Faculty of Manufacturing Engineering

BIOMECHANICAL COMPARISON CONSIDERING RISK OF BACKPACK ON LUMBOSACRAL JOINT AMONG PRIMARY STUDENT: DURING STANDING AND CLIMBING STAIRS

Nur Alya Syaherah Binti Mohd Hassan

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NUR ALYA SYAHERAH BINTI MOHD HASSAN

Submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Master of Industrial Engineering in Manufacturing Engineering

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DECLARATION

I hereby, declared this report entitled "Biomechanical Comparison Considering Risk Of Backpack On Lumbosacral Joint Among Primary Student: During Standing And Climbing Stairs" is the results of my own research except as cited in the references.

Signature : ……

Author's Name : NUR ALYA SYAHERAH BINTI MOHD HASSAN

Date :

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTEM as a partial fulfillment of the requirements for the Master of Manufacturing Engineering, Department of Manufacturing Engineering (Industrial Engineering). The member of the supervisory is as follow:

Signature	:	……..
Supervisor Name	:	Profesor Madya Dr Mohd Shahir Bin Kasim
Date	:	……..

DEDICATION

This work is humbly dedicated to all my valuable treasures in my life:

To my Beloved Family

Noraizam Binti Mat Nor and *Mohd Hassan Bin Ismail*

To my Brothers

Amirul Hakim, Aliff Hakimi and *Adib Hazmi*

Who served as my inspiration and strength during stormy days.

My friends

Asra Quzzaimi, Sabrina Yusoff and *Wafa Izzati*

Who always beside me even for better and worse

PERBANDINGAN BIOMEKANIKA TENTANG RISIKO BAG GALAS TERHADAP SENDI LUMBOSAKRAL DI KALANGAN PELAJAR SEKOLAH RENDAH: BERDIRI DAN MENAIKI TANGGA

ABSTRAK

Beg galas merupakan kaedah yang paling banyak digunakan untuk membawa barang sekolah di kalangan kanak-kanak dan remaja dengan peratusan hingga 90% dan lebih. Beg galas yang berlebihan boleh menyebabkan pelbagai gangguan muskuloskeletal di kalangan pelajar sekolah rendah. Beg galas berat biasanya dikaitkan dengan prevalensi sakit bawah belakamg yang lebih tinggi di kalangan pelajar sekolah rendah. Berat beg sekolah yang disyorkan adalah 10% daripada berat badan mereka. Kajian ini dilakukan untuk menilai kesan berat beg galas terhadap sendi lumbosacral (L5 / S1) pelajar sekolah rendah dalam tiga keadaan berbeza yang berdiri tanpa beban, berdiri dengan beg galas dan menaiki tangga dengan beg galas. Seramai 10 orang responden dari pelajar sekolah rendah akan terlibat semasa tinjauan kajian ini. Satu set soal selidik mengenai pengalaman psikofizik mereka akan diedarkan di kalangan responden. Para peserta dikehendaki melakukan tiga aktiviti iaitu berdiri tanpa beban di belakang mereka, berdiri sambil memikul beg galas dan menaiki tangga sambil membawa beg galas. Ketiga-tiga aktiviti ini akan dirakam dengan menggunakan kamera digital. Perisian ImageJ digunakan untuk mengukur sudut sendi dan parameter gaya berjalan. Berdasarkan data yang diukur oleh perisian, analisis statik akan diterapkan untuk menghitung torsi dan daya untuk otot batang, mampatan dan daya ricih yang bertindak pada sendi lumbosakral. Sudut lenturan tulang belakang meningkat dari berdiri tanpa beban ke berdiri sambil membawa beg galas hingga menaiki tangga sambil membawa beg galas. Jumlah besar daya kilas luaran dan daya tindak balas sendi yang dihasilkan meningkat daripada tanpa beban untuk membawa beg galas dan menaiki tangga.

ABSTRACT

Backpack represent the most widely used method to carry the school items among children and teenagers with percentages up to 90% and more. Excessive load of backpack may lead to various musculoskeletal disorder among the primary student. Heavy backpack is commonly associated with higher prevalence of low back pain among the primary student. The recommended weight of schoolbags are 10% of their body weight. This study was conducted to assess the effect of the weight of the backpack towards the lumbosacral joint (L5/S1) of primary student in three different condition which are standing with no load, standing with a backpack and climbing the stairs with a backpack. A total of 10 respondents from the primary school students will be involved during the survey of this study. A set of questionnaires of their psychophysical experience will be distributed among the respondents. The participants were required to perform three activity which are standing without a load on their back, standing while holding a backpack and climbing the stairs while carrying the backpack. This three activity will be recorded by using a digital camera. ImageJ Software was used to measure the joint angles and gait parameters. Based on the data measured by the software, a static analysis will be applied to calculate the torque and force for the trunk musle, compressive and a shear force acting on the lumbosacral joint. The trunk flexion angle increased from standing with no load to standing while carrying a backpack to climbing the stairs while carrying a backpack. The sum of the magnitude of external torque and the resultant joint reaction forces increased from no load to carry a backpack and climbing the stairs.

