A Healthy Childrens Backpack Product for Childrens Spine Development

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Abstract. There is an urgent need for an effective auxiliary tool to help parents detect spinal development in children who have difficulties in spinal development detection. In this article, we introduce the concept of integrating a sensor with a backpack and discuss practical advice on developing a child's spine to enable parents to understand the development of the child's spine. The backpack includes hardware and software applications with sensing technology that can collect real-time data and connect to the hardware device for display. And tested children's backpacks through target users to help parents understand the potential of children's spine development in time.

Keywords. Health products, Spine development, Sensors, Children

For children who have carried the backpacks in this paper, parents can understand the problems of children's spine development and pay attention to the problems of children's spine development. To evaluate our conceptual system, we created an initial prototype and conducted user research in semi-structured interviews. The findings suggest that backpacks are a promising tool as a foundation for parents to understand their children's spine development conservation education. In the application scenarios from preschool to university and even more, backpacks have become a habit of people. At the same time, due to its ubiquity and popularity, special attention should be paid to carrying backpacks, as various studies have shown its negative consequences, many people believe that the appearance of bags is more important than their function, and many people place heavy objects in backpacks. Health of the spine. The health of the spine in children and adolescents is especially important as they go through a period of physical development. In addition, carrying a schoolbag for long periods of time has been reported as a major and common factor in back pain. Because back pain in childhood and adolescence is considered a significant cause of back pain in adulthood, it is important to study its risk factors to prevent back pain. In fact, children with low back pain blame heavy school backpacks, as well as biomechanical factors, such as the characteristics of school bags, traditionally associated with back pain in children and teens. These data reinforce the notion that spinal health problems such as low back pain and back pain among school-aged children are very common in our lives. Studies have shown that heavy backpacks can lead to muscle problems in the neck, shoulders and back, such as scoliosis. Growing

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children use backpacks for a lot of time, and backpacks have a great impact on children's spine development and health.

1. Introduction

Screening of children's spinal deformities and early diagnosis is not a new global problem, but with some reports of poor physical development in adolescents, the problem of high incidence and severity of children's spine has become increasingly prominent, and children's spine development is a global concern, many children have problems with the development of the spine, the incidence of spinal deformities in children is alarming, partly caused by the current lifestyle of children, families and the whole community, poor posture of children's spine can damage the respiratory system and thus the central nervous system, May cause memory and learning disabilities in young adults. As one of the ways for children to transport items, backpacks are widely used in life. However, 49% of students with low back pain carry backpacks in the wrong way, and the probability of causing low back pain is 1.83 times that of correct carrying. The impact of backpacks on the health of adolescents has gradually been paid more and more attention by researchers. Related research mainly focuses on the effects of different backpack loads, weight-bearing positions, and backpack methods on adolescents' body balance, body posture, and gait. Studies have found that adolescents' rapid growth and development, poor backpack posture, and excessive weight-bearing can cause problems in adolescents' posture and posture. Likewise, these inappropriate habits during childhood increase the chances of developing spinal problems in children. Therefore, this paper comprehensively studies the influence of children's backpacks on children's spine development, explores the relationship between backpacks and children's spine morphology, evaluates children's spine posture when backpacking, and studies the impact of related behaviors on spine development, so as to provide reference for the prevention of children's spine development problems, to provide a theoretical basis for reducing the incidence of spinal diseases.

