Development of an Ergonomically Designed Backpacks for Junior High School Students

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Abstract. Backpacks are ever used to transport everyday essentials from one place to another which also come in a variety of design and specification that personify the person; yet most manufactures often overlook the importance of comfortability and posture support instead of aesthetics. Segment of the population suffer from excessively heavy loads of backpacks which lead to plenty of health problems. Contradictory to public beliefs, wearing heavy backpacks will not stunt growth [1], but will breed health problems nonetheless; bad posture, shoulders bending inwards and improper spine alignment. Furthermore, prolong carriage of heavy loaded backpacks brings great stress to a single muscle group resulting to muscle fatigue and causes the user's body to compensate to the weight misaligning the axis of the body [2, 4]. As backpacks have a high demand of use for students the researchers envision of creating a backpack that diminish the payload by properly distributing the weight. This method utilizes the muscle's carrying capacity and improves of the user's posture [3, 7]. In order to develop this design, anthropometry and statistics are used to determine the appropriate dimensions for each part of the product: Shoulder breath (Bideltoid), Shoulder breath - (Biacromial), Lumbar height and average bag weight. Choosing junior high school students as participants, ranging from 13–17 years old, who are typically carrying a heavy loaded bag. Gathering the participant's body segments and integrating it for the dimensions of the design with respect to the 5th and 95th percentile of the stated body measurements. The design serves the purpose of bringing materials with the minimal possibility of having discomfort due to overstressing of muscles [7]. Applying stress absorbers in the straps of the bag which will be designed to minimize the strain received by the user's shoulders. The ergonomic design should bring the user comfortability as well as functionality.

Keywords: Backpack · Junior high school · Posture · Anthropometry

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1 Introduction

Backpacks are often used in transporting the user's belongings from one place to another. Backpacks in the modern times comes in various of ways and designs personifying the bag, while serving its primary purpose of carrying things, most manufacturers often overlook the importance of safety. Over the years, people suffered from excessively heavy loads of back packs, which in long term, leads to health problems and possible injury [7, 9]. Contrary to public beliefs, "wearing heavy backpacks will not stunt growth" [1], but will breed health problems nonetheless, bad posture, shoulders bending inwards, improper back bone alignment to name a few [2, 3]. Without proper equipment these pre-existing problems that result from regular use of conventional back packs will worsen let alone multiply. Junior high students are the most viable subjects for the test given their demographic nature. Junior high-school students are observed to carry backpacks way more than their suggested capacity. With these age group 13–17, where human bones are in its developmental stage are viable for series of tests. Most of the students used traditional backpacks as their school bags which greatly affects their health, productivity and safety [9]. At times, students tend to disrupt the natural posture of their musculoskeletal system causing the body to go off-Axis of its natural position which lead the body to compensate with postural distortion [7, 8]; is one of the reasons for causing musculoskeletal pain. To counteract this regrettable reality, the researchers partake into a research devising a bag that alleviates and/or prevents the aforementioned health problems brought about by using a poorly designed back pack. Chronic musculoskeletal pain may arise from frequent incorrect use of heavy backpacks.

2 Conceptual Model

In order to develop an ergonomically designed back-pack for junior high-school students, the researchers identified the functions of the existing bags with regards to their study and recommend an abstract design improving the usage of back-packs. The approach requires survey questionnaire for gathering the necessary data and measurements; integrate the initial concept design with the gathered data. Finally, the projected output of the study comprises ergonomically intervened back-pack prototype preventing posture misalignment while serving the purpose of carrying the user's belongings (Fig. 1).

