A Study of the Design for Trolley School Bag of Elementary Children in Grades 1-3 Using the National Institute for Occupational Safety and Health (NIOSH) Lifting Equation

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Abstract

The Philippine education system specifically for grade school students require a high number volume of books, and other educational items e.g. notebooks that are required to bring every day to class. The findings of this research suggest that the actual and current strollers for the school children produce a lot of stress, strain and long-term gradual health deterioration. Stroller type was highly correlated with high level of strain, stress and decrease in children output productivity. Considering the preliminary findings of this study, the parents and the teachers should evaluate, decrease the volume of books and school materials, and if not possible, produce a more ergonomic design for the stroller or bag of the school children. The findings of this study recommend the need to change and standardize stroller bag designs using the evaluation from the National Institute for Occupational Safety and Health Lifting Equation.

Keywords
Ergonomics, School Children, Trolley, Manual Material Handling, National Institute for Occupational Safety and Health

Chapter 1

THE PROBLEM AND ITS BACKGROUND

1.1 Introduction

It has been widely observed that children who go to school in their early preparatory education, grades 1 to 3 that they are required to bring a heavy number of books as part of compulsory requirements for their education. Every subject of the curriculum needs about 1 to 2 textbooks for every semester that the students are enrolled in. On average, there are seven subjects taken by grades 1 to 3 students on various schools. In addition to these textbooks are notebooks paired for every subject, and other minor materials for some subjects such as journals and educational materials. Backpacks are not suitable for all of these materials and textbooks because of the insufficient space and excessive weight. The common alternative is to use a backpack and a separate carry method that is using a rope to tie around the books for hand carry. This not favorable because of time constraints, distracting environment and school children had to be nursed by the teachers or their respective guardians and caretakers. The most practical and convenient for both the parents and the children is the trolley bag, a high capacity sturdy bag that can cater to all the educational materials of the students. However, an obvious result is seen as the children suffer from body and hand strain, physical stress generating low productivity output and also contributes to long term health deterioration.

1.2 Background of the Study

Based on the Australian Physiotherapy Association approximately 70% of school aged children suffer back pain from poorly fitted school bags. Other causes of back pain in children can be caused by poor posture, obesity, sedentary lifestyle and soft tissue injuries (sprains and strains). This only presents the case of backpacks for the school children. The trolley bags are also not recommended as an alternative for students with back problems. These bags often weigh a lot more and are not easy to manipulate around stairs and on buses etc. The action of pulling these bags is difficult to perform without twisting the spine and can cause uneven load distribution through the spine. The trolley bag clearly presents danger concerning the children's health with both short term and long-term injuries.

Furthermore, children's skeletons are still growing so carrying heavy bags can cause lasting damage. Many are carrying their bags on one shoulder or are increasingly carrying them on the crook of their elbow, so are placing a strain on the spine. A lot of the bags being used are bulky sports bags, which are twice the size of backpacks used a decade ago. If children have bigger bags, then they tend to fill them. It is seen that children carry up to a quarter of their body weight around. This study encompasses this issue that has not been addressed properly worldwide.

1.3 Statement of the Problem

The study aims to design a Trolley School Bag of elementary children using ergonomics assessment tool.
Specifically, the study aims to answer the following questions:
1.What is the profile of the student / respondents in terms of age and gender?
2.Is there a significant relationship between the student's profile and their preferences in choosing school bags?
3.How does the school bag design affect the load on spinal posture during stair use by children?
4.What are the effects of postural discomfort on school going children due to carrying/lifting heavy bags?
5.What is the advantage of using trolley school bags rather than heavy backpacks?
6. What is the degree of disability, anthropometric variables, and allowable school bag weight in boys and girls from grades 1-3 in must carry?

1.4 Objective of the Study

General Objective:

- To develop a design for a Trolley School Bag of children in grades 1-3 using ergonomic assessment tools

Specific Objectives:

- To determine a significant relationship between the children's profile and preferences in choosing school bags
- To analyze how the school bag design affects the load on spinal posture during stair use by children
- To assess and reduce the effects of postural discomfort on school going children due to carrying/lifting heavy bags
- To describe the advantages of using trolley school bags rather than heavy backpacks
- To define the degree of disability, anthropometric variables, and necessary school bag weight of schoolchildren from grades 1-3 in elementary

