the image of the participant is located at the centre of the grid when the photograph is taken. Using a masking tape, make another parallel line (5 cm in front of the string) on the floor from the grid towards the camera. Mark off a distance at 25 cm on the masking tape from the grid. Using the set square and masking tape make a perpendicular line on this mark to form the letter T.

Participants will be positioned so that their right side is closest to the camera. The outer border of the right foot will be lined up with the inner edge of the stem of the T, and the toes will be on the inner edge of the top of the T. The tripod (with the set square and number board attached) is in a fully extended position and will be lined up using a plumb line, so that when looking directly down, the set square is above the inner edge of the stem of the masking tape T. A spirit level is used to check that the board is parallel with the floor (use spirit level attached to the board, as the spirit level supplied with the tripod is unreliable). The centre of the two feet of the tripod is positioned at a distance 5 cm away from the inner edge of the top of the T.

2. At the Camera's end:

Mark off the string at 3.10 m from the grid with a piece of masking tape measuring about 8.5 cm. This piece of masking tape extends from the string to the right, when facing away from the participants end. At the end of this piece of masking tape, the mid-point of the front foot of the tripod is positioned, all legs fully extended. Adjust the tripod top so the handle is facing right when facing away from the participants end. Place camera on a tripod facing participant end. Tilt handles up until it stops so that the camera is rotated 90° anti-clockwise and check that it is level with a spirit level across the front of the lens in a vertical alignment. The adjustable arm on the tripod is to be fully retracted. Ensure that the camera is cantered over the string using a plumb line.

3. Camera settings

- a) Cameras will be switched off after each session.
- b) This is the camera's automatic set up; thus it will select the appropriate shutter speed and aperture.
- c) Pop up flash.
- d) Affix camera to tripod.
- e) Ensure participants are looking straight ahead at all times.
- f) Ensure markers are visible in viewfinder.
- g) The first shot should be normal standing posture (as normal as possible).
- h) The second shot should be of the participant standing as straight as possible.

4. Before the shot is taken to ensure that:

- a) All dots / markers are visible.
- b) Hair is tucked out of the way and the C7 marker is clearly visible.
- c) All markers are still attached.
- d) Feet are flat on the floor, toes are not raised.
- e) Participants are looking straight ahead, head is not tilted.
- f) Upper limb (arms) is in the correct position.

Experimental condition allocated via latin square design

- a) The same Latin Square pattern is used for each year level. As participants enter the experiment, they are sequentially allocated to the next Latin Square pattern.
- b) Weigh participants on the digital weighing scale, and measure their height using the body meter fixed to the wall. Calculate from their weight 5%, 10% and 15% of BW and organize the packets of dried sand (weights) into these loads. Load the first weight as dictated by the Latin Square pattern into the backpack.
- c) Position the participant without a backpack (unloaded) as described later in this manual. Photograph within 5 seconds of assuming this position.
- d) Commence the Latin Square allocation. Position the appropriately loaded backpack with the green dot on its front level with the participants' required anatomical position (T7, T12 or L3). Photograph within 5 seconds of assuming this position.
- e) Continue until you have allocated four experimental conditions. Position the participant (unloaded) for the second baseline short. Photograph within 5 seconds. Continue until all the experimental conditions have been allocated. Photograph the participant again in the unloaded position (3rd baseline).

Protocol for Positioning the Participants

- a) To get precise positioning of the markers, make sure participant have to wear appropriate attire (bike shorts and sleeveless t-shirt). After placing the markers, the participant will be asked to stand and look straight ahead. Landmark (footprints) is placed on the floor to ensure the same positioning of all participants in front of the camera. ID Number is placed on the board (write in large numbers in black). Take a sagittal view photograph by facing participant to the ID board, then change to the frontal view by facing to the camera.
- b) After taking each photograph, take off the backpack from participant's shoulder. Ask the participant if she/he feels discomfort at any part of his/her body by referring to the Wong-Baker Faces and the body diagram. While preparing for the next measurement, ask participant to take a few steps. During this break, researcher can check the position of all the markers on the participant's body and change the position if necessary.
- c) If you suspect that the shot did not work (i.e. someone walked in front of the camera, the participant changed position or the flash did not fire), you will need to take another shot. Reposition the participant and take another shot.