The use of backpacks is one of the factors that cause musculoskeletal diseases in children. Heavy backpacks can affect the changes in children's body posture and harm children's spine and musculoskeletal problems. The burden of a school backpack is a risk factor for back pain, symptoms that can persist into adulthood. Backpacking often contributes to the development of the neck, shoulders, lower back and other potential risk factors, and early detection of problems in children's spine development is necessary for children to maintain musculoskeletal function. Stamenka Mitova believes that early detection, correct diagnosis, adequate treatment and rehabilitation, prevention, and appropriate active exercise routines can prevent the adverse effects of postural disorders and spinal deformities and ensure smooth functioning of the adolescent body [1]. Scoliosis, also known as scoliosis, refers to the lateral curvature of the human spine into an S shape or a C shape. When the spine bends more than 10 degrees to one side, it is called scoliosis, usually between 10 and 18 years old. Occurs during skeletal development, mild scoliosis generally does not have many symptoms, but if the scoliosis continues to deteriorate if it is not treated in time, severe scoliosis (over 70 degrees) may cause back pain, difficulty breathing, and compression of the internal organs, affecting the patient's life, and even life-threatening [2]. Body posture is a key aspect of spinal health. Prolonged use of poor posture can lead to changes in spine morphology, lower back pain, and related musculoskeletal disorders, while posture habits established in

childhood and adolescence often persist until adulthood [3]. Wang Jia et al. studied the effect of backpacks on the health of school-aged children's cervical vertebrae posture under different load conditions, and provided a reference for guiding children and adolescents to form a healthy body shape [4]. Zhu Houwei et al. explored the influence of different backpack weights and backpacking methods on the body posture of children when backpacking [5]. Zhang Qiuxia proposed the relationship between backpack and healthy posture [6].

In this paper, we introduce a backpack, an interactive system for the detection of children's spine development based on sensor technology, consisting of a hardware backpack and a software program. When the user interacts with the backpack, the user can understand the child's spine development through the data detection of the supporting app. The bottom of the backpack is designed with a weighing function. If the weight of the schoolbag exceeds 10% of the body weight, a red reminder will be displayed on both sides of the backpack, otherwise it will be green to represent safety, and the data will also be transmitted to the APP software for reminder.

To study this backpack, we conducted research discussions with experts and developed a design prototype, and in order to assess what parents and children think about this backpack, we conducted a preliminary user study. The results show that parents and children are willing to use this backpack in life, and believe that using this backpack in real life is very useful for children's spine development and health, parents gain more peace of mind, children gain health, and product use Figure 1. The main contributions of our work are:

- We designed an interactive system, including a backpack and a software application, to enhance real-time feedback from parents on the healthy development of the child's spine, as well as explain the child's spine development considerations.

- We propose a method to detect children's misbehavior during the development of children's spine and prevent the emergence of children's spine development problems.

- We further derived knowledge about normal spine development in children through prototype interviews and semi-structured interviews.

Figure 1. Product usage diagram

2. Related Work

2.1. Children's spine development support

Previous work has confirmed that children's spine development support tools can effectively improve the quality of children's spine development health. Due to its importance, many support methods to help children's spine development and health have been proposed. For example, the utility model patent proposed by Cao Qing belongs to the field of electronic technology, and provides a detection belt for preventing scoliosis and kyphosis. There is a sensing mechanism inside to detect compressive stress and tensile stress, and a processor is used to compare the sensing The detection signal transmitted by the agency determines whether the human body has problems such as hunchback and scoliosis. If there are these irregular sitting postures, the alarm will remind [7]. Huang Xiuqiong proposed a utility model patent for a spinal correction and rehabilitation device for children. It adopts high-strength resin material, which has high density, uniform force, and is not easily deformed. Local adjustment and application of force, targeted to play a fixed and supportive role on the wearer's spine, can be adjusted according to the wearer's development, suitable for children in the development process [8].

    In addition, they are insufficient in improving the health of spine development for children, ignoring the problem that parents do not understand the knowledge of children's spine development and health. For this reason, this article explores the possibility of parents learning and paying attention to children's spine development, so that parents can better care for and care for children's spine health problems. Children with high and low shoulders, the spine will bend and skew to one side of the body when standing, etc. The incidence of scoliosis is hidden and difficult to detect in the early stage. Many parents easily ignore the children's spinal problems. The incidence of scoliosis among adolescents in my country has reached 2%-3%, Scoliosis often deteriorates rapidly during the peak development period, causing physical deformities, pain, and difficulty breathing in children. In severe cases, it may lead to paralysis. Scoliosis needs early detection. Early diagnosis, treatment and prevention are very important. Regular spinal Health assessment and rehabilitation.