1.5 Scope and Delimitation of the study

In general, the main concern of the study is to develop a design for a Trolley School Bag of elementary children in grades 1-3 using ergonomics assessment tool. The target population of the research sample is composed of students in the first three grades of primary school, aged 6-10 years in Plaridel Central School Plaridel, Quezon. Sample size calculation was carried out assuming an overall prevalence of back pain of 30% based on data from previous studies. There were at least 47 students per grade resulting in a minimum total sample population of 140 students in overall. This study limits its coverage on the 1st to 3rd grade elementary students only which are identified as frequent users of trolley bags and are the ones who experience stress and back pain for carrying such heavy backpacks to school. The primary data gathering method used was observation and ergonomic assessment through anthropometry to ensure a more accurate data of the sample. The interview schedule consists personal details like name, age, class, board, distance of school, mode of transportation, physical characteristics like height, weight and bag weight. The subject weight was measured with a weighing scale. Standard height and other anthropometric measurement data needed was measured with measuring tape secured to the wall. The school bag was also weighed.

1.6 Significance of the Study

The researchers would like to present the case as a significant issue that addresses the current and future school children. If the educational system does not change the standard of requiring school textbooks and using the solution of the heavy school materials to be left at school, lockers or switching to online books, then the research would be significant in the current and the next years addressing the school children worldwide. The research study could provide solution, recommendations on the issues of school children having body strain, physical stress and body deformity over long period usage of stroller bags. Further, this study would also be beneficial to the Department of Education, and Department of Health because as the research has not been prevalent here in the Philippines. In a study of the "Preference of Filipinos in choosing Bags" (Source: Lifestyle Inquirer) indicates that there is a preference of backpacks over duffle bags and suitcases or trolley bags which as the case has presented generates health related problems. Choosing trolley bags or backpacks both generate problems but the research study determines the less injury prone and design a new ergonomic bag which are suitable and appropriate for school children. The study found that although children adopted asymmetric postures while both toting a backpack and pulling a trolley, a trolley was also associated with a rotation of the spine, which could be an extra source of stress on children's bodies, leading the team to advise using a backpack, if the weight is within recommended limits However, the team behind the new study believes that pulling a trolley to school is better for children than carrying around a heavy backpack. After assessing body weight and posture of 78 schoolchildren aged six to 12, results showed that 47 percent of schoolchildren are carrying a load in their trolley or backpack above what is recommended daily.

Chapter 2

REVIEW OF RELATED LITERATURE AND STUDIES

This chapter presents an intensive review of related literature and studies on the previous research writing which have significant relation to the problem under investigation.

According to Akdag, U. Cavlak, A. Cimbiz, H. Camdeviren (2011), Low back pain (LBP) is a common disease among people under the age of 20. To the best of the researcher's knowledge, few studies have been carried out on low back pain among school children in Turkey, and none of them studied the correlation between pain intensity and related variables with LBP. A cross-sectional study was carried out to investigate the risk factors and correlations with pain intensity among 222 school children (106 girls and 116 boys) aged 10-18 years in the city of Denizli. A self-reported questionnaire was used to collect the data. The regression tree method (RTM) was used to determine the risk factors by using the STATISTICA program package. Pain intensity was the outcome variable, and 8 independent variables (body mass index (BMI), sex, regular exercise habit, studying posture, transportation to/from school, duration of studying, bag handling, and type of bed) were used to detect the effect on pain intensity.

According to Grimmer KA, Williams MT, Gill TK (1999), a cross-sectional, observational study, examining the effects of backpack weight on adolescent posture investigates the response of the craniovertebral angle to backpack load. The study shows that repeatedly carrying heavy backpacks making students prone to postural change. A significant change in craniovertebral angle was found at every year level, when comparing standing posture with no backpack with posture when carrying a backpack. The change was greatest for the youngest students. The association became stronger for the oldest girls when controlled for body mass index and for weight. The article states that the repeated carrying of heavy backpacks make it more injury prone for the students and consequently, a negative postural change. With the load present in the school backpacks, there would be a postural sway of balance.

According to Pau M, et.al (2010) the aim of this investigation is to assess modifications in sway parameters introduced by backpack carriage in Italian primary school children (6-10 years old, n = 447). Two 30-s trials (without and with backpack) were performed directly at a school on a regular school day to collect data on sway area, center of pressure path length and maximum displacement range in antero-posterior and medio-lateral directions. The results show a significant load-induced increase in all sway parameters and the existence of a linear relationship between sway area and backpack weight. Since postural sway represents an effective indicator of balance abilities, the alterations observed suggest that backpack carriage originates balance. Loss of balance is among the primary causes of unintentional falls and postural sway represents an effective indicator of balance abilities. The differences that were observed showed that backpack carriage potentially increases the risk of falls.