Make sure that you note the new shot number on the recording sheet with the ID number. Mark an 'R' on the photo ID card for the second shot ('R' = repeat). Take the markers off the student, remove the colour dot on the card that corresponds to the posture station and thank the participant.

Protocol for Digitizing Photographs

The program used for digitizing photographs is called UTHSCSA Image Tool for Windows version 3.0. All photographs must be analyzed in the same way by the same researcher to optimize the reliability of the results. Steps of digitizing photographs are as follows:

- a) Start Image Tool from the start programs menu.
- b) Start Microsoft Excel from the start programs menu.
- c) Open the Excel work sheet on your floppy disk that you will be saving you data to.
- d) Switch to Image Tool and select 'Settings' from the toolbar and click the preferences. Select the 'Points' tab and uncheck the pixel value box. Click on 'apply' then click on 'OK'.
- e) Click on the 'Open File' button (furthest left on the toolbar), this will open the window asking where to look for the file. On the 'Look In', drop down menu select 'Backpack00' then select the image you want.
- f) Scroll the image until the respondent becomes visible, it is quicker to click on the scroll bar itself rather than use the arrows. Click on the 'Point' button on the toolbar; this is the button in the middle of the toolbar with dots on it (next to the 123 button). This will cause the cursor to change to a pencil when placed over the image.
- g) Using the very tip of the pencil cursor, click once in the centre of the white dot at the canthus of the eye.
- h) Move next to the tragus of the ear, C7, shoulder, iliac, trochanter, knee, ankle, tragus, acromion and pelvic.
- i) Close the image and background data sheet will become visible and should have numbers on it.
- j) 'Cut' the data sheet and 'Paste' onto the 'Scrap' sheet of your Excel file.
- k) The scrap sheet now has the mean and standard deviation and the pixel values for the participants. Ignore the mean and standard deviation; we are not interested in these values. The pixel values run vertically with the x value in the first column and the y value in the second.
- l) 'Cut' the value from the scrap sheet and paste them horizontally into the template. The normal shot is condition 1 and the tall shot is condition 2.
- m) Repeat this process from step 5 until all images have been distinguished.
- n) Save your excel file onto a floppy disk.

Experiment script

1. Measuring height:

- a) '(Shoes off) Put your both feet here, like this'.
- b) 'Place your foot evenly and distribute your weight through both feet'.
- c) 'Hang your arms freely by the side of the trunk with the palms facing the thighs'.
- d) 'Make sure your scapulae and buttocks touch the wall'.
- e) 'I need you to stand still, looks straight ahead at the vertical line and inhales deeply for 5 seconds until measurement is taken'.
- f) 'This process will be repeated 3 times and the mean will be recorded as your height'.

2. Measuring body weight:

- a) '(Shoes off) Step onto the weighing scale, like this'.
- b) 'Place your foot evenly and distribute your weight through both feet'.
- c) 'Hang your arms freely by the sides of the trunk with the palms facing the thighs'.
- d) 'I need you to stand still, looks straight ahead at the vertical line and inhale deeply for 5 seconds until measurement is taken'.
- e) 'This process will be repeated 3 times and the mean will be recorded as your body weight'.

3. Positioning the participant

- a) '(Shoes off) Put your right foot here, with toes behind the edge of the tape.'
- b) 'Put your left foot up to the masking tape'.
- c) 'Distribute your weight through both feet'.
- d) 'Stand comfortably in your normal standing position i.e. if you are waiting for a bus or at the canteen etc. and look straight ahead at the vertical line'.
- e) 'I need you to cross your arms in front of your chest with minimal shoulder movement, so we can see the dots on your hip'.
- f) 'Stand still and look straight ahead at the vertical line for 5 seconds until photograph is taken'.
- g) 'Ensure that posture is as "normal" as possible and all dots are visible'.