2.2. Backpack Design

The design of children's backpacks and the incorrect use of backpacks are one of the musculoskeletal diseases caused by children. Heavy backpacks can affect changes in children's body posture, injure their spine and musculoskeletal problems, and backpacks that exceed 15% of the backpacker's weight can cause exponential damage to the body. Studies have shown that carrying more than 10% of body weight in a backpack also results in a shallower lumbar lordosis and a tendency for the sacrum to assume a vertical position [9], which may increase the curvature of the upper thoracic thrust and move the head forward, resulting in a posterior thoracic spine. Flattening of convexity and flattening of curvature may lead to increased forces affecting the spine and decreased spinal biomechanical endurance, which are risk factors for scoliosis. In addition to the weight of the bag, the type of bag and the carrying time, as well as the position of the schoolbag on the back of the school children also affect the occurrence of back pain [10]. Therefore, we combine the health of children's spine development with the backpack.

When the user's backpack is more than 10% of his body weight, a warning will be issued. The backpack is equipped with sensors to detect children's spine development and health.

3. Design process

To design and build the backpack, we first spoke with experts in a design exploration session. In this section, we describe the design process and the resulting design goals.

3.1. Design discussions with experts

We conducted a preliminary study with 4 children's health experts (2F, 2M, average age = 38, P1, P2, P3, P3) from Guangzhou Children's Hospital, China, who have more than 5 years of experience in children's spine health and relevant education. Each design exploration session lasts approximately 90 minutes and includes presentation of our initial ideas and related research, discussions with experts, sharing their relevant experiences with children's spine health, and sharing their views on our backpack design prototype related semi-structure interviews. They all agreed with our starting point of "promoting the healthy development of children's spine", and put forward the following suggestions:

- P1 and P2 suggested that when there is a problem in children's development of the spine, they should correct it in time and give feedback to the parents or the child;

- P2 and P3 revealed that, many parents have not understood the health problems of children's spine development, lack of theoretical knowledge, and are at a loss when facing the problems of children's spine development.

- P2 recommends that we control the weight of the backpack to be less than 10% of the backpacker's weight.

- P4 recommends that we vigorously publicize school children and related personnel to carry as few items as possible in children's school backpacks.

3.2. Design goals

According to our design discussion meeting with experts and related preliminary work, we have synthesized the following key goals to support parents to understand the interactive system of children's spine development and health:

- Real-time feedback to avoid problems that affect children's spine development and health. The situation occurs; real-time detection of the weight carried by the backpack does not exceed 10% of the child's weight, notification and warning when it exceeds; real-time detection of the development and health of the child's spine.

- Understanding of relevant knowledge, allowing parents to pay attention to the health problems of children's spine development and related prevention knowledge, etc.

- Health inspection, the backpack is set up to detect the health of spine development, real-time detection of problems and detection problems, APP program matching Spine health doctor allows users to have some basic understanding and consultation on spine development.

- Considering the interactive relationship between the backpack and the healthy development of the children's spine at ordinary times, the material of the backpack, the comfort, the lightness, etc., because it involves the health of the children's spine development.

4. System description

Based on design exploration with experts, we developed a prototype backpack. The backpack consists of hardware and software. Hardware refers to backpacks with functions such as spine pressure detection, strength point health, spine health, and self-weighing. The software is an application that provides health data analysis and provides real-time spine condition feedback and knowledge about spine health. The software and hardware are connected through Bluetooth, as shown in Figure 2.
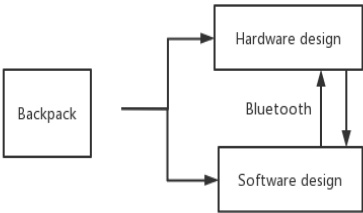

