Application research of a device with an anti-fall warning function on infant clothing

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ABSTRACT – REZUMAT

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The safety issues caused by falls during the growth process of infants and young children aged 0–3 have always been a concern. Currently, young parents need to take good care of their infants' and young children's daily lives while facing heavy work. While balancing life and work, anxiety is inevitable. This project mainly focuses on the safety of infants and young children and conducts online research on the feasibility of applying anti-fall warning devices to infant clothing. SPSS software is used to analyse the reliability, validity, and correlation of the collected data, and the necessity of using devices with anti-fall warning functions on infant clothing is concluded. We have developed and conducted relevant experimental data analysis on the function of anti-fall warning equipment. When the infant's body exceeds the set tilt angle, the warning equipment will emit a buzzing sound to remind the caregiver to understand the infant's activity status at first, reduce the risk of the infant falling, and alleviate the pressure on the caregiver. At the same time, the overall design of infant clothing, the design of anti-fall parts, and the placement of anti-fall warning devices on infant clothing were conceptualized, and corresponding finished products were produced. At the end of the project, an evaluation and assessment of the application of anti-fall warning devices in infant clothing was conducted to verify their market and functional feasibility, and to provide prospects for future research.

Keywords: *anti-fall warning equipment, evaluation and assessment, functional design, infant and toddler clothing, research and analysis*

Cercetări privind aplicarea unui dispozitiv cu funcție de avertizare anti-cădere pe îmbrăcămintea pentru sugari

Problemele de siguranță cauzate de căderi în timpul procesului de creștere a sugarilor și a copiilor cu vârste cuprinse între 0 și 3 ani au fost întotdeauna o preocupare. În prezent, tinerii părinți trebuie să aibă grijă de viața de zi cu zi a sugarilor și copiilor lor mici, în timp ce se confruntă cu o muncă grea. În timp ce echilibrează viața și munca, anxietatea este inevitabilă. Acest proiect se concentrează în principal pe siguranța sugarilor și a copiilor mici și efectuează cercetări online cu privire la fezabilitatea aplicării dispozitivelor de avertizare anti-cădere pe îmbrăcămintea pentru sugari. Software-ul SPSS este utilizat pentru a analiza fiabilitatea, validitatea și corelația datelor colectate și se concluzionează necesitatea utilizării dispozitivelor cu funcții de avertizare anti-cădere pe îmbrăcămintea pentru sugari. Am dezvoltat și am efectuat o analiză relevantă a datelor experimentale privind funcția echipamentelor de avertizare anti-cădere. Atunci când corpul bebelușului depășește unghiul de înclinare stabilit, echipamentul de avertizare va emite un sunet de bâzâit pentru a atenționa asupra stării de activitate a bebelușului de la bun început, a reduce riscul de cădere a bebelușului și a ușura activitatea îngrijitorului. În același timp, au fost conceptualizate designul general al îmbrăcămintei pentru sugari, designul pieselor anti-cădere și amplasarea dispozitivelor de avertizare anti-cădere pe îmbrăcămintea pentru sugari și au fost fabricate produsele finite corespunzătoare. La sfârșitul proiectului, a fost efectuată o evaluare și o analiză a aplicării dispozitivelor de avertizare anti-cădere pe îmbrăcămintea pentru sugari, pentru a verifica fezabilitatea lor comercială și funcțională și pentru a furniza perspective pentru cercetări viitoare.

Cuvinte-cheie*: echipament de avertizare împotriva căderii, evaluare și analiză, design functional, îmbrăcăminte pentru sugari și copii mici, cercetare și analiză*

INTRODUCTION

With the development of society, contemporary young parents need to learn how to become qualified parents while facing work pressure. The environment in which infants and young children grow up is quickly changing, and compared to traditional family care, modern parenting care is more challenging [1, 2]. With the transformation of consumer consumption concepts and the updating and iteration of high-tech, intelligent clothing is gradually occupying a high proportion in the infant and toddler clothing market, showing a trend of more specialization, intelligence, and segmentation [3]. When parents choose clothing for their children, they no longer only consider the comfort, safety, style, and structure of the clothing, but also pay more attention to its functionality.

According to research reports, the mortality rate of accidental injuries among children in China is 3–11 times that of developed countries, and accidental injuries among infants and young children are on the rise. Among accidental injuries among infants and young children, falls/falls are the highest, and the safety issues of infants and young children have

Table 1

CAUSES OF ACCIDENTAL INJURIES IN CHILDREN (%)							
Age group	**Gender**	**Falling**	**Blunt force injury**	**Knife/sharp instrument injury**	**Other**	**Motor vehicle accident**	**Nonmotorized vehicle accident**
0–4	male	60.42	9.9	6.01	9.89	6.71	7.07
	female	56.34	11.27	7.75	10.56	4.93	9.15

attracted more attention [4]. According to Huang Zhaosheng's [5] "Analysis of Children's Injury Monitoring Results", the top three causes of accidental injuries in children aged 0–4 are falls/falls, blunt object injuries, and nonmotor vehicle injuries. Children in this age group exhibit low cognitive abilities, strong curiosity, poor motor coordination, and are susceptible to injuries such as falls, bumps, and ingestion of foreign objects. The proportion of accidental injuries is shown in table 1.