4. Measuring discomfort:

- a) 'Look at the first diagram (Wong-Baker rating scale)'
- b) 'There are six faces in this diagram, start from No Discomfort to Pain'.
- c) 'There are also scores at the bottom of each face start from 0 to 10'.
- d) 'I need you to tell me if you feel discomfort at any part of your body while carrying the backpack by pointing at one of these faces'.
- e) 'Now, look at the second diagram (back view of body diagram with labels)'.
- f) 'This diagram will help you to tell us which part of your back that you

feel discomfort’.

- g) ‘Based on these diagrams, can you tell me which part of your body you feel discomfort (if any) and the faces to illustrate discomfort?’

Appendix 11: Explanatory Statement (English Version)



EXPLANATORY STATEMENT

Date:

Dear Parents/Guardians,

THE EFFECTS OF BACKPACK LOAD AND PLACEMENT ON POSTURAL DEVIATION IN HEALTHY SCHOOL CHILDREN

My name is Abdul Mujid Abdullah, and I am conducting a research project with Dr. Rachael McDonald a Senior Lecturer in the Department of Occupational Therapy and Dr. Shapour Jaberzadeh a Senior Lecturer in the Department of Physiotherapy, towards a PhD degree at Monash University, Australia. This means that I will be writing a thesis which is about the equivalent of a 300 page book.

Why did we choose this particular person/group as participants?

Scientific papers have shown that carrying an excessive load, such as a school bag that is too heavy may affect physical growth of children and also affect their ability to participate in daily activities. The placement of a backpack load on the back may also contribute to musculoskeletal problems, injuries and predispose children to suffer back pain in adulthood. Participants of this research are school children aged 7-12 years old in Australia (Pilot Project) and Malaysia (Main Project). Consent will be obtained from the parents or guardians by completing a Consent Form and returning the signed form to the researcher.

The purpose of the research

To investigate the effects of backpack loads and placements on postural deviation in healthy school children.

Possible benefit

There are no immediate benefits for the participants in taking part in the research. However, research results may be used by manufacturers to design ergonomic backpacks and also contribute to scientific research, especially on the optimal load and the best load placement for primary school children. We hope to influence policy on backpack carriage in Malaysia.

Inclusion criteria

- i. Participants must be:
- ii. 7 to 12 years old.
- iii. Free from recent fractures or sprains anywhere in the body.
- iv. Free from musculoskeletal or neurological diseases.
- v. Able to stand upright for 30 minutes.
- vi. Happy to wear bike shorts and sleeveless t-shirt.

What does the research involve?

The project will involve measuring the height and weight of the child as well as measurement while the child carries various loads in the backpack. We will photograph the child wearing the backpack while standing against a wall chart, which is a measurement grid to see how straight the child's posture is. This will tell us how straight the child stands when carrying a backpack. This procedure will be repeated three (3) times, with the backpack held in different positions on the child's back. It would be helpful if the parent or guardian will be with the child during the measurement. If you have any questions regarding this project, please do not hesitate to contact the researcher. The researcher will always be ready to answer your enquiries.

How much time will the research take?

The experiment will take approximately one hour. This will include a briefing session; 30 minutes collect the data (measure height and weight and take photo's in three positions) as well as ample time to rest.

Inconvenience or discomfort

Discomfort is unlikely but if any pain or discomfort occurs, the measurement will be stopped immediately.

Payment

Participation in this research is a voluntary and no payment will be offered.

Can participant withdraw from the research?

Participants have the right to withdraw from this research any stage. without being penalised or disadvantaged in any way.

Confidentiality

All information obtained in this research will be treated as confidential. Only the researchers will have access to the information.

