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KYPHOTONE: Wearable Hunchback Corrector for Women

Yousheng YAO [ab,*], Yuan XIE [a,*], Fangtian YING [b,1], Zhihao HUANG [a], E TANG [a], Xiqin PAN [a], Junpeng ZHENG [a], Junqi ZHAN [a], Jin PENG [a], and Haoteng CHEN [a]
[a] *Zhongkai University of Agriculture and Engineering*
[b] *Macau University of Science and Technology*

Abstract. In human-computer interaction, there is a close relationship between "beauty" and empowerment. Aesthetics in human-computer interaction is not only about pursuing external beauty and visual appeal, but also about empowering users with better experience and functionality, and enhancing the capabilities of the interaction system, thereby improving user satisfaction and efficiency. In the real world, wearable testing systems are becoming increasingly popular for autonomous health testing. Hunchback is a problem that is detrimental to healthy growth and self-confidence. In this article, we introduce KYPHOTONE, an interactive system that can help hunchbacked women with their hunchback problems, designed for women. We analyze the materials, anthropometric measurements, and garment assembly of KYPHOTONE. KYPHOTONE consists of hardware and software programs. The hardware and software are utilized to provide real-time feedback based on the movements of women with hunchbacks during the wearing process, enabling real-time medical diagnosis, correction detection, and correction management. In addition, we conducted a preliminary user study of KYPHOTONE, which showed that women with hunchbacks are willing to wear it, which gives them more confidence in preventing hunchbacks.

Keywords. Sensor devices, hunchback correction, human-computer interaction, female design

1. Introduction

In human-computer interaction, aesthetic empowerment should not just be an empty pursuit of beauty, but is combined with the realization of functions. Through rational design and innovative interaction, aesthetics can make functions more intuitive and easy to use, providing a better user experience. Women are often excluded from the design process of wearable sensors due to the need for real-time biosignal detection systems. KYPHOTONE addresses the problem of atypical anthropometric measurements in the development and validation of current wearable technologies. This paper presents KYPHOTONE, a wearable female hunchback corrector based on sensing technology, including hardware and a software program with real-time feedback. When interacting with KYPHOTONE, the user determines whether she is hunchbacked or not through data

[*] The first two authors contributed equally to the article.

[1] Corresponding author,Ying Fangtian, Macau University of Science and Technology, Avenida WaiLong, Taipa, 999078,Macau,13067848819@163.com.

analysis and feedback from the hardware, and if she is hunchbacked, KYPHOTONE alerts the user through vibration. A three-step investigation was conducted through an iterative and innovative design process:

- Using current and past wearable devices for hunchback correction, we identified the unique design challenges associated with non-ideal models, this is especially relevant to women who have breast tissue to deal with.
- Following step 1, we identified design prototypes and iterations of design prototypes to determine optimization aspects of the hardware that have achieved accuracy in sensor data detection.
- A path forward for future research in this area is provided based on the results of design validation with four female participants.

2. Motivation and related work

2.1. hunchback corrector

The condition of hunchback is a habitual chronic disease, and body posture is an important factor in spinal health. As a result of prolonged poor posture, spinal morphology may change, lower back pain may develop, and musculoskeletal disorders may occur [1]. Known also as scoliosis, scoliosis is a lateral curvature of the spine in the shape of an S or C. When the spine is curved to one side more than 10 degrees is called scoliosis, and usually occurs at the age of 10 to 18 years old, If not treated in time, minor scoliosis generally does not have too many symptoms. However, if not treated in time, scoliosis may worsen. Severe scoliosis (more than 70 degrees) can lead to back pain and breathing difficulties. If scoliosis continues to worsen without treatment, severe scoliosis (more than 70 degrees) can lead to back pain, breathing difficulties, and compression of internal organs, affecting the patient's life and even becoming life-threatening[2]. With the continuous development of information technology, intelligent wearable device systems can be continuously enhanced and widely used in the fields of physical therapy health, and rehabilitation. Concepts such as telemedicine and telerehabilitation have emerged to assist patients in getting rehabilitation advice and physiotherapy information daily. This will also be one of the future directions of smart development in the field of treating female hunchbacks. There are various correction products on the market, such as Deng Yongcong proposed a utility model patent: a hunchback correction belt with intelligent reminder against strangulation [3]. Zhang Li proposed a utility model patent: a hunchback corrector with a detachable support structure, which provides a hunchback corrector with a detachable support structure to remind users to change their posture by vibration or sound, and the correction induction host and support structure can be easily detached and portable [4]. Luo Guanqiong invented a corrective apparatus for hunchback [5].