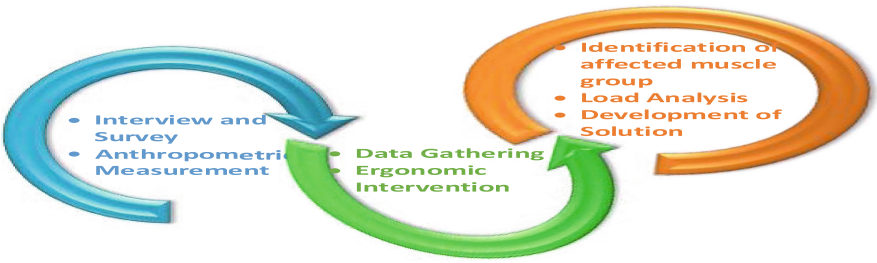


Fig. 1. Conceptual model

3 Methodology

Sampling Procedure: The study followed a procedure using a close ended proportion questionnaire. The research instrument contains a questionnaire wherein respondents are to state their perception of their bags in a physical comfort/discomfort sense. The research instrument is then given to the eligible test participants within ages 13–17 on the selected population, which has a total of Six Thousand and Forty-Two (6042); and composing of Three hundred Eighty Seven (387) respondents. The researcher presumed that this group of students are the ones who often carry a heavy bag. The queries are constructed based on factors affecting the user and backpack, one of which quantifies the factors in concern with the comfort ability of the user's backpack while wearing it, regardless of the payload carried. Another concern is the load they set in the backpack, considering if they place all of their things within the backpack. Moreover, we need to look over is how they wear their backpack, despite the different built or design of the backpack have. Additionally, we also considered the discomfort to the body while wearing he bag especially on shoulders and the stress on the back or the pain that users feel while wearing it for long periods of time. After filling out the information necessary, the researchers proceed to get the lengths of the student's following body parts: Shoulder Breadth (Bideltoid), Shoulder Breadth (Biacromial), and their Lumbar height, as well as their bag weight; which are essential data in the process of incorporating the concept.

Sampling: There was Six Thousand and forty-two (6042) number of population during the time of the study. Using the Slovin's formula to calculate the sample size, it was approximated that Three Hundred and Seventy-Six (376) respondents were required to obtain ± 0.05 margin of error. However, the proponents gathered data from Three hundred eighty Seven (387) respondents thus giving a margin of error of ± 0.0492.

Data Analysis: The current study used descriptive statistics, anthropometric statistics and inferential statistics for the demographic profile of the respondents. The fundamental means were analysed to identify which fragment greatly affects the general accomplishment of the goal. Finally, a test of hypothesis one-sample p-test and z-test validated the qualitative evaluation of the respondents [5].

4 Results and Discussion

Demographic Factors: Surveys had been done to determine the factors that cause shoulder and back pains among junior high schools student in publics school in Bulacan. Age, Gender and Bag weights were assumed to be occurrences to be related to the problem. Since the target population of Three Hundred and Seventy-Six (376) was exceeded and Three hundred eighty Seven (387) respondents were gathered giving the study, Four point Ninety Two percent (4.92%) error.

The total sample gathered from the three (3) Institutes is comprised of One Hundred and Seventy-Five male respondents (45.22%) and Two Hundred and Twelve female respondents (54.78%). See Figs. 2 and 3.

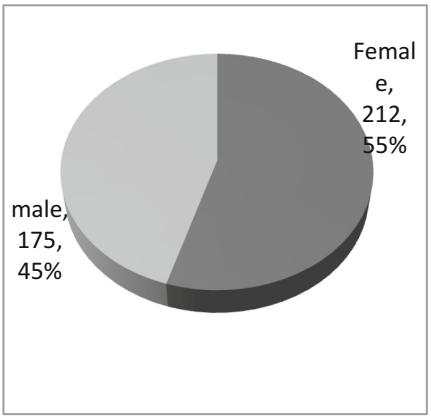


Fig. 2. (Gender)

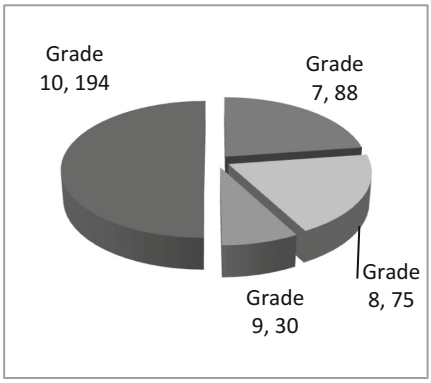


Fig. 3. (Year Level)

Diagnostics: The proportion who answered that they feel comfortable wearing their backpacks exceeds by 72 respondents, and 258 reported that they place most of their belongings within the backpack, the majority answered that they wear their backpacks loose, exceeded by 95 respondent replies, and 200 respondents reported they feel shoulder pain, while 275 stated that they suffer from back pain after prolonged use of heavy loaded backpack. The relationship observed that wearing backpacks loose result in higher probability of having shoulder pain as well as back pain after using heavy loaded backpack (Table 1).