Storage of data

Storage of the data collected will adhere to the Monash University regulations and kept on University premises in a locked cupboard/filing for 5 years. Written documents and computer files will be destroyed (via shredding of written documents and erasing of computer files) 5 years after the project has been completed. No one apart from Dr. Rachael McDonald, Dr. Shapour Jaberzadeh and Mr. Abdul Mujid Abdullah will have access to the photographs, computer files and written forms.

Use of data for other purposes

Results of this research will be written up as a PhD thesis for Mr. Abdul Mujid Abdullah. Findings may be published in professional journals and in presentations at conferences. In any publication and presentation, information will be provided in such a way that participants cannot be identified.

Results

If you would like to be informed of the aggregate research findings, please contact:

Dr. Rachael McDonald

[REDACTED]
[REDACTED]
[REDACTED]

or

Dr. Shapour Jaberzadeh

[REDACTED]
[REDACTED]
[REDACTED]

If you would like to contact the researchers about any aspect of this research, please contact the Local Supervisor:

Dr. Rachael McDonald (Australia)

[REDACTED]
[REDACTED]
[REDACTED]
[REDACTED]

Dr. Shapour Jaberzadeh (Australia)

[REDACTED]
[REDACTED]
[REDACTED]
[REDACTED]

Mrs. Maria Justine (Malaysia)

[REDACTED]
[REDACTED]
[REDACTED]

If you have a complaint concerning the manner in which this research is being conducted, please contact:

Executive Officer, Human
Research Ethics
Monash University Human
Research Ethics Committee
(MUHREC)
Building 3e Room 111
Research Office
Monash University VIC 3800

[REDACTED] [REDACTED]
[REDACTED]
[REDACTED]
[REDACTED]

Thank you for your cooperation and assistance.

Dr. Rachael McDonald
Chief Researcher

Dr. Shapour Jaberzadeh
Co-Researcher

Abdul Mujid Abdullah
Researcher

Appendix 12: Explanatory Statement (Malay Version)



PENERANGAN TENTANG KAJIAN

Tarikh:

Kepada Ibu/Bapa/Penjaga,

KESAN-KESAN MUATAN DAN POSISI BEG GALAS KE ATAS DEVIASI POSTUR DI KALANGAN PELAJAR-PELAJAR YANG SIHAT

Nama saya Abdul Mujid Abdullah, dan saya akan menjalankan satu projek penyelidikan bersama Dr. Rachael McDonald, Pensyarah Kanan di Jabatan Terapi Pekerjaan dan Dr. Shapour Jaberzadeh, Pensyarah Kanan di Jabatan Fisioterapi untuk mendapatkan PhD dari Monash University, Australia. Ini bermakna saya akan menulis sebuah tesis yang setara dengan buku 300 halaman.

Kenapa kami memilih individu/kumpulan khusus ini sebagai peserta?

Kajian-kajian saintifik telah menunjukkan bahawa memikul muatan berlebihan seperti beg sekolah yang terlalu berat mungkin menjejaskan pertumbuhan fizikal kanak-kanak dan mempengaruhi kemampuan mereka untuk mengambil bahagian dalam aktiviti seharian. Posisi muatan beg galas di belakang mungkin menyumbang kepada masalah-masalah rangka otot, kecederaan dan boleh mempengaruhi kanak-kanak menderita sakit belakang di masa dewasa. Para peserta penyelidikan ini adalah murid-murid sekolah berumur 7 hingga 12 tahun di Australia (Projek Percubaan) dan di Malaysia (Projek Kajian Utama). Kebenaran akan diperolehi dari ibu/bapa/waris dengan melengkapkan Borang Kebenaran dan mengembalikan borang yang telah ditandatangani kepada penyelidik.

Tujuan penyelidikan

Untuk menyiasat kesan muatan dan posisi beg galas ke atas deviasi postur di kalangan murid-murid sekolah yang sihat.