Figure 2. Conceptual Framework of the Backpack

4.1. Application

Parents can use the application (APP) to select the opening of the backpack detection mode. In addition, the application is used in conjunction with the backpack, and it is used with instructions when using it. The APP is divided into 5 parts, the first part is the home page: in this part, some knowledge related to children's spine development and health will be pushed; the second part is the discovery part: in this part, you can see other families' information about spine development and health .The third part is the "＋" part: in this part, you can click the "＋"symbol to share your own experience; the fourth part is the consultation part: in this part, an exclusive chiropractor will conduct Health consultation; the fifth part is my part: in this part, you can see the personal information related to the use of the backpack, the spinal health test report and so on. At the same time, when the child is using the backpack, the APP will display the reminder of the child's spine condition and problems in real time according to the child's usage. For example, if a child packs too many items in the backpack, the backpack recognizes that the situation is not conducive to the healthy development of the child's spine, it will send a signal to the app, which will display real-time reminders of the problem and suggestions for correction. The interface design of part of the APP is shown in Figure 3.

Figure 3. APP interface of the backpack part (a) Personal information (b) Usage time and weight (c) Consultation questions (d) Health report

4.2. Backpack

In order to measure the weight of the schoolbag more accurately, we added a load cell at the bottom of the schoolbag. When you place the schoolbag on a stable surface when using the schoolbag, the backpack will weigh itself, as shown in Backpack design (a), and perform data processing operations. Then pass it to the APP software program. When the weight of the backpack exceeds 10% of the body weight, the schoolbag will issue a red warning, and the APP software program will also issue a warning, otherwise it will be green, as shown in Backpack design (b). A sensor is installed on the back of the backpack to detect compressive stress and tensile stress. The processor is used to compare the detection signals transmitted by the sensing mechanism to determine whether the human body has hunchback, scoliosis and other problems, as shown in Backpack design (c). If these irregularities are found When posture, the alarm will remind. The detected schoolbag weight and spinal health data will be transmitted to the APP software in real time. Parents can understand the health of children's spinal development through data analysis. The software will also provide relevant knowledge instructions such as precautions and preventive measures, as shown in Backpack design (a) and Backpack design (b).

Figure 4. Backpack design (a)Backpack design (b)Backpack design (c)

5. Relevant user research

To confirm children's use of backpacks and how parents and children feel about backpacks, we conducted preliminary user studies. We recruited 4 parents A, B, C, D (2F, 2M, Mean age = 28) from the local community. All participants (PA, PB, PC, PD) learned basic knowledge of children's spine development and health through the Internet and other channels, and the whole process was recorded with the consent of the participants.

5.1. Procedure

The experiment was conducted in a room. First, we briefly introduced and explained the backpack. Then, the participants had 1 hour to use the backpack independently. During this 1 hour, participants were observed. Upon completion, participants are encouraged to take the backpack home and continue to use it for a week. After the use, we explored the participants' perceptions of the backpack in the form of a questionnaire and conducted semi-structured interviews, focusing on three questions:

- their interactions and problems with the backpack.

- Any suggestions for backpacks.

- The difference between ordinary backpacks on the market and this backpack.

5.2. Results

As shown in Table 1 on the Likert scale, all participants showed a high willingness to use the backpack. However, they have different opinions on the detection of children's spine, for example: the 5-point PA of question c tells us that the detection of the weight of schoolbags can make us pay more attention to not let children's backpacks become overweight in life, and prevent overweight schoolbags from affecting children's spines development. PC scored 4 points in question d. He believes that when we make an incorrect operation, we should not only make a reminder, but also make an intervention behavior. All four participants pointed out that the weight test of schoolbags is helpful for children's spine development.