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TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATION

3DSSPP	3D Static Strength Prediction Program
BW	Body Weight
COM	Center of Mass
GRF	Ground Reaction Force
L5S1	Lumbosacral Joint
MSD	Musculoskeletal Disorder
MRI	Magnetic Resonance Imaging

CHAPTER 1

INTRODUCTION

1.1 Background

In spite of advances and technology of transportation in this modern society, backpack carriage stays as basic mode of item transportation in the school. The scientific community of ergonomics has been brought to the attention of elementary school students regarding the issue of load in backpacks. Such students have a daily routine of using a transporting material during the school day. In this routine, the backpack is mostly used for carrying the material. Incomprehensibly, a similar rucksack that was intended to make the home school route simple and relaxed will deviate serious posture for the children (de Paula and Silva 2015). According to an article, it stated that a child's knapsack ought to gauge close to 10% of the student weight (Orantes-Gonzalez, Heredia-Jimenez, and Robinson 2019). For example, a girl or a boy that weight around 50kg, the maximum recommended weight for the backpacks should be 5kg. Heavy backpack can cause muscle soreness as well as back and neck pain.

Postural deviations is considered as a significant public health issue, as it could cause a permanent or temporary impairment to the population, and children has no exception. A study depicted that the low backpain prevalence among children and adolescents ranges between 11% and 52.1% (Amyra et al. 2018). An overweight school backpack is a common issues in Malaysia. As the year past, the weight of backpack has roses significantly due to the necessity of carrying academic materials. Most of the parents does not aware the weight that their children has to bare during the school day. Until now, there is no clear solution regarding the issues of an overweight backpack.

1.2 Problem Statement

Backpack speak to the most broadly utilized technique to convey the school things among youngsters and adolescents with rates up to 90% and that's only the tip of the iceberg. The weight of the backpack has risen day by day linearly with the academic requirement. There has been a growing concern about the potential adverse effects arising from the use of backpack, especially in relation for a heavyweight, bag positioning during the carriage period and Suboptimal design features like uncomfortable shoulder straps. A current report demonstrated that the backpack could add to postural changes, for example, expanded in trunk forward twisting because of the adjusted situation of the body's focal point of mass in addition to backpack framework (Pau et al. 2015). The modified stance may prompt various musculoskeletal side effects, including muscle irritation, back torment, deadness and torment in the shoulder.

According to US Consumer Product Safety Commission (CPSC), the hospitals treated more than 13,260 backpack-related injuries in 2000 (Juanita Conkin 2004). The Ministry of Education has implemented periodic table and serial textbooks in Malaysia to reduce the weight of backpacks in schools. The changes were made when, particularly in early 2002, many teachers and parents expressed their concern about the load of school bags. However, heavy school bags remain an annual issue, as some subjects require five or six exercise books (except the textbooks), especially the language classes. The bags can weigh up to 10 kg, approximately half the body weight of the student.

1.3 Objectives

These study has been developed based on several objectives :

1) To measure the angle of trunk flexion during carrying a backpack and without carrying the backpack.
2) To analyze the compression and shear force exerted at lumbarsacral joint.
3) To investigate the relation between backpack and backpain among primary student.

1.4 Scope

This study compromises the measuring of the backpack's weight and the body weight of the primary students. This research is done by distributing the questionnaires among the primary students regarding to their opinion on the weight of backpack that they carried everyday in the school. There were three activity that will be observed throughout this study which are standing with no load, standing with load and climbing stairs with load. The trunk flexion angle remains the same as this study focus on the static equilibrium modelling. Majority of the measurement will be conducted by using the ImageJ software. However, the data collection was limitedly to upper limb and low back of the body part. Below are the parameters that will be studied:

- Physical Posture
- Psychophysical (feeling – level of pain)
- Biomechanical (force exerted on vetebrae)

1.5 Research Questions

1. How does the forward lean angle change and affect the force and torque acting at the L5S1 joint ?
2. Does carrying the backpack during climbing the stairs would induced more or less injury than holding the backpack during standing ?