Manfaat yang berpotensi

Peserta tidak akan mendapat manfaat secara langsung semasa mengambil bahagian dalam projek ini. Bagaimana pun, hasil dari projek ini boleh digunakan oleh para pengeluar beg untuk merekabentuk beg galas yang ergonomik dan juga menyumbang kepada hasil kajian saintifik berkaitan pembawaan muatan optimum dan posisi

muatan terbaik bagi murid-murid sekolah rendah. Kami berharap keputusan kajian ini akan mempengaruhi polisi berkaitan penggunaan beg galas di Malaysia.

Kriteria inklusif

Peserta mestilah:

- i. Berumur 7 hingga 12 tahun.
- ii. Seluruh badan bebas dari patah tulang atau seliuh yang baru.
- iii. Bebas daripada penyakit rangka otot atau saraf.
- iv. Mampu untuk berdiri tegak selama 30 minit.
- v. Sanggup untuk memakai seluar pendek senaman dan kemeja-t tanpa lengan.

Apa yang diperlukan dalam penyelidikan?

Projek ini akan melibatkan pengukuran tinggi dan berat badan kanak-kanak dan juga pengukuran ketika kanak-kanak sedang membawa pelbagai muatan dalam beg galas. Kami akan mengambil photo kanak-kanak memakai beg galas ketika berdiri mengadap satu carta di dinding bagi melihat sejauh mana postur kanak-kanak tersebut tegak. Prosedur ini akan diulang sebanyak tiga (3) kali iaitu posisi beg galas yang berbeza di atas belakang kanak-kanak. Adalah sangat membantu jika ibu/bapa/waris dapat bersama-sama dengan anak semasa pengukuran tersebut. Jika anda mempunyai sebarang soalan berkenaan projek ini, sila hubungi penyelidik. Penyelidik sentiasa bersedia untuk menjawab pertanyaan anda.

Penyelidikan ini akan mengambil masa berapa lama?

Ujian akan mengambil masa lebih kurang 1 jam iaitu termasuk sesi taklimat, 30 minit untuk mengumpul data (mengukur tinggi dan berat dan mengambil foto dalam 3 kedudukan) serta memberi mereka masa yang cukup untuk berehat.

Kesulitan atau ketidakselesaian

Ketidakselesaian hampir tidak akan berlaku, tetapi jika ada rasa sakit atau tidak selesa, pengukuran akan diberhentikan serta-merta.

Bayaran

Penyertaan dalam projek ini adalah secara sukarela dan tiada bayaran akan ditawarkan.

Bolehkah peserta menarik diri dari penyelidikan?

Peserta berhak menarik diri daripada projek ini pada bila-bila masa mereka mahu tanpa didenda atau kerugian dengan apa-apa cara sekali pun.

Kerahsiaan

Semua maklumat yang diperolehi berkaitan dengan projek ini adalah sulit. Hanya penyelidik sahaja yang dapat mengakses maklumat tersebut.

Penyimpanan maklumat

Penyimpanan maklumat yang dikumpul adalah mengikut peraturan-peraturan Monash University dan disimpan di premis Universiti di dalam almari berkunci / difailkan selama 5 tahun. Dokumen-dokumen bertulis dan fail-fail komputer akan dimusnahkan (melalui penyincangan dokumen bertulis dan pemadaman fail-fail komputer) lima tahun selepas projek ini tamat. Tidak seorang pun selain Dr. Rachael McDonald, Dr. Shapour Jaberzadeh dan Encik Abdul Mujid Abdullah mempunyai akses bagi foto-foto, fail-fail komputer dan dokumen-dokumen bertulis.

Menggunakan data untuk lain-lain tujuan

Hasil projek ini akan ditulis sebagai tesis Ph.D. untuk Encik Abdul Mujid Abdullah. Dapatan daripada projek ini mungkin diterbitkan di dalam journal-journal profesional dan pembentangan di persidangan atau mesyuarat. Di dalam mana-mana terbitan dan penyampaian, maklumat akan diberikan dengan cara para peserta tidak boleh dikenali pasti.