According to Negrini S1, Carabalona R. (2002), a cross-sectional study was conducted to investigate schoolchildren's subjective perceptions of their daily backpack loads, to ascertain whether an association exists between these sensations or the load itself and back pain, and to identify the school, family, and personal factors that determine the backpack load, and that might, with a view to primary prevention, be addressed with specific interventions. Backpack carrying has been shown to constitute a considerable daily "occupational" load of the spine in schoolchildren. All the backpacks of the 237 year 6 children in a school catchment area of Milan were weighed on six school days. A validated questionnaire also was administered to 115 schoolchildren (54 boys and 61 girls; average age, 11.7 years) whose anthropometric characteristics and loads carried daily were known. The associations among features of backpack carrying, subjective perceptions of the load (fatigue, feeling it to be heavy, pain) and back pain (point and life prevalence) were assessed and verified. School backpacks are felt to be heavy by 79.1% of children, to cause fatigue by 65.7%, and to cause back pain by 46.1%. Fatigue during and time spent backpack carrying, but not the backpack's weight, are associated with back pain.

According to Macedo RB, et al. (2015), eighty-six girls (13.9 ± 1.9 years of age) and 63 boys (13.7 ± 1.7 years of age) participated. Low Back Pain (LBP) was assessed by questionnaire, and disability using the Roland-Morris Disability Questionnaire. Quality of Life (QoL) was assessed by the Pediatric Quality of Life Inventory (PedsQL). Multivariate analyses of variance and covariance were used to assess differences between groups. Girls had higher disability and lower QoL than boys in the domains of physical and emotional functioning, psychosocial health, and physical health summary scores, and on the total PedsQL score; however, similar school backpack weight was reported. Participants with LBP revealed lower physical functioning and physical health summary score, yet had similar school backpack weight to those without LBP.

According to Cervantes (2009), the Angeles City Representative Carmelo Lazatin has expressed concern over the health of school children, especially those enrolled in private schools, burdened with school bags weighing about half as much as they do. The representative introduced in the 14th Congress House Bill 6644, An Act Limiting the Amount of Bags Carried by Children in School and Implementing Measures to Protect School Children's Health from the Adverse Effects of Heavy School Bags. He cited reports of recent random weighing showing that pupils bring school bags that weigh as much as 50 percent or even more of the body weight. It is recommended that schools should limit the weight of bags to less than 15 percent of the students' body weight. According to the representative, a 1994 Scandinavian study showing that 53.7 percent of children who carried packs on one shoulder complained of back pain. Forty-five percent of two shoulder pack wearers complained of back pain. Interestingly, the highest level of back pain, 68.6 percent, carried the bag in one hand. The representative cited the case of the Mary Help of Christians school in Mabalacat, Pampanga where the weight of bags carried by its grade schoolers is about 40 percent of the children's body weight.

Definition of Terms

BMI (Body Mass Index) - A weight-to-height ratio, calculate by dividing one's weight in kilograms by the square of one's height in meters and used as an indicator of obesity and underweight.

Craniovertebral angle - Angle between horizontal line passing through C7 and a line extending from the tragus of the ear to C7.

Low back pain - Pain, muscle tension, or stiffness localized below the costal margin and above the inferior gluteal folds, with or without sciatica, and is defined as chronic when it persists for 12 weeks or more.

Pediatric quality of life - A brief measure of health-related quality of life in children and young people.

Postural discomfort - A condition where pain is felt in the lower back, however, there is no significant damage or trauma to tissue

Static pose - A posture of a person standing, sitting, or lying still.

Chapter 3

RESEARCH METHODOLOGY

This chapter contains the methods of research used, source of data gathering procedures in this study. It explains the method used whether historical, descriptive or experimental method. It includes how the researchers able to get the ideas contained by previous chapter and enhancing the study, gathering data, collection of the related information and the designs used in this study.

3.1 Method of Research Used

In gathering the data for this study, the researchers used observation and ergonomic assessment through anthropometry. Interview is a qualitative research technique that is particularly useful for getting the story behind a participant's experiences and as a follow-up to certain respondents to questionnaires as to further investigate their responses. The researchers also carried out ergonomic assessment through anthropometry to know the health status of all students who have been using poorly designed school bag.

The data were measured with the help of various tools. After data collection and analysis, authors came up with exhaustive dimensions for designing the desired trolley school bag. Dimensions recommended include; Fold Pull Rod Bracket Roll Cart height, trolley's bench surface height, bench depth and width, trolley's back rest width and height, trolley's backrest angle, detachable bag's depth and width, bag's height and weight.