Table 1. Questionnaire diagnostic

Questionnaire diagnostics										
	Comfortability Q1		Placement Q2		Loose Q3		Pain while wearing Q4		Pain after wearing Q5	
Grade	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
7	50	50	98.86	1.14	52.27	47.73	63.64	36.36	77.27	22.73
8	45.33	54.67	72	28	58.67	41.33	58.67	41.33	76	24
9	30	70	76.67	23.33	73.33	26.67	60	40	66.67	33.33
10	42.27	57.73	58.25	41.75	70.1	29.9	43.81	56.19	70.62	29.38

Anthropometric Measurement: Harvested data are segmented into two (1) anthropometric measurement for male, and (2) anthropometric measurement for female in consideration to the variation of anthropometric measurement of genders.

Measurements for male are as follow: Bag Weight 4.807, Shoulder Breadth (bideltoid) 16.823 inches, Shoulder Breadth (Biacromial) 19.537 inches, Lumbar Height 18.903 inches (Table 2).

Table 2. Anthropometric measurement for male users

Male				
	Bag weight	Shoulder breadth (bideltoid)	Shoulder breadth (biacromial)	Lumbar height
Max	10.3	21	26	25
Min	1.1	12	13	13
Mean	4.807	16.823	19.537	18.903
Std dev	2.045	1.504	2.358	2.465

Measurements for female are as follow: Bag Weight 4.807, Shoulder Breadth (bideltoid) 16.823 inches, Shoulder Breadth (Biacromial) 19.537 inches, Lumbar Height 18.903 inches. (Table 3)

Table 3. Anthropometric measurement for female users

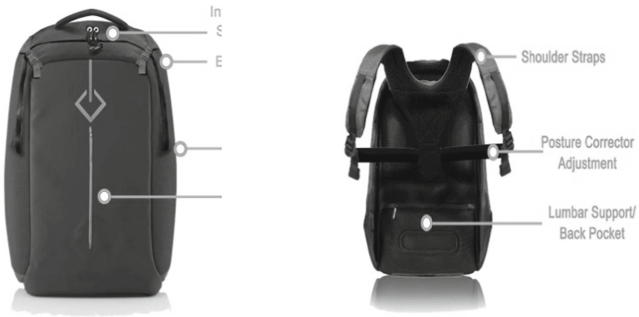
Female				
	Bag weight	Shoulder breadth (bideltoid)	Shoulder breadth (biacromial)	Lumbar height
Max	8.5	20	29	21
Min	1.2	13	12	12
Mean	3.697	8.359	18.359	17.160
Std dev	1.617	2.590	2.59	1.633

5 Recommendation

The current attributes of the mainstream bag line-up has significantly improved through generations. The room of improvement was filled by researchers. But as good as these improvements may come, much work is still needed. The tolerability level of having the strap on for extended periods of time varies from user to user and the level of comfort, occurrence of health problems over time from misuse, and all other relative factors that is in need of addressing.

With further research and development, optimum comfort and safety can be achieved by making the strap adapt into the user's body and make them part of the body, thus further reducing body sway and therefore reducing the overall multiplying factor of weight when moving. By successfully decreasing body sway, the bag will further reduce the likelihood of developing an ailment related to misuse of a backpack.

Skin torsion is another observable immediate negative effect of a heavy bag. The researchers took this factor into account. By using dampening systems on the straps of the back pack combined with materials less abrasive to human skin, the researchers lessened skin torsion, abrasion and shoulder bruising therefore effectively relieving pain from the user (Fig. 4).