Keputusan

Sekiranya anda ingin dimaklumkan tentang dapatan kajian, sila hubungi:

Dr. Rachael McDonald

████████████████████
████████████████████
██

atau

Dr. Shapour Jaberzadeh

████████████████████
████████████████████
██

Sekiranya anda ingin berhubung dengan para penyelidik tentang sebarang aspek projek ini, sila hubungi Penyelia Tempatan:

Dr. Rachael McDonald (Australia)

Email:

[REDACTED]
[REDACTED]
[REDACTED]

Dr. Shapour Jaberzadeh (Australia)

[REDACTED]
[REDACTED]
[REDACTED]
[REDACTED].

Pn. Maria Justine (Malaysia)

[REDACTED]
[REDACTED]
[REDACTED]

Terima kasih di atas kerjasama dan bantuan anda.

Sekiranya anda mempunyai sebarang aduan tentang cara penyelidikan ini dijalankan, sila hubungi:

Executive Officer, Human Research Ethics

Monash University Human Research Ethics Committee (MUHREC)

Building 3e Room 111

Research Office

Monash University VIC 3800

[REDACTED] [REDACTED]
[REDACTED]
[REDACTED]

Dr. Rachael McDonald
Ketua Penyelidik

Dr. Shapour Jaberzadeh
Penyelidik Bersama

—
Abdul Mujid Abdullah
Penyelidik

Appendix 13: Consent Form (English version)



CONSENT FORM

Dear Researcher,

THE EFFECT OF BACKPACK LOAD AND PLACEMENT ON POSTURAL DEVIATION IN HEALTHY SCHOOL CHILDREN IN MALAYSIA

I have had the project explained to me and have read the research Explanatory Statement, which I keep for my records.

☐ I agree to allow my child to take part in the research project as specified above.

☐ I do not agree to allow my child to take part in the research project as specified above.

I understand that agreeing to take part means that:

I agree to give my child's demographic information

☐

Yes

☐

No

I agree to make my child available in the experiment session

☐

Yes

☐

No

I agree to make my child available in further experiment sessions
(if required)

☐

Yes

☐

No

I understand that my child participation is voluntary, that he/she can choose not to participate in part or all of the research project and that he/she can withdraw at any stage of the project without being penalised or disadvantaged in any way.

I understand that any data that the researcher extracts from the research project for use in reports or published findings will not, under any circumstances, contain names or identifying characteristics.

I understand that any information my child provide is confidential, and that no information that could lead to the identification of any individual will be disclosed in any reports on the project, or to any other party.

I understand that data from the research project will be kept in a secure storage and accessible to the research team. I also understand that the data will be destroyed after a 5 year period unless I consent to it being used in future research.

Parent's / Guardian's Name : _____

Address : _____

Tel. : _____ Signature: _____ Date : _____

Appendix 14: Consent Form (Malay version)



BORANG KEBENARAN (IBU/BAPA/PENJAGA)

Para Penyelidik,

KESAN BEBAN DAN KEDUDUKAN BEG GALAS KE ATAS PERUBAHAN POSTUR KANAK-KANAK SEKOLAH YANG SIHAT

Saya telah diberikan penjelasan tentang kajian di atas dan telah membaca Huraian Kajian yang saya simpan sebagai rekod.

☐

Saya bersetuju untuk membenarkan anak saya mengambil bahagian dalam kajian di atas.

☐

Saya tidak bersetuju untuk membenarkan anak saya mengambil bahagian dalam projek di atas.

Secara khususnya:

Saya bersetuju untuk memberikan maklumat demografi anak saya.

☐

Ya

☐

Tidak

Saya bersetuju untuk membenarkan anak saya menghadiri sesi tersebut.

☐

Ya

☐

Tidak

Saya bersetuju untuk membenarkan gambar anak saya diambil.

☐

Ya

☐

Tidak

Saya faham bahawa penyertaan anak saya adalah secara sukarela dan dia boleh memilih untuk tidak mengambil bahagian dalam sebahagian atau seluruh kajian tersebut dan dia boleh menarik diri pada mana-mana peringkat kajian tanpa didenda atau menerima kesan buruk dalam apa jua cara.