3.2 Respondents of the Study

The respondents of this study were the Fifty-Nine (59) 1st to 3rd grade elementary students of Plaridel Central School in Plaridel, Quezon School Year 2017-2018 from three sections per grade.

3.3 Sampling Technique

The stratified random sampling technique together with the Slovin's formula was used to determine the number of the student-respondents involved in this study. Not all 1st to 3rd grade elementary students of Plaridel Central School would serve as respondents in this study. However, the samples to be taken are expected to possess characteristics identical to those of the population. The data gathered from the respondents have been tabulated and interpreted. The researchers used a marginal error of 10% as the basis and used the Slovin's formula.

$$\mathbf{n = N / (1 + Ne^2)}$$

where:

n = number of samples
N = total population
e = margin of error
The researchers applied the Slovin's formula that gives the data needed in finding the sample with 10% margin of error. A sample size of 59 1st to 3rd grade elementary students out of the total population of 140 is needed.

3.4 Research Instrument

In this study, the researchers used different Microsoft applications like Word and Excel that helped to collect and encode the information and data gathered throughout the study. Various statistical and ergonomic tools are also used that helped the researchers to know the causes, effects and solutions to the problems in this study. The NIOSH Manual Material Handling Booklet is used as guideline to help the researchers to recognize high-risk Manual Material Handling tasks of the sample and choose effective options for reducing their physical demands. Minitab is used to analyze anthropometric data to present descriptive statistics. Measuring tape and weighing scale are used as a tool for gathering anthropometric data for the design of the trolley bag.

3.5 Data Gathering Procedure

The researchers gathered data and information through actual anthropometric assessment on the students. This data was thoroughly analyzed and interpreted to be able to find out the best design for a trolley school bag that will fit elementary children in grades 1-3. The researchers analyzed all the data gathered to improve the health status of all students who have been using poorly designed school bag.

Chapter 4

PRESENTATION, ANALYSIS, AND INTERPRETATION OF DATA

4.1 Selection of Body Dimensions

Designing of an ergonomic trolley bag for elementary children needs directly involvement of anthropometric measurements. There are existing body dimensions which are essential in designing furniture especially for students.

But for this research, collection of all required anthropometric dimensions from elementary children in grades 1-3 in Plaridel Central School adapted ISO 7250 as the standard for all 6 selected student's body dimensions. Fig. 3.1 shows all five (5) body dimensions which were selected for this study with additional of weight as the 6th body measurement while Table 4.1 indicates the number and description of the selected student's body dimensions according to Fig 3.1. These body dimensions were wisely selected for the study with the consideration of the body dimensions to help in enhancing comfort, safety and ease of getting the required dimensions for designing the bag.

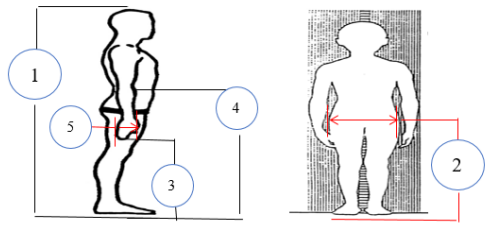

Fig.4.1 Anthropometric data required in ergonomic trolley bag design for elementary school children: stature (1), hip width (2)), fingertip height (3), waist height (4), palm width (5)

Table 4.1 The table shows the basic student's body dimensions and the description per ISO 7250.

No. according to Fig 4.1	Child's body dimensions	Description of the body dimensions according to ISO 7250
1	Stature	Vertical distance from the floor to the height point of the head (vertex)
2	Hip width	Horizontal distance between the upper outer edges of the iliac crest bones of the pelvis
3	Fingertip height	Vertical distance from the floor to the dactylion (i.e. the tip of the middle finger).
4	Waist height	Vertical distance from the edge of the waist to floor
5	Hand Span	Width of the hand. Horizontal distance from the tip of the thumb to the tip of the pinky finger.
6	Body mass	Total mass (weight of the body) which was measured with the help of weighing scale

4.2 Data analysis

The collected anthropometric data were thoroughly analyzed with the help of Minitab 15 as Statistical Package and Microsoft Excel 2013. The data were analyzed in terms of minimum (min), maximum (max), Standard Deviation (SD) 5th, 50th, 95th percentile and mean. All dimensions are in centimeters (cm) except for body mass (weight) which is in kilogram (kg).

Table 4.2 Descriptive statistics for measured anthropometric dimensions for both male and female students.

