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Smart Backpack Technologies to Avoid the Musculoskeletal Pain

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Abstract

Back pain is the most common health concern in recent times. Musculoskeletal pain is one of the major problems affecting the muscles and bones of the back body. Bad posture, overuse, injury, jerking-movements, falls, fracture, dislocations, and sprains are the main reason for musculoskeletal pain. In recent times, school children are mostly affected by musculoskeletal pain as bag weight plays an important role in a child's health. Thus, the identification of an optimum back bag is important to overcome the musculoskeletal pain which comes from carrying excess backpack weight. The conventional methods used are not practical to determine the optimum bag weight in real-time as it is a time-consuming analysis. Thus, Smart back bags are introduced to detect the optimum weight to avoid musculoskeletal pain are introduced. In this review, it is found that the technologies developed are capable of determining the total weight of the backpack determine the total weight of the backpack and notification to the user to adjust the bag straps according to the center of mass using the mobile application using different statistical techniques.

Keywords: Smart back-pack; Smart Bag; Back-pack; Back pain; musculoskeletal pain; School bag.

1. Introduction

Back pain is a general and worldwide health concern which affects the aspect of people's lifes and it increases the working disability [1].

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According to the Global Burden of Disease research, back pain is the top cause for lived with disability in many countries [1]. Back pain affects the people of all ages and the conditions commonly linked to back pain are muscle or ligament strain, arthritis, osteoporosis, bulging or ruptured disks and, etc. [5,6]. The lifelong vulnerability of common back pain is estimated at 60% to 70% in industrial countries [2]. Among them, musculoskeletal pain is a common condition affecting the muscles and bones of the back and about 40% of the population have this condition at some point in their life [3]. The factors which depend on musculoskeletal pain are bad posture, overuse, injury, jerking-movements, falls, fracture, dislocations, and sprains [3,4]. But in recent times, school children are most affected by musculoskeletal pain as bag weight plays an important role in a child’s health [18,19]. And also, studies have confirmed that the length of the spine is being affected by school backpack weight [20]. Fortunately, we can take measures to prevent or relieve most of the musculoskeletal pain. Therefore, optimum weight should be identified to overcome the health issues which come from carrying excess backpack weight. There are researchers who have done some analysis to identify the suitable optimum weight [5,7,8]. The suggested load limit value of load carried by school children is 10% to 15% of the child’s body weight [7]. The weight limit of a backpack should be 10% to 15% of a child’s Body Mass Index [5]. Some researchers used a weight measuring scale to determine the weight of the backpack in two different ways, such as measuring body weight with the schoolbag and measuring body weight without the schoolbag to determine the weight of the backpack [8]. However, it is not practical to determine the bag weight and avoid the back pain in real-time due to time-consuming analysis. Therefore, the development of an intelligent backpack which can detect the optimum weight to avoid musculoskeletal pain is vitally important. Recently, innovative technologies were developed by several researchers. Therefore, a comparison of available products and identification of drawbacks are important in developing novel smart bag technologies. Therefore, this paper will focus on the comparison of methods developed for avoiding back pain among school children under laboratory conditions and real-time basis. In this article, a brief discussion on conventional methods used for analysis followed by existing technologies is also discussed. Then, statistical algorithms which were used in the analysis will be discussed.

2. Methodology

2.1. Conventional methods used to analyze the optimum weight

Identification of maximum load limit was done using a back posture monitoring system [14,20]. Here curvature of the different parts of the spine was analyzed with different weights of backpacks and with different positions. The threshold points for the spine pain caused by bending were analyzed and provided the recommended result understandably [14]. The recommended load limit of load carried by school children was 10% to 15% of the child’s body weight [7]. Another set of researchers have studied about the demographic characteristics of schoolchildren, aged 11-14 years [15]. In this study, 454 were selected to analyze the usage of schoolbags and discovered that parental awareness plays an important role in changing the school bag carrying habits of children to reduce the load weight [15]. Another study was done among 13 students and collected their body mass, backpack weight and percentage of backpack weight in body weight. According to this postural assessment, it was concluded that the backpack weight affects the changes in cervical and shoulder posture and advised that carrying 15% of body weight would be extremely heavy for school children, aged between 13 to 16 years [16]. A cross-sectional study was done among government and private school students in the Kashmir valley about back pain and school bag usage [8]. A study was conducted to show the world research productivity in the field of back pain and help the researchers to flow the scientific development and through that promote the cooperation in the back pain field [1]. For that research, the Web of Science database was searched from 1995 to 2016 and many research articles, reports were collected [1]. However, these methods are not practical to determine the bag weight and avoid the back pain in real-time due to time-consuming analysis and they have limitations to adapt the regular monitoring on the real-time basis. Nowadays, these conventional techniques are used to compare the results of smart electronic systems when calibration is required.