Saya faham bahawa apa-apa data yang diambil oleh penyelidik dari kajian tersebut untuk digunakan dalam laporan atau dapatan yang diterbitkan tidak akan dalam apa jua keadaan menyatakan nama atau mengenalpasti sifat seseorang.

Saya faham bahawa apa-apa maklumat yang diberikan oleh anak saya adalah sulit dan maklumat yang akan membawa kepada pengenalpastian sifat mana-mana individu tidak akan didedahkan dalam mana-mana laporan kajian atau kepada mana-mana pihak lain.



Saya faham bahawa gambar anak saya akan digunakan untuk tujuan pengukuran sahaja. Data kajian akan disimpan dengan selamat dan boleh digunakan hanya oleh pasukan penyelidik. Saya juga faham bahawa data tersebut akan dimusnahkan selepas tempoh 5 tahun melainkan saya membenarkan ia digunakan untuk penyelidikan akan datang.

Nama Ibu/Bapa/Penjaga : _____

Alamat : _____

Telefon : _____ Tandatangan: _____ Tarikh : _____

Appendix 15: Letter from Economic Planning Unit (EPU), the Prime Minister's Department, Malaysia

	UNIT PERANCANG EKONOMI <i>Economic Planning Unit</i> JABATAN PERDANA MENTERI <i>Prime Minister's Department</i> BLOK B5 & B6 PUSAT PENTADBIRAN KERAJAAN PERSEKUTUAN 62502 PUTRAJAYA MALAYSIA	 EPU <small>ECONOMIC PLANNING UNIT</small> Telephone : 603-8888 3133 Telefax : 603-888
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	<i>Ref. Took:</i>	
	<i>Your Ref.:</i>	UPE: 40/200/19/2635
	<i>Ref. Kami:</i>	
	<i>Our Ref.:</i>	11 June 2010
	<i>Tarikh:</i>	
	<i>Date:</i>	

Abdul Mujid Abdullah
15 Beddoo Ave
Clayton Vic 3168
Australia
Email: ahmad2@ekustent.morosh.edu.au

APPLICATION TO CONDUCT RESEARCH IN MALAYSIA

With reference to your application, I am pleased to inform you that your application to conduct research in Malaysia has been approved by the **Research Promotion and Co-Ordination Committee, Economic Planning Unit, Prime Minister's Department**. The details of the approval are as follows:

Researcher's name :	ABDUL MUJID BIN ABDULLAH
Passport No. / I. C No:	640528-08-5045
Nationality :	MALAYSIAN
Title of Research :	"THE EFFECTS OF BACKPACK LOAD AND PLACEMENT ON POSTURAL DEVIATION IN HEALTHY SCHOOL CHILDREN"

Period of Research Approved: **18 MONTHS**

2. Please collect your Research Pass in person from the Economic Planning Unit, Prime Minister's Department, Parcel B, Level 1 Block B5, Federal Government Administrative Centre, 62502 Putrajaya and bring along two (2) passport size photographs. You are also required to comply with the rules and regulations stipulated from time to time by the agencies with which you have dealings in the conduct of your research.

3. I would like to draw your attention to the undertaking signed by you that you will submit without cost to the Economic Planning Unit the following documents:

- a) A brief summary of your research findings on completion of your research and before you leave Malaysia; and
- b) Three (3) copies of your final dissertation/publication.

4. Lastly, please submit a copy of your preliminary and final report directly to the State Government where you carried out your research. Thank you.

Yours sincerely,



(MUNIRAH ABD. MANAN)
For Director General,
Economic Planning Unit.
E-mail: munirah@epu.gov.my
Tel: 88725281/88725272
Fax: 88883961

ATTENTION

This letter is only to inform you the status of your application and cannot be used as a research pass

Cc:

Ketua Setiausaha
Bahagian Perancangan dan Penyelidikan Dasar Pendidikan
Kementerian Pelajaran Malaysia
Aras 1-4, Blok E-8
Kompleks Kerajaan Parcel E
Pusat Pentadbiran Kerajaan Persekutuan
62604 Putrajaya.