Body Dimensions	Min	Max	Both Male and Female Percentile			Mean	SD
			5th	50th	95th		
Standing height (cm)	101	136	104.9	118	134.2	118.42	9.40
Hip width (cm)	13	43	22.9	28	40.1	28.98	5.61
Fingertip height (cm)	28	52	34.9	41	48	41.31	4.51
Waist height (cm)	56	88	61.95	69	85.05	70.88	6.97
Hand span (cm)	13	22	14	16	20.05	16.3	1.92
Weight (kg)	15	49	17	25	45.73	26.72	8.91

Table 4.3 Descriptive statistics for measured anthropometric dimensions for male and female students

Body Dimensions	Male Percentile					Female Percentile					Mean	SD
	Min	Max	5th	50th	95th	Min	Max	5th	50th	95th		
Standing height (cm)	101	136	102.9	120	131.25	104	136	105	115	135	119.2	9.26

Hip width (cm)	13	41	22.5	29.5	38.15	22	43	23.5	28	40.5	29.5	6.53
Fingertip height (cm)	28	48	31.8	42	48	36	48	37	41	48	40.8	5.42
Waist Height (cm)	56	84	58	70	77.6	62	88	62.5	69	85	69.31	6.36
Hand Span (cm)	13	21	13.5	16	18.5	14	22	14.4	16	20.6	16	1.84
Weight (kg)	18	47	19.9	26	39.4	15	49	17	22	45.5	27.9	6.84

4.2 Results and Discussion

Tables 4.2, 4.3 and 4.4 present descriptive statistics of all the measured anthropometric measurements for both male and female (grades 1-3) students respectively. Trolley bag is currently being preferable due to its capability of increasing the comfortability while reducing the chance of MSDs in the long run. Table 4.5 shows various criteria which have been suggested as the guidelines at whatever time there can be a need of designing a trolley bag for grades 1-3 students and another population group.

Table 4.4 Determinant criteria for ergonomic design of trolley school bag.

Features	Anthropometric measure	Design dimension	Criteria Determinant (ergonomic school bag)
Bag height	Fingertip height	37-48 +4 (cm)	5th percentile to the 95th percentile (both male and female) + 4cm wheels allowance
Bag height including handle	Stature, waist height	69-77.6 (cm)	50th percentile female to 95th percentile male
Bag width	Hip width	40.5 (cm)	95th percentile of female hip width
Bag length	Standard bag length	21 (cm)	-
Handle width	Hand Span	20.05 + 5 (cm)	95th percentile (both male and female) = 5cm allowance
Bag volume	Weight	4.55 kg	10 % of the 95th percentile (female)
Bag weight	Standard bag weight	1.5 kg	-