1.6 Significant/Important of Study

The outcomes of this research are expecting on bringing a benefit towards:

a) Enhance the awareness in the society towards the risk of an overweight backpack on the primary students.
b) This research can offers new references and methods for future exploration.
c) The outcomes of the proposed study i.e. database on psychophysical ratings can be used by potential users such as primary school student, secondary school student, university students, teachers and lecturer as a guideline to imposed an ergonomic ways in carrying the backpack.

CHAPTER 2

LITERATURE REVIEW

In this chapter, all of the sources of literature study (journals, websites, books, etc.) are used to obtained the information related to the area of study. At the beginning of this chapter the issues regarding the backpack is explained (Overweight backpack, Design of Backpack and Methods to carry the backpack). Next, the effect of carrying an overweight backpack is reviewed in this chapter.

2.1 Backpack

2.1.1 Overweight Backpack

The use of backpack is the most important factor amongst students that lead to a low back pain. Most elementary school students carry bags to school as they need to bring all the books and other materials for study. Some of them are carrying a very heavy bag to school after years of wearing the bags, without caring for the consequences. The children's body development during the early school era is fairly stable (Kellis and Emmanouilidou 2010).

The occurrence of low back pain is associated with the weight of the backpack exceeding 15 percent of the total body mass and an extended period of carrying the bag (Amyra et al. 2018). Understudy rucksacks may have numerous wellbeing impacts, including back strain, modified stride, helpless stance and resulting low back agony. Nonetheless, ergonomics issues among younger students in Malaysia are not broadly recorded contrast and different issues in school, for example, air contamination, water contamination and different risks.

In Malaysia, school kids dragging bag stuffed with books were an enduring issue. Service of Education has now actualized intermittent table and sequential course books to diminish the heaviness of knapsacks in study halls (Ismail, Tamrin, and Hashim 2009). Nevertheless, until these days this issues remain as an annual issue as some of the subject requires five or six workbooks especially for the student that has an upcoming important examination such as UPSR. One of the reasons that contribute to this perennial problem is

the students themselves are often to overlooked at the given timetables which causing them to end up carrying more books than they needed.

Yet, one wonders what number of guardians ever set aside their ample time to give an effort to check the loads or contents of their children rucksacks. A study found that most parents whose backpack weighs 10% and more of their body weight do not know the weight or content of their children backpack (S. N. Forjuoh et al. 2003).

There is still no consensus on a school bag weight guideline. A study from Ireland mentions that it is fair for school children to bear 10 per cent of body weight. A specific body weight limit of 10 per cent is recommended in Europe. The Singapore Health Promotion Board also makes 10% of body weight guidelines. In a 2004 study of Canadian literature, it was concluded that a body weight limit of 10-15 per cent is appropriate. The American Department of Occupational Therapy recommends a 15 per cent limit on body weight (Al-Saleem and Ali 2016). Hence, the parents needs to pay more attention on their children's school backpack to ensure that their bag does not exceed the recommended weight as per recommended by the American Physical Therapy Association (APTA).

Table 2.1: Maximum Backpack Weight Chart for Children (APTA, 2009)

Weight of Human (Kg)	Maximum Backpack Weight (Kg)
27.21	2.26
27.21-34	4.53
34-45.30	6.80
45.30-56.63	8.16
56.63-68	9.07
68-90.70	11.33

2.1.2 Design of Backpack

School bag comes in several sizes , colors, materials and shapes that will offer a range of choices to children. However when it comes to the bag's real purpose or work, it's important to look into specifics about the ergonomically appropriate for the kids to take to school. A research has demonstrated that school sacks with numerous examples and structures including weight, conveying process, tie length, time spent conveying the school pack are one of the elements affecting the danger of musculoskeletal side effects, for example, agony and distress in different body areas of elementary younger students (E.S. et al. 2014)

The design of backpack amongst students often influences low back pain. The most ergonomic design is the two strap rucksack. Because of an imbalanced distribution of load between the shoulders, single-strapped and handheld bags may cause stress strain on the back muscle. Conveying a backpack rather than the two shoulders on one shoulder likewise expands the danger of low back torment because of postural deviation. A two-strap backpack is related with less torment at the rear of the neck, less recognizable strain,on the shoulders and less discernible pressure (Amiri, Dezfooli, and Mortezaei 2012). Changing strap location will increase the contribution of vertical loading on the shoulder. The contact field, on the other hand, would be increased, so the pressure felt by the students would be decrease.