For women with a hunchback, a series of hunchback correction devices have been introduced in the market, mainly two categories of physical sitting posture correctors and intelligent hunchback correctors, as follows:

(1) Physical hunchback braces

Physical hunchback braces are inexpensive, mainly of human frame type, and are mandatory corrections. Often, when using such hunchback braces, the human body

cannot operate other things, which generally have the defects of poor independence, inconvenient carrying, poor stability, low convenience of use, and no social attributes, and are not suitable for correction in daily life, and the correction effect is short and effective.

(2) Intelligent hunchback correction device

Smart hunchback corrector has a wearable, seat and writing pen, etc. It uses the principles of gyroscope, intelligent acoustic wave, and infrared ray, and adopts intelligent voice prompts, light prompts, or vibration prompts to urge correction of hunchback posture, which is more comfortable than physical sitting posture corrector, but it also lacks social attributes, and the hunchback corrector on the market often ignores anthropometric considerations of female body shape.

Smart clothing is an organic combination of many scientific fields such as traditional textile and clothing technology, fiber forming and processing technology, information sensing technology, communication technology, artificial intelligence, and biotechnology [6]. KYPHOTONE in this paper is a wearable smart clothing component that integrates advanced technology sensors into the garment and considers the female user's body structure in the design to achieve functionality and socialization.

2.2. Human structure design considerations

The failure to take into account anatomical differences between men and women has long plagued many industries. The term female is used to denote a female human (only for humans can it be called “female”), in contrast to a male human (i.e., male), who can produce egg cells in the body. The term female is used to denote a biological gender division or a cultural gender role. In contrast, the term "male" is defined as an individual who lacks the anthropometric characteristics associated with being female due to low or reduced levels of estrogen and progesterone. This definition is not limited to the gender of the individual but is also strictly limited to physical characteristics. Many garments are designed primarily for men and then modified for women. [7] This dissertation study aims to change this paradigm and suggests that female anthropometry and unique anthropometric differences be placed at the forefront of design.

3. Design Process

To design and develop KYPHOTONE, we first conducted design exploration sessions with experts. Here we described the design goals that emerged during the design process.

3.1. Design exploration with experts

We conducted a preliminary study with four spine specialists (2F, 2M, mean age = 38 years, P1, P2, P3, P4) from Guangzhou City, Guangdong Province, China, who had more than 5 years of experience and education in hunchback health care. Each design exploration lasted approximately 60 minutes and consisted of our initial ideas, a discussion session with experts who shared their previous experience in treating hunchbacks, and a semi-structured interview with their perceptions of the KYPHOTONE design prototype. They all agreed with our starting point “There is a real need for a wearable hunchback brace for women” and suggested the following: (1) P1 and P2 suggested that women's hunchbacks should be corrected in time to avoid further health

problems. (2) P1 and P3 reveal that although many women are aware of the problem of their hunchback, it is difficult to correct it. (3) P2 and P4 suggested that we should provide timely feedback on women's hunchback problems and visualize the hunchback data.

3.2. Design Objectives

Based on our design exploration sessions with experts and related preliminary work, we synthesized the following key objectives for a wearable female hunchback orthosis: (1) Real-time feedback during exercises that allow users to demonstrate hunchback behavior. (2) To display female hunchback correction data and spinal development data in a visual way so that users can understand the data more clearly.

4. KYPHOTONE Design

4.1. System Description

Based on design discussions with experts, we developed a prototype of KYPHOTONE, which consists of hardware and software. The hardware is a module with clothing, a posture detection module, a vibration warning module, and an energy supply module. The software is an application that provides real-time data feedback. The software and hardware are connected through a WIFI, as shown in Figure 1. The application is divided into four parts. The first part is the home page, where other users and experts can share their hunchback problems and communicate with each other. the second one is Discover, in which you can share your situation; the third one is Insights, in which you have a dedicated doctor for health consultation; the fourth one is Profile, in which you can see your personal information such as your hunchback health test report. The interface design of some parts of the application part is shown in Figure 2(a), Figure 2(b), Figure 2(c), and Figure 2(d).

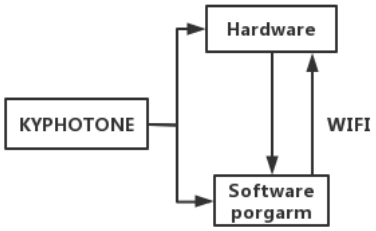

Figure 1. KYPHOTONE's conceptual framework.