4.3 Design for the Proposed Trolley School Bag

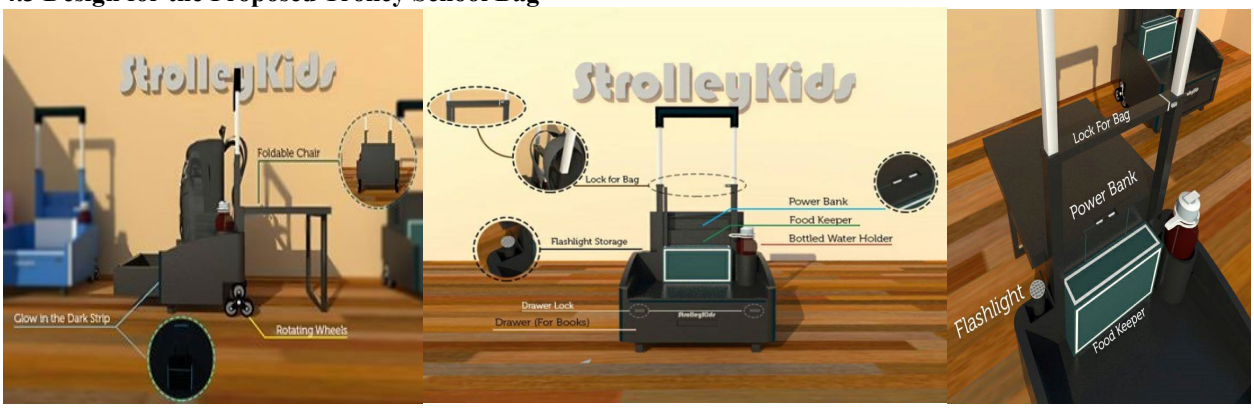

Fig 4.2 Proposed Design of Trolley Bag

The trolley bag design features various features that helps the school children in their academic lives.
In Figure 4.3, there exists a small horizontal drawer embedded in the base of the stroller exclusively for books, this minimizes space in the bag in the stroller. The bag is removable via Velcro strap so if the load is light, the bag can be removed and the trolley is no longer needed. The wheels of the trolley are three interconnected wheels that each consists of a ball bearing in the center of a multi-lobed flat structure made from metal or plastic designed to spin along its axis with little effort. This greatly minimizes effort in climbing up the stairs. The additional features of the bag are following: portable chair integrated in the back of the stroller, removable Power bank for charging phones, LED Light connected to the power bank, canteen holder and waterproof bag cover. The composition of materials for the bag are the following: waterproof lightweight fabric, coated by polyurethane. Trolley is made of lightweight

thick aluminum for the handles, High Density Polyethylene (HDPE) for the base and book drawer. Measurements are as standard with the market sold trolleys and are indicated on table 4.5

4.4 Risk Analysis for Carrying Backpacks

This checklist is not designed to be a comprehensive risk assessment technique but rather as a tool to quickly identify potential problem jobs. Additional risk factors may exist that are not accounted for in this checklist. It is common practice to follow up checklist observations with more precise techniques to confirm problem risk factors. **"Yes"** responses are indicative of conditions that pose a risk of developing low back pain. The larger the percentage of "Yes" responses that are noted, the greater the possible risk.

Risk Factors	**Yes**	**No**
1. General		
1.1 Does the load handled exceed 50 lb.?		/
1.2 Is the object difficult to bring close to the body because of its size, bulk, or shape?	/	
1.3 Is the load hard to handle because it lacks handles or cutouts for handles, or does it have slippery surfaces or sharp edges?		/
1.4 Is the footing unsafe? For example, are the floors slippery, inclined, or uneven?	/	
1.5 Does the task require fast movement, such as throwing, swinging, or rapid walking?	/	
1.6 Does the task require stressful body postures, such as stooping to the floor, twisting, reaching overhead, or excessive lateral bending?	/	
1.7 Is most of the load handled by only one hand, arm, or shoulder?	/	
1.8 Does the task require working in extreme temperatures, with noise, vibration, poor lighting, or airborne contaminants?		/
1.9 Does the task require working in a confined area?		/
2. Specific		
2.1 Does lifting frequency exceed 5 lifts per minute?		/
2.2 Does the vertical lifting distance exceed 3 feet?		/
2.3 Do carries last longer than 1 minute?	/	
2.4 Do tasks that require large sustained pushing or pulling forces exceed 30 seconds duration?		/
2.5 Do extended reach static holding tasks exceed 1 minute?	/	

Table 4.5 Hazard Evaluation Checklist for Lifting, Carrying, Pushing, or Pulling
(Source: T. R. Waters, "Manual Materials Handling", in: Physical and Biological Hazards of the Workplace (Second edition). Edited by P. Wald and G. Stave. New York: John Wiley and Sons, 2002.)

As observed in Table 4.6, for the hazard evaluation checklist there are greater "Yes" responses than no which are indicative of conditions that pose a risk of developing low back pain. This also indicates that with the large percentage of "yes' the greater the possible risk results from carrying bag packs.

4.4 National Institute for Occupational Safety and Health (NIOSH) LIFTING EQUATION for the Proposed Trolley School Bag

The researchers embrace the knowledge of NIOSH Lifting Equation to evaluate the manual material handling risks associated with students lifting their bags. The equation considers job task variables to determine safe lifting practices and guidelines. The main creation of the NIOSH lifting equation is the Recommended Weight Limit (RWL), defines the maximum suitable weight load that virtually all healthy employees could lift. Over without raising the risk of musculoskeletal disorder to the lower back. In addition, the lifting index is calculated to provide a relative estimate level of physical stress and MSD risk associated with the manual tasks evaluated.

Recommended Weight Limit (RWL): Answers the question "Is this weight too heavy for the task?"
LIFTING INDEX (LI): Answers the question "How significant is the risk?"

A Lifting Index value of less than 1.0 indicates a nominal risk to healthy employees. A Lifting Index of 1.0 or more denotes that the task is high risk for some fraction of the population.
As the LI increases, the level of low back injury risk increases correspondingly. Therefore, the goal is to design all lifting jobs to accomplish a LI of less than 1.0.