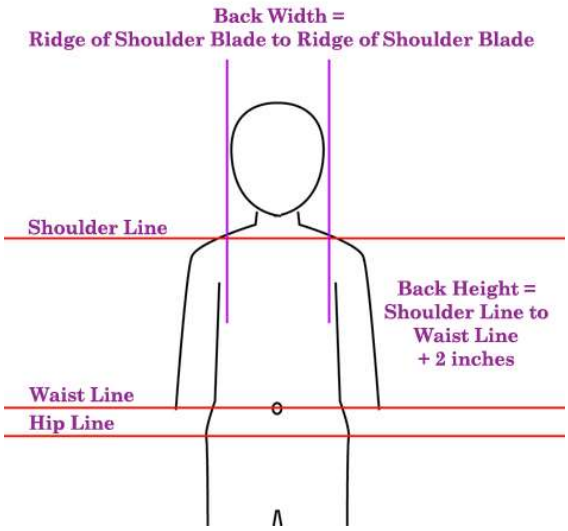

Figure 2.1: Fitting guide for a child's school bag

When choosing the right backpack, the parents should look for one that suits their kids' size. One of the features that the parent should look for is broad and padded shoulder straps. A non-padded straps dig inside the shoulders causing pain in the upper back and shoulder. Arms and hands gradually tingling and becoming stiff due to compression of the nerves and a weakened circulatory system. Padding on the backpack section that reaches the pack will provide protection against any strange objects inside it. Having a waist strap also would be helpful in reducing the risk of musculoskeletal disorder as it will more fairly distribute the weight of a heavy load. A multiple compartment also helps in distributing the weight more evenly.

2.1.3 Methods of Carrying The Backpack

A portion of the children were utilizing only one backpack strap to convey materials and books. One-tie sacks would in general encourage horizontal spinal bowing and rise of the shoulder, while two-lash knapsack diminished sidelong spinal twisting and rise of the shoulder however significantly expanded head and trunk forward leanings (Trevelyan and Legg 2006). Past studies have indicated that the forward inclining of the upper trunk increments considerably when subjects wear a knapsack in a lower position with a more extended shoulder strap (Kim, Kim, and Oh 2015).

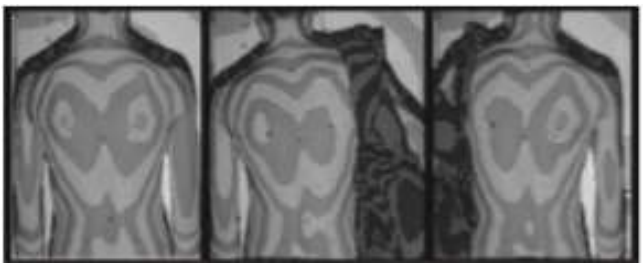

Figure 2.2: Effect of using single-strap backpack (Drzał-Grabiec et al. 2015)

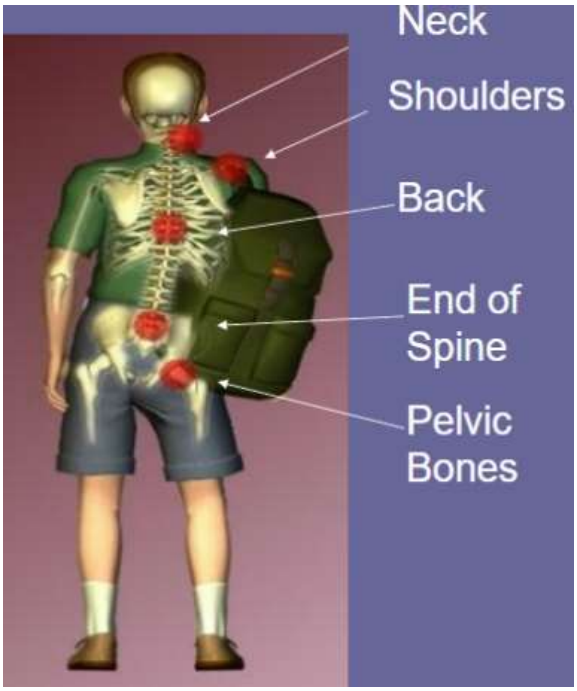

Figure 2.3: Pressure point involve by using one shoulder strap

In a study by Ingrid et al, it is discovered that the power of the utilization of two strap knapsack paying little mind to class evaluation and sex altogether, 85.3% of all members assessed utilized twofold tie rucksack. The result of the study is depicted by the Table 2.2 below:

Table 2.2: Mode of Carrying Schoolbag (Ingrid et al, 2016)