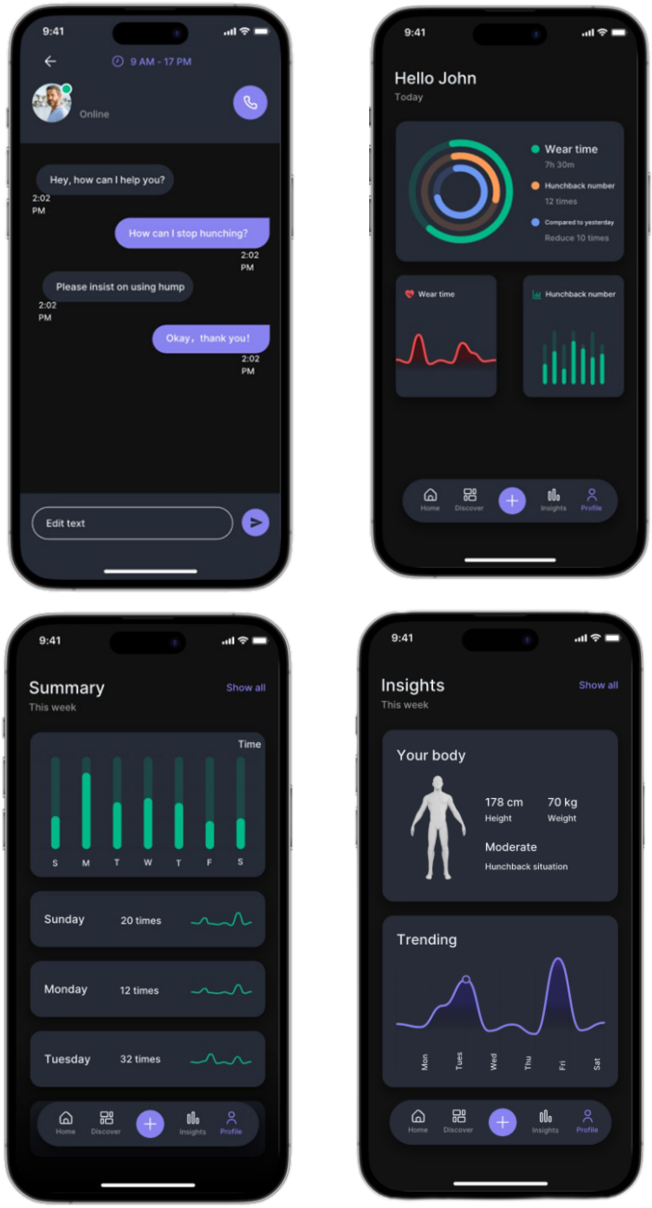

Figure 2. (a)User interface to ask questions to doctors (b)User Daily Camelback Data (c)User Weekly Camelback Data(d)User personal information interface

4.2. Requirements and User Experience

Researchers have made great strides in developing stylish, user-friendly systems where high-quality data detection is critical for hunchback identification and correction. The challenge for designers was to balance performance and form capabilities to make KYPHOTONE socially wearable. KYPHOTONE is a design solution for female-centric, real-time monitoring. When designing a wearable system for physiological signal

collection, certain requirements of the overall system needed to be met in order to achieve a successful design that was both functional and aesthetically pleasing. When designing wearable systems for physiological signal collection, certain requirements of the overall system need to be met in order to achieve a successful design that is both functional and aesthetically pleasing [8]. These requirements are continuous data collection, unobtrusive design, easy data access and interaction, comfort, electronic durability, and reliability [9, 10, 11]. The challenges posed by these requirements are intuitive user interfaces, and privacy control and fit. During the development of KYPHOTONE, our main focus was on fit, signal quality, accessible electronics, and repeatability. Each aspect of the garment is specifically selected and validated to maximize each area of performance and create a total garment that meets the needs of the wearer. Our approach emphasizes the importance of innovative, iterative design methods to maximize performance in all areas. In developing effective women's undergarments, we identify areas of improvement that can be iterated upon, and these design iterations address the interface between the user and the sensor to meet the user's needs with the user's experience.