Bag Height	420 mm
Bag Width	265 mm
Bag Breadth	160 mm
Bag Strap Adjustment	510 mm

Fig. 4. Propose designed with ergonomic intervention

The proposed design was then constructed to aid the user in developing good body posture, while serving the principal purpose of carrying materials from one point to another. The designed back-pack has one primary opening as its main storage and a front pocket providing easy access. Furthermore, the bag provides a compression system by pulling the string placed at the upper section of the bag; the system will reduce the movement of things within the bag which causes the movement of the load away from the core [7, 10] of the user and direct the pull of the load downhill. External adjustable snap locks were also placed to help the compression of the upper section of load and provide added security to the primary opening. The backpack straps were designed to pull the user's shoulders backwards serving as a posture correction system to the user, allowing the shoulders muscles to adapt in the position, eventually developing good posture habits and the backpack's dimensions are projected to fit user's body measurement; with respect to the 5th and 95th percentile quantities gathered. Because the back-pack is design in a way to help the user's posture, the initial phase of using the bag will cause discomfort-ability to the user due to it adjustments of the muscles to its proper alignment. The lower section of the bag then provides lumbar support with thick paddings as most of the weight

rests there, and an additional secret back pocket for small important things. Developing good posture habits prevents slouching and hunching of the back which then leads to rounded shoulders and spine which are causes to many disorders. Likewise, mounting good posture habits prevents the compensation of the body to the weight thus avoiding the posture misalignment; moreover the designed system also contributes to the muscle exercise of the user strengthening the core muscles.

6 Conclusion

After verifying the factors that gives pain in the lower back of the body, the application of ergonomics specifically human factors and ergonomics the following are suggested to the natural structures of backpacks; the placement of the bag should be at thoracic region correlated to the body structure- according to Kroemer, in her study the "Muscle functions and disorders" stated that, there are three types of muscle that the human body, Cardiac, the smooth muscles and the skeletal muscles which the maintains the body's postural balance, and with the backpacks unbalanced weight the body's balance is broken thus gives the body pain in the lower back which is the core. The researchers redesigned the backpack for ergonomics function providing the user minimal risk of having injuries and strain on the muscles. Adjustments and features with regards to the back-pack considering the response of the user's body–with accordance to Forester's study, posture distortion, pain and injury are factors to consider. Moreover, with respect to the Fifth and Ninety-Fifth percentile of both male and female, the adjustment range used are the fifth percentile from the female which has smaller body structure and the Ninety-fifth percentile from the male with broader body structure.

References

1. Rosenbrock, K.: The Negative Health Effects of Heavy Backpacks, And How Your Kids Can Avoid Them. The Active Times, 3 September 2015
2. Foerster, M.M.: Marilyn Miller Von Foerster. Retrieved from marilyn von foerster (2018)
3. Kroemer, K.H.: Fitting the Task to the Human. Taylor & Francis, London (1997)
4. Garcia, M., Laubli, T., Martin, B.: Long term muscle fatigue after work. Hum. Factors Ergonomic Soc. **57**, 1162–1173 (2015)
5. Isip, J., Caparas, H.: Advance in Usability and User Expirience. Springer, Orlanfo (2019)
6. Rawkls, A., Fisher, R.: Development and Functional Anatomy. Springer, Heidelberg (2010)
7. Athanassiou, G., Spyropoulos, E., Chroni, E.: Muscle fatigue estimation in repetitive lifting task using electromyography-based analysis. J. Ergonomics (2015)
8. Holewun, M., Lotens, W.: The influence of backpack design on physical performance. J. Ergonmics **35**, 149–157 (1992)
9. Milanese, S., Grimmer-Somer, K.: Backpack weight and postural angles in preadolescent children. Indian Pediatr. **47**, 571 (2018)
10. Ramadan, M., Al-Shayea, A.M.: A Modified backpack design for male children. Int. J. Ind. Ergonomics **45**, 462–471 (2013)
11. Perron, M., Hing, W., Orr, R., Milne, N., Pope, R.: The impact of backpack loads on school children: a critical narrative review. Int. J. Environ. Res. Public Health, 23–25 (2018)