Appendix 16: Discomfort Assessment Scale

DISCOMFORT ASSESSMENT SCALE

THE EFFECTS OF BACKPACK LOAD AND PLACEMENT ON POSTURAL DEVIATION IN HEALTHY SCHOOL CHILDREN



Comfortable

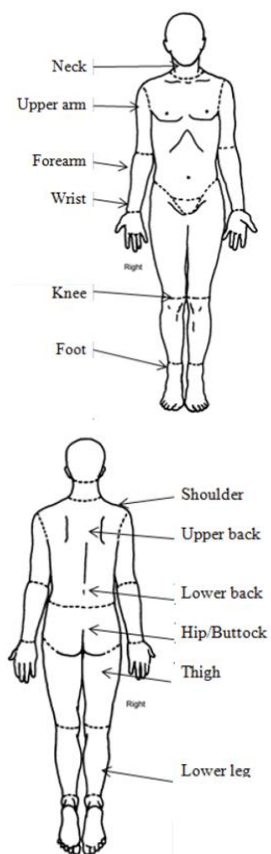
Little bit
discomfort

Little more
discomfort

Even more
discomfort

Large
discomfort

Pain

		Testing / Rating									
		Weight			5% BW			10% BW			15% BW
Locations		T7	T12	L3	T7	T12	L3	T7	T12	L3	
	Neck										
	Shoulder	Right									
		Left									
	Upper Back										
	Upper Arm	Right									
		Left									
	Lower Back										
	Forearm	Right									
		Left									
	Wrist	Right									
		Left									
	Hip/Buttocks										
	Thigh	Right									
		Left									
	Knee	Right									
Left											
Lower Leg	Right										
	Left										
Foot	Right										
	Left										

Participant's Name : _____
 Signature : _____
 Date : _____
 Assessor's Name : _____

Appendix 17: Posture Recording Sheet

POSTURE RECORDING SHEET (OFFICE USE ONLY)

THE EFFECTS OF BACKPACK LOAD AND PLACEMENT ON POSTURAL DEVIATION IN HEALTHY SCHOOL CHILDREN

ID No.

Participant's Background

Today's Date dd mm yy

Date of Birth

Height cm

Weight kg

Gender M ☐ F ☐

Latin square pattern												
Photograph	1	2	3	4	5	6	7	8	9	10	11	12
Shot numbers (sagittal)												
Any repetition												
Shot numbers (frontal)												
Any repetition												

Latin square arrangement of test conditions:

Pattern 1	Pattern 2	Pattern 3	Pattern 4	Pattern 5	Pattern 6	Pattern 7	Pattern 8	Pattern 9
T12-10%	L3-5%	T12-5%	L3-3%	T7-3%	T7-5%	L3-10%	T12-3%	T7-10%
L3-10%	T12-3%	T7-10%	T12-10%	L3-5%	T12-5%	L3-3%	T7-3%	T7-5%
L3-3%	T7-3%	T7-5%	L3-10%	T12-3%	T7-10%	T12-10%	L3-5%	T12-5%
L3-5%	T12-5%	T12-10%	T7-3%	T7-5%	L3-3%	T12-3%	T7-10%	L3-10%
T12-3%	T7-10%	L3-10%	L3-5%	T12-5%	T12-10%	T7-3%	T7-5%	L3-3%
T7-3%	T7-5%	L3-3%	T12-3%	T7-10%	L3-10%	L3-5%	T12-5%	T12-10%
T12-5%	T12-10%	L3-5%	T7-5%	L3-3%	T7-3%	T7-10%	L3-10%	T12-3%
T7-10%	L3-10%	T12-3%	T12-5%	T12-10%	L3-5%	T7-5%	L3-3%	T7-3%
T7-5%	L3-3%	T7-3%	T7-10%	L3-10%	T12-3%	T12-5%	T12-10%	L3-5%