Grade	Sex	Double-strap backpack	Single-strap backpack	Wheeled backpack	Other modes
1st grade	Male (n=12)	83.3%	0.0%	16.7%	0.0%
	Female (n=11)	63.6%	0.0%	36.4%	0.0%
2nd grade	Male (n=16)	100%	0.0%	0.0%	0.0%
	Female (n=11)	81.8%	0.0%	9.1%	9.1%
3rd grade	Male (n=19)	73.7%	10.5%	5.3%	10.5%
	Female (n=18)	83.3%	5.6%	11.1%	0.0%
4th grade	Male (n=27)	88.9%	7.4%	3.7%	0.0%
	Female (n=22)	95.5%	4.5%	0.0%	0.0%
5th grade	Male (n=22)	90.9%	0.0%	4.5%	4.5%
	Female (n=33)	81.8%	0.0%	6.1%	12.1%

2.2 Effect of Carrying Heavy Backpack

2.2.1 Mechanical Effects of Backpack Loads

The spinal erectors plainly are more dynamic under heavier knapsack loads than during emptied strolling. The increments are especially articulated when the heap mass is more noteworthy than, 30-40 kg. This was ascribed to a stacked stance wherein the focal point of body weight in addition to rucksack mass is further rearward than the focal point of the storage compartment mass alone when no heap is conveyed (Knapik, Harman, and Reynolds 1996).

While the span of the position stage walk (foot on the ground) isn't influenced by loads up to half of body weight, the term of the swing stage (foot noticeable all around) diminishes with expanded burden. The overabundance weight of a knapsack prompts asymmetry in the front and back burden appropriation, constraining the upper trunk to lean forward to suit postural pressure and hold postural balance (Kim, Kim, and Oh 2015). In a study by Kerr et. Al. they analyzed the variables individually, and found that all measured biomechanical variables displayed significantly higher exposure rates for cases than controls, except for a measure of low (static) charge. For comparisons of the indi-vidual self-reported psychosocial variables, such consistency was not observed (Kerr et al. 2001).

2.2.2 Musculoskeletal Disorder

Most research investigating musculoskeletal disorders in children locate that back torment just or low back torment and upper back agony just as a typical MSD. Be that as it may, Murphy et al proposed,that the spine ought to be treated as three unmistakable substances (neck pain, upper back pain and low back pain) as thoracic pain is increasingly regular in more youthful kids (Murphy, Buckle, and Stubbs 2007). 142 out of 392 students age of 9 years-old in Antwerp City complained that they have experience a low back pain at least once during the school period (Gunzburg et al. 1999)

While musculoskeletal symptoms are thought to be multifactorial in nature, carrying heavy school bags is obviously a suspected factor (Whittfield, Legg, and Hedderley 2001). It is become contributory factor to the musculoskeletal pain. A study by Sheir et al has concluded, that there is an association between the frequency of back pain and the weight of

the backpack and the amount of backpack use (Sheir-Neiss et al. 2003). When the body are exposed to the overload school bag they might resulting to get a musculoskeletal pain. A research by Dockrell et. al. were based on musculoskeletal distress in elementary school children with an average age of 10 years and their relationship to carriage from backpack. Students were found to be more likely to have discomfort after carrying their backpack, rather than before carrying their backpack. It also found that women and children with prior musculoskeletal discomfort were more likely to report discomfort in the shoulder (Lashway, Aqlan, and Ford 2017).

From the previous report, it demonstrates that ergonomic risk factors for musculoskeletal pain can be changed using the EHPP, which consists of exercises, presentations and ergonomic risk awareness training, and that these improvements are successful in improving body posture in the school setting (Nurul et al, 2009). Most kids bring a school bag to school on a regular basis and some work has been done to address a healthy load cap for kids bring their school bags. Back pain in school-aged children is becoming a major health issue because of the use of heavy school bags.

2.2.3 Body Discomfort

Schoolbag carrying is a common phenomenon in children and has been associated with musculoskeletal discomfort. The current study investigated the relationship between musculoskeletal discomfort associated with the schoolbag and human, physical and psychosocial risk factors in Ireland's primary school children. According to the Wettenschwiller et al., the backache component typically occurred in human backbone by the carriage load and typically the lumbar spine disk (L4-L5) (Wettenschwiler et al. 2017).

Based on the analysis by Lashway et. al., the changes in the lumbosacral spine forces under different loads on the backpack were investigated in. Stride length and walking speed were not impacted by heavier backpack loads based on the study of ten male subjects but the force on the L5 / S1 joint increased as the backpack 's weight increased. Heavy loads on the backpacks can also affect posture and gait (Lashway, Aqlan, and Ford 2017). The analysis is concluded that the weight of the backpack had the greatest effect on stress and pressure in the shoulder.