4.3. Sensors

The ten-axis posture sensor (Guangzhou Starwing Electronic Technology Co., Ltd.) used in KYPHOTONE is 1.5 cm square in size, as shown in Figure 3, and the posture sensor data test page is shown in Figure 4. This sensor integrates a three-axis angle, a three-axis gyroscope, a three-axis magnetometer, a three-axis acceleration, a quaternion, barometric pressure value, and a poster height expansion port, and the serial port directly outputs the posture angle, acceleration, angular velocity, magnetic field, barometric pressure and other data, easy to use.KYPHOTONE includes intelligent reminder hardware, said intelligent reminder hardware includes a motherboard, a key switch electrically connected to the input side of the motherboard and a USB external charging port, an angular sensing module electrically connected in both directions to the motherboard, a vibration reminder module, a charging module, and a WIFE transmission module, and through the posture sensing module promptly senses that the After the user produces a certain degree of inclination due to incorrect posture, the main board controls the vibration reminder module to remind the user to change the posture, and after restoring the normal state, the angle sensing module senses that the user is in the correct posture and stops the vibration reminder module vibration, so it can correct the wearer's irregular posture in a timely manner, and prevent the hunchback.

KYPHOTONE undershirt is designed to take into account the wearing comfort of women's compression garments as well as to take into account the maximum prevention of effects such as affecting the sensor data detection. The human body is not constantly in motion, it will submit to the requirements of the sensor system and user experience, requiring the ease of use, comfort, and localizability of the garment, the most comfortable and inconspicuous location of the sensor, and the accuracy of data detection is the center of the back.

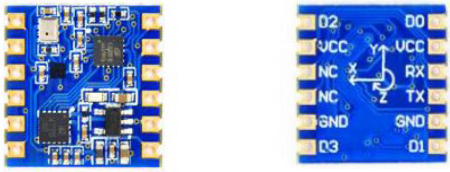

Figure 3. Positive and negative side of the posture sensor

Figure 4. Posture sensor data test page

4.4. Wearing style

Traditional women's bras are worn from the overhead pull type, but considering that KYPHOTONE is required with sensors, the comfort of two closure methods (front zipper and front snap) was tested to prevent the overhead pull type from interfering with the sensor data detection. Initially, the front zipper was chosen as the closure method, as shown in Figure 5, which allows the user to put on and take off the undershirt by themselves, but it was found that the clothing with zipper comfort type was not high, as well as would interfere with the sensor signals. The second design iteration, shown in Figure 6, utilized a front snap closure, which was easier for the user to put on and take off on their own with less obstruction, and was a better design choice. The third iteration of the design, shown in Figure 7, is based on the second iteration of the design, with an additional adjustment strap to make the undershirt fit the body better and the sensors more stable.

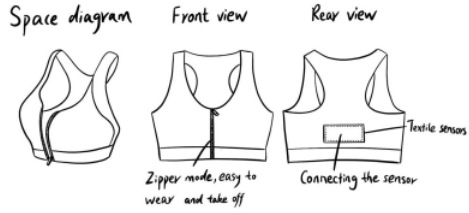

Figure 5. Concept sketch of the first iteration of KYPHOTONE

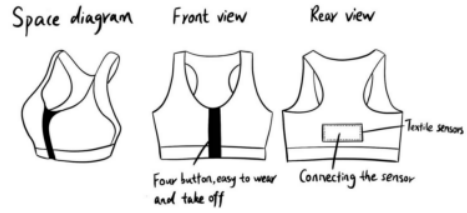

Figure 6. Concept sketch of the second iteration of KYPHOTONE

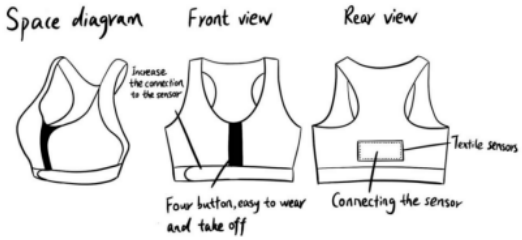

Figure 7. Concept sketch of the third iteration of KYPHOTONE

4.5. KYPHOTONE

In terms of the structure of the undershirt, the electronic components such as the smart correction component, control circuit board, and signal output module are designed as a template placed on the inside of the undershirt, and this module can be disassembled to facilitate later finishing such as washing and cleaning of the undershirt. While considering the aesthetics, we emphasize the comfort of the smart correction electronics in the design of the undershirt, and the undershirt meets the ergonomic requirements of women. The final KYPHOTON undershirt with integrated sensors, electronics, and closure mechanism is shown in Figure 8.

Figure 8. KYPHOTONE physical picture

5. Initial user research

To identify how women interact with KYPHOTONE and their perceptions of KYPHOTONE, we conducted a preliminary user study. We recruited 20 hunchbacked females (P1, P2, P3, P4,P5, P6, P7, P8,P9, P10, P11, P12,P13, P14, P15, P16, P17,P18, P19, P20) from the local community (mean age = 25 years). So the participants were taught how to use and introduce KYPHOTONE through our training, and the whole process was recorded with the participants' consent.