NIOSH Lifting Equation: LC x HM x VM x DM x AM x FM x CM = RWL

Task variables needed to calculate the RWL:

- H = Horizontal location of the object relative to the body
- V = Vertical location of the object relative to the floor
- D = Distance the object is moved vertically
- A = Asymmetry angle or twisting requirement
- F = Frequency and duration of lifting activity
- C = Coupling or quality of the workers grip on the object

LIFTING INDEX (LI): Weight / RWL = LI
Additional task variables needed to calculate the LI:

- Average weight of the objects lifted
- Maximum weight of the objects lifted

Step 1. Measure and record task variables

Object Weight		Hand Location (Inches)				Vertical Distance(in)	Asymmetric Angle (Degrees)		Frequency Rate	Object Coupling
		Origin		Destination			Origin	Destination	Lifts/ min	
L (AVG.)	L (Max)	H	V	H	V	D	A	A	F	C
4	6	25	70	2	85	25	0	90	7	Good

Step 2. Determine the multipliers and compute the RWL's

			RWL = LC * HM * VM * DM * AM * FM * CM							
			LC	**HM**	**VM**	**DM**	**AM**	**FM**	**CM**	**TOTAL**
ORIGIN		RWL	23	1	0.99	1	1	0.7	1	**15.93 Kg**
DESTINATION		RWL	2	1	0.97	1	0.71	0.7	1	**11.09 Kg**

Step 3. Compute the lifting index

ORIGIN	Lifting index	$\frac{OBJECT\ WEIGHT(L)}{RWL}$	**0.3764**
DESTINATION	Lifting index	$\frac{OBJECT\ WEIGHT(L)}{RWL}$	**0.5411**

Fig. 4.3 Task Analysis Worksheet

After gathering the data, the researchers come up with horizontal location (H) of the hands 25 in both origin and destination, this declare the distance between the technician's ankles to a point projected on the floor directly below the mid-point of the hands. Followed by the vertical location (V) of technician's hands above the floor 70 (origin) and 85 (destination). Next is the vertical distance of 15 which is calculated through subtracting the vertical location (V) at the start of the lift from the vertical location (V) at the end of the lift but as said in the rule it should be set to a minimum of 25. After the travel distance is angle of asymmetry (A) of 0 for the origin and 90 for destination which refers to the measurement of the degree to which the body is required to twist or turn during the lifting task. Followed by the frequency rate (F) of 7 lifts/min, this determines the appropriate lifting frequency of lifting tasks by using the average number of lifts per minute. Then the researchers labeled the coupling as *"good"* which determines the classification of the quality of the coupling between the technician's hand and the trolley. Our Lifting Index shows how significant the risk is. The researchers come with a LI of less than one so we therefore conclude that it is not risky. We consider the fact that a lifting index of 1 or more denotes a higher risk factor and will increase level of injury risk. The computed LI is 0.3764 and 0.5411. Therefore, the trolley does not contribute a high of risk injury.

4.5 Comparative Analysis

	Without Proper Manual Handling	**With Proper Manual Handling Techniques**
Advantages	Cost for more appropriate material and design of bag is unnecessary	High productivity output from the School children
		Reduce level of possible injuries
		Lessen indirect costs
Disadvantages	School children are likely to have incorrect postures	Cost for more appropriate material and equipment
	Developing stress and strain on the user	
	School Children are exposed to injuries	

Table 4.6 Table of comparison between using backpack versus a stroller bag for school children
The table above shows the comparison between the positive and negative effects of using a backpack to carry the school children's educational materials and the proposed stroller type bag design for school children. It is evident that there needs to be a standardization of the proper school bags to avoid injuries and indirect costs.

4.6 Problem Tree Analysis

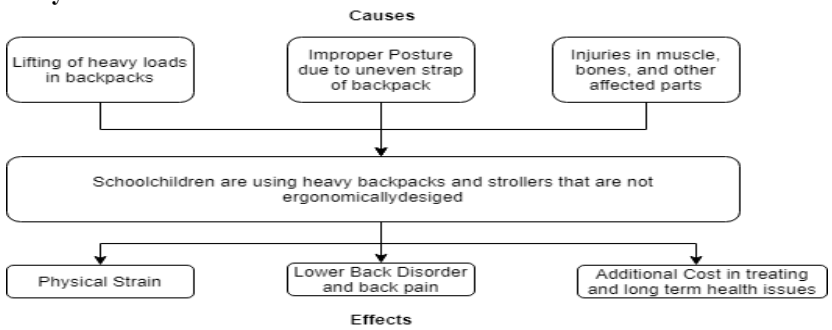

Fig 4.4. Problem Tree Analysis for the currently used bags of school children

Main problem: School children are using heavy backpacks and strollers that are not ergonomically designed.