2.2. Smart back-pack technologies

Many researchers have focused on making a smart backpack that can measure weight, but they have not made a smart backpack that can display which age people category can be able to carry the weight of the backpack. A backpack which is called “Smart Backpack” developed and that would be able to measure its own weight and the weight can be monitor on a smartphone by an application via Bluetooth and Short Message Services (SMS) [17,12]. It has other utility features such as a power unit, and a proximity sensor [11], GPS system [10,12,17] to find the location coordinates [10]. These were developed using a weight measuring sensor [9], load cell [10,17] and digital weighing scale [11] to measure the optimum weight of backpacks [10,17]. The weight measuring sensor is made of conductive foam and the foam has the property to change the resistance value with compression [9]. They can allow the user to identify the backpack weight by using a mobile phone wirelessly [11]. Notifications/suggestions related to bag positions are given in real-time to reduce the number of backpack related injuries [9]. Time table management system is an added advantage to the smart backpack to avoid adding unnecessary books [12]. Some intelligence bags contain RFID tags [12] and the books, using in these bags contain unique ID [12]. In addition to the system, different varieties of microcontrollers (Atmega [10], Node MCU [10], and etc.) were used to develop the data acquisition system of the smart backpack. Microcontrollers transmit the data to the mobile applications [9], developed by android [9,10] and iOS [11] platform through the wireless technologies (Wi-Fi [10], Bluetooth [9,11]). Swift application has been used in the development of mobile app using the iOS platform [9]. The power unit has been developed using solar panels, rechargeable battery packs [9,10,11] to interface the microcontrollers. Arrays of the sensors were fixed on the back straps of the backpack to measure the weight (Ex. EquiPack) [9]. In this case, the center of mass is determined by a custom developed algorithm in a mobile app [9].

2.3. Validating of the smart bags

The backpack has to be tested in the real-world to ensure the assumptions made while calculating the models are correct and the testing will be conducted when the sensors have been implanted in the actual backpack [9]. A cross-sectional study was conducted about the use of school bags and the prevalence of musculoskeletal symptoms among 307 Iranian primary school children [7]. Multiple logistic regression models indicated that the method of carrying the schoolbag was significantly associated with hand/wrist and shoulder symptoms, and that the time spent carrying a schoolbag was associated with hand/wrist and upper back symptoms [7]. Testing has been done with several data [17]. 90 % of accuracy has been provided as a result of this testing.12V 1.3Ah lead acid battery was used to power up the back-pack and the battery worked up to 18hours with a fully charged capacity. Then, a power supply mechanism has been added to optimize the battery usage and it is taken 1-2 hours to charge fully with a supplied adapter [10].

3. Data Analysis

A proper data processing algorithm has been developed in the mobile app to determine the total weight of the backpack and center of mass of the backpack, and to notify the user to adjust the bag straps according to the center of mass [9]. Data analysis of studies have been done using Microsoft Excel (2007) [8] and SPSS software (version 11.5 ,14, 20) [1,7,8,15]and Chi-square test [8], Spearman's test [1] and fisher's exact test [15] were performed to analyze the data statistically. Bullet (Open-source physics engine) was used to analyze the active forces as it simulates collision detection as well as soft and rigid body dynamics [9]. Two-way analysis of variance (ANOVA) and Tukey's tests [7] had been used for the continuous variable evaluation [7]. Multinomial Logistic Regression analysis has been used to evaluate the relationships between prevalence rate and severity of musculoskeletal symptoms [7]. Two-step hierarchical logistic regression analysis [7] was used to estimate the association between dependent variables and independent variables. Odds Ratio (OR) and Confidence Interval (CI) were calculated from the relevant multiple logistic regression model and Hosmer-Lemeshow goodness-of-fit test was used to analyze the fit of each of the logistic regression models [7].

4. Conclusions

Musculoskeletal pain is the most common health concern, which comes from carrying excess backpack weight among school children. Prevention of these problems is vitally important for a healthy future generation. Therefore, finding optimum bag weight is crucial to maintain healthy lives in the future. In this review, the methods developed for avoiding back pain among children are discussed. The developed smart bags consist of a weight measuring sensor, power unit, proximity sensor and GPS system. The response of the sensor is used for the statistical analysis for the finding of bag weight and preventing the placement of unwanted books. The results obtained are sent to the user mostly using Bluetooth and short message service technologies. However, current systems developed require a deeper understanding of the following perspectives for further development. All the studies have been conducted under controlled conditions. Finding optimum bag weight depends on several features of the child, such as age, gender, height, weight, heart disease and, etc. Therefore, the future smart bag should be able to predict the optimum weight according to that features. Thus, machine learning technology should be incorporated during the prediction of optimum bag weight to prevent the pain. In recent times, the Internet of Things (IoT) is mostly used to collect and transfer data over a wireless network without human intervention. Therefore, IoT technology is the best way for monitoring and prediction purposes.

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5. Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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