5.1. Procedures

The experiment was conducted in a classroom. First, the KYPHOTONE was briefly introduced and explained for use, and then participants were given 1 hour to use the KYPHOTONE for independent use. During this 1 hour, participants were observed. Upon completion, we encouraged participants to take the KYPHOTONE home and continue to use it for one week. After use, we explored participants' perceptions of the humpback corrector based on a questionnaire and conducted semi-structured interviews focusing on three questions:(1) Their interactions and problems with the back

KYPHOTONE. (2) Any suggestions for KYPHOTONE. (3) Differences between common back hump correctors on the market and KYPHOTONE.

5.2. Results

As shown in Table 1 Likert scale, all participants showed a high willingness to use KYPHOTONE. However, they had different opinions about female hunchbacks, for example, P4, who scored 5 in question c, told us that the hunchback detection can make us hunchback less often and make our female form and health better.P3, who scored 4 in question d, believed that it is more effective to not only make reminders, but also intervention behaviors when KYPHOTONE detects our hunchbacks. And all 20 participants pointed out that KYPHOTONE is helpful and a good experience and socialization for women with hunchback problems.

Table 1. Questionnaire results for hunchbacked women

Question	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**	**P10**	**P11**	**P12**	**P13**	**P14**	**P15**	**P16**	**P17**	**P18**	**P19**	**P20**	**Avg**
a. Would you like to use this KYPHOTONE Hunchback Corrector? (1: No - 5: Yes)	5	5	5	5	5	5	4	5	5	5	5	5	4	5	5	5	5	5	5	5	4.9
b.You can easily understand how to use this KYPHOTONE Hunchback Corrector? (1: Difficult - 5: Easy)	5	5	5	5	4	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	4.9
c. Does KYPHOTONE Hunchback Corrector help to correct hunchback in women? (1: Not useful -5: Useful)	5	4	4	5	5	5	4	5	5	5	4	4	5	5	5	5	5	4	5	5	4.7
d. Is it useful to remind KYPHOTON when you are hunched over? (1: Not useful - 5: Useful)	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	4.9
e. After using this KYPHOTON Hunchback Corrector, do you feel confident in correcting your hunchback? (1: no-5: yes)	5	4	5	5	5	5	4	5	5	5	4	5	5	5	5	5	4	5	5	5	4.8

When participants were asked about their opinions on the humpback corrector, P1 said, "I think the humpback corrector is particularly useful." and P10 said, "The

humpback corrector reminds me every moment not to hump my back like it's my own doctor." P15 said, "The hunchback corrector lets me know when I hunch, how many times I hunch today, and makes me more aware of my physique." P1-10, P13, P15, and P17-20 all wished that the hunchback corrector would add more features.

6. Discussion and future work

6.1. Conduct other explorations

This undershirt can record the female user's humped back in real-time The concept proves that the human body is made up of many complex tissues, and the KYPHOTONE humped back corrector, to be adaptable to all people and used for daily testing, needs to be explored in more other ways, such as exploring the variability of human morphology and breast size in different groups to achieve the universality of KYPHOTONE.

6.2. Reflection

We found some shortcomings in the study. Firstly, affected by the epidemic, we only managed to have 4 experts as representatives of knowledge about women's hunchback health. If more experts had been included, we might have collected more relevant knowledge about women's humpback health. Secondly, the number of female users in the study is also low, as well as the lack of time for users to experience and the lack of long-term usage and feedback from users on the hunchback corrector.

7. Future Work

In the future, we will further improve the design of hardware and applications, expand the coverage of female hunchback health detection and prevention, optimize the performance and indicators of sensors, and apply more "micro feedback" to KYPHOTONE hunchback correctors, so that users can be more aware of their hunchback and the health condition of correction. Consider more functional components for the hunchback brace. Through the research in this paper, we hope to provide more resources to promote the development of wearable technology, designed more for women, to create a comfortable, socially acceptable, and effective wearable hunchback brace.

8. Conclusions

In this article, we introduce KYPHOTONE, an interactive system that helps women better correct their hunchbacks by providing real-time feedback and corrections based on the behavior of women with hunchbacks, allowing them to change their hunchback behavior while wearing KYPHOTONE. Our user studies have shown that women with hunchbacks can more effectively correct their hunchbacks and build self-confidence in correcting their hunchbacks by wearing the KYPHOTONE. The innovation of this paper is to improve the comfort and wearability of the garment-integrated electrodes and to achieve user testing, and this research opens the door to zero-distance communication

between doctors and hunchback patients, reflecting "beauty" and empowerment in human-computer interaction.

9. Acknowledgements

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