Causes

Lifting of heavy loads in backpacks – School children normally and on average carry around 3 kilograms of weight in their backpacks, the mounting of the backpack results in spinal twist and strain, shoulder strain, and back spinal posture problems.

Improper Posture due to uneven strap of backpack – the two straps of the backpack needed to be mounted at the same time while carrying the backpack in order to avoid the improper posture.

Injuries in muscle, bones, and other affected parts – a number of children have weak bones and also frequently carrying heavy loads may result in injuries to the affected parts of the body.

Effects

Physical Strain – A great or excessive pressure or stress on one's body because of the heavy loads in the backpack

Low Back Disorder and back pain – Because of poor posture given by carrying uneven loads in the backpack, there occurs various issues with the low back such as Muscle Spasms which means that the body is attempting to protect a sore back, Disc trouble which means the jelly like material inside this disc is prone to slip or break

Additional Cost in treating and long term health issues – The frequent usage of heavy backpacks and injury prone stroller builds up long term health issues such as scoliosis – a medical condition wherein the spine has a sideways curve, which tantamount to a great expense in healthcare over a long period.

Chapter 5
SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATION

This chapter presents the summary of the findings, conclusions and recommendations based on the data analyzed in the previous chapter. Some limitations have been identified and the new designed school backpack using

ergonomics assessment tool was researched by determining to what extent to some of the objectives have been attained.

5.1 Summary of Findings

The focus of this study was to determine the faults of using backpack and trolley bag specifically for school children grades 1 – 3, and the computations and results of the several ergonomic tools have indicated that there is indeed a great discrepancy between the two comparisons for the school bag. This research used the ergonomic tools as assessment indicators from these objectives to establish what extent has been viable. The background of this study was done by examining and analyzing several relevant literatures on the case internationally and locally. The background of this study covers the impact and initial indicators that there is indeed a problem on school children backpacks and trolleys. The research approach used was qualitative, associational research approach. The research population was school children from grades 1 – 3, ages 7 to 11 years old. The sampling method used in this study was the cluster sampling method, with population in the Plaridel Central School, in groups of the grades 1 to 3 school children, and obtaining a sample to the several sections in their respective sections of classes.

To develop a design for a Trolley School Bag of elementary children in grades 1-3 using ergonomic assessment tool.
The combination of needs assessment, convenience features and ergonomic factors have paved the way to create a design that is appropriate to use by school children grades 1 – 3. As evidenced by the illustration provided in the previous chapter, the several features and dimensions are seen.

To determine a significant relationship between the children's profile and their preferences in choosing school bags
School children grades 1 -3 are separated by gender, and their average measurements were taken such as arm length, hand grip strength and hip width. These data together with their preferences in choosing school bags were taken into consideration for the comparative analysis and other necessary tools for this research.

To analyze how the school bag design affects the load on spinal posture during stair use by children
The trolley bags of the school children mainly have the problem by stair use because of the heavy loads their bag has and that these school children pull it up the stairs on the daily basis or on their school academic days. Also, on backpacks, the heavy loads would put stress on their shoulders, backs and spinal column.

Summarizing our study this research showed how the proponents applied the knowledge they learned in course ergonomics in designing a product that will maintain right posture of the students in using such material the result of NIOSH Hazard Evaluation Checklist state that further investigation has to be made in the working process in immediate action is needed to ensure the safety of the students.

5.2 Conclusion

It is evident by the results displayed in the computations for ergonomic assessment tools that the school children experience too much weight on carrying backpacks and trolley bags during their utilization of these bags. The newly designed trolley bag would result in a significant change and improvements for the school children because of the adaptations and considerations for the trolley bag. The researchers conclude that there needs to be a new design for school trolley bags in order to reduce risk of injury, reduce stress and strain, and ease the school children's academic life.

5.3 Recommendations

The school children should be assessed by the doctors on a frequent basis to check their bone structure, posture, mental and overall physical health. Elimination of large backpacks only for children who are not able to support a full weight on that backpack should be done. Concentrate the market of school bags in a trolley type design appropriate for school children in that age range and grade range.

Further research can be done on the actual application and habitual observation use of newly designed trolley type bags for school children. Additional research can also be conducted on the materials to be used that would benefit

most the user. Further study is needed on the market feasibility of the proposed product, considering not just school children but also widen the target market. Furthermore, the benefactors of the newly designed trolley bags in terms of age range, physical factors should also be identified. Lastly, the quality of the bag overall, the prolonged usage of the bags, the further identification of errors in the bag and the improvement in design and features can be further studied.

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