Table 1: Survey results from parents

Question	PA	PB	PC	PD	Average
a. Would you like to use this backpack? (1: not willing -5: willing)	5	5	5	5	5
b. Is it easy for you to understand how to use this backpack? (1: difficult-5: easy)	5	4	4	5	4.5
c. Does the weight test of the backpack help children's spine development and health? (1: useless -5: useful)	4	5	4	5	4.5
d. Remind you when you make an incorrect operation? (1: useless -5: useful)	5	5	4	5	4.75
e. After using this backpack, are you confident in solving the health problems of children's spine development (1: no-5: yes)	5	5	5	5	5

When the participants were asked what they thought about the backpack, the PA said: "I think this backpack is very meaningful to use, it is also very comfortable for children to carry, and the experience is very good." PB said, "I think he is like a private chiropractor. I can know about spinal problems at any time, and get real-time feedback and attention." Similarly, the participants are also full of expectations for the follow-up work of the backpack, and also gave us some Suggest. Both PC and PD hope that the backpack can be lighter and smarter in the future.

6. Limitations and future work

We found some shortcomings in our research. First of all, due to the impact of the epidemic, we only have 4 experts as representatives of children's spine development and health knowledge. If more experts join, we may gather more knowledge about the development and health of children's spine. Secondly, there is not enough time for users to experience, and there is a lack of users' long-term use and feedback on the backpack.

the future, we will further improve the design of backpacks and applications. It is necessary to determine the characteristics of the goods that students usually carry , to understand the impact of the same load backpack on the spine, and to expand the coverage of children's spine development health detection and prevention. Optimize the performance and indicators of the sensor, and apply more "micro-feedback" to the backpack, so that users can better understand their spine health. The backpack will also be considered with more functional components.

7. Conclusion

In this article, we introduce a backpack that can help parents and children understand the health and development of the spine. The backpack provides real-time feedback and correction based on the behavior of the children's backpack, allowing them to correct the behaviors that are not conducive to the healthy development of the spine in time. According to user research, backpacks can allow parents or children to understand the child's spine development in a timelier manner and give correct attention and prevention to this, which is conducive to the healthy development of children's spine. Compared with the existing products on the market, our backpack can measure the weight of the backpack, control the weight of the backpack to not exceed 10% of the body weight, detect the situation of the child's spine in real time, and give real-time feedback and error correction reminders, so that Child users learn about the behaviors that are not conducive to the healthy development of the spine and make timely adjustments, which is beneficial to the healthy development of the child's spine.

8.Acknowledgments

References

[1] Mitova S. Frequency and prevalence of postural disorders and spinal deformities in children of primary school age[J]. Research in Kinesiology, 2015.

[2] Jiang Hui. Bend over, hunchback, and crooked sitting posture? It may be caused by scoliosis [J]. Medical Food Reference, 2022(1):1.

[3] Han Xu. Research on risk factors related to postural spine morphology change in adolescents and children [C]. 2018 Chinese Physiological Society Exercise Physiology Professional Committee Meeting and "Science and Technology Innovation and Exercise Physiology" Academic Symposium. 0.

[4] Wang Jia, Wang Jie. Effects of backpacks with different loads on posture health of school-aged children [J]. China School Health, 2020, 41(9):3.

[5] Zhu Houwei, Shi Shusheng, Shen Cuimei, et al. The influence of backpack weight and backpack style on children's body posture [J]. Chinese Journal of Sports Medicine, 2019(8):11.

[6] Zhang Qiuxia. Scientific backpacks make children healthier [J]. Popular Medicine, 2019(2):1.

[7] Cao Qing. A detection tape for preventing scoliosis and kyphosis: CN211325054U[P]. 2020.

[8] Huang Xiuqiong. A spinal correction and rehabilitation device for children: CN213098570U[P]. 2021.

[9] K. Walicka-Cupryś, R. Skalska-Izdebska, M. Rachwał and A. Truszczyńska, "Influence of the Weight of a School Backpack on Spinal Curvature in the Sagittal Plane of Seven-Year-Old Children", BioMed Research International, vol. 2015, pp. 817913.

[10] WR Guessogo, "Effect of Schoolbag Weight on Musculoskeletal Pain among Primary School Children in Yaounde Cameroon: A Crosssectional Study", Int J Med Students, vol. 8, no. 2, pp. 96-101, Aug. 2020.