The combination of an anti-fall Warning device and infant clothing needs to achieve the following functions:

1. The anti-fall Warning device should have the function of setting the tilt angle. Observing the physical activity of infants and young children can help determine the tilt angle of the body when it is about to fall.
2. The anti-fall Warning device should have a call function. When the body tilt angle exceeds a certain value, an alarm sound will be emitted.
3. Infant and toddler clothing can demonstrate protective performance. When infants and young children accidentally fall, clothing can provide some protection for areas that are prone to impact.
4. The integration of Warning devices and infant clothing. The Warning device can be integrated with infant clothing, and it should be easy to disassemble and recycle.

MARKET RESEARCH AND ANALYSIS OF ANTI-FALL CLOTHING FOR INFANTS AND YOUNG CHILDREN

The survey mainly adopts online research methods to distribute questionnaires in the mother and baby product group and the mother group, mainly targeting groups who need safety protection issues such as fall protection for infants and young children or have purchasing experience in infant clothing and supplies, providing data support for innovative design of fall protection clothing for infants and young children.

Research methods

Using online survey methods, questionnaires were distributed to shopping malls, maternity and baby stores, online maternity and baby groups, etc., over two and a half months. A total of 310 data research samples were collected, of which 301 were valid samples, with an effective rate of 97%. Using the SPSS system to analyse 301 questionnaires, reliability analysis, factor analysis, and correlation analysis were conducted on the collected data to analyse the impact of structural rationality, fabric composition, safety protection functionality, and the combination of infant clothing and intelligent devices on the demand for anti-fall clothing for infants and young children.

Questionnaire analysis on the demand for anti-fall clothing for infants and young children

Questionnaire Reliability analysis test

This article conducted a reliability test on question numbers 12–15 in the questionnaire data sample, with a total of 16 items. Cronbach's alpha coefficient is the most commonly used reliability testing method in questionnaire surveys. The value of Cronbach's alpha coefficient is usually between 0 and 1. If the alpha coefficient is lower than 0.6, it is considered to have poor reliability; If it reaches 0.6~0.7, it indicates good reliability; When it is higher than 0.8, it indicates high reliability. If the CITI value is below 0.3, it may be considered to delete the item; If the value of the "alpha coefficient for deleted items" is significantly higher than the alpha coefficient, it may be considered to delete the item and reanalyse it.

According to the results in table 2, the total Cronbach's alpha coefficient of this questionnaire is 0.923, which is higher than 0.8, and the coefficient values of the questions are all greater than 0.8, indicating that the various analysis categories of this questionnaire have high authenticity and accuracy, and the reliability quality is very high. Regarding the "CTIT" value, the CTIT values of the analysis items are all greater than 0.4, indicating a good correlation between the analysis items and a good level of reliability. The reliability coefficient of the research data is higher than 0.9, which comprehensively indicates that the data has high reliability quality and can be further analysed.

Questionnaire, Factor analysis, and validity testing

Questionnaire factor analysis aims to ultimately reduce its numerous variables into several factors, to verify the rationality of the selected data in the questionnaire. Commonly used test indicators are KMO value and Bartlett's sphericity value. If the KMO value is higher than 0.8, it indicates that the research data is very suitable for extracting information, that is, it reflects good validity from a lateral perspective; If the KMO value is between 0.7 and 0.8, it indicates that the research data is suitable for extracting information; A value less than 0.6 indicates that the data is not suitable for extracting information and has average validity. Validity analysis requires Bartlett's test (corresponding p-value should be less than 0.05).

Table 2

RELIABILITY ANALYSIS			
Name	**Total correlation of correction items (CITC)**	**The deleted α coefficient**	**Cronbach's α coefficient**
Problem 12-1	0.542	0.921	0.923
Problem 12-2	0.677	0.918	
Problem 12-3	0.583	0.920	
Problem 12-4	0.543	0.921	
Problem 13-1	0.663	0.918	
Problem 13-2	0.616	0.919	
Problem 13-3	0.583	0.920	
Problem 13-4	0.587	0.920	
Problem 14-1	0.651	0.918	
Problem 14-2	0.689	0.917	
Problem 14-3	0.574	0.920	
Problem 14-4	0.508	0.922	
Problem 15-1	0.473	0.922	
Problem 15-2	0.671	0.918	
Problem 15-3	0.554	0.920	
Problem 15-4	0.491	0.922	
Problem 16-1	0.701	0.917	
Problem 16-2	0.715	0.917	
Problem 16-3	0.588	0.920	
Problem 16-4	0.517	0.921	

Table 3

KMO AND BARTLETT'S TESTS			
Bartlett sphericity test	**KMO value**		**0.903**
		Approximate chi-square	1141.977
		df	36
		p-value	0.000

KMO and Bartlett were used to validate the validity of the anti-fall clothing requirements for infants and young children in questions 14–16. From table 3, it can be seen that the KMO value is 0.903, which is greater than 0.8 and meets the prerequisite requirements for factor analysis. At the same time, the data passed Bartlett's sphericity test ($p<0.05$), indicating that the research data is very suitable for factor analysis and reflects good validity indirectly. The questionnaire data meet the requirements of factor analysis and can proceed to the next step of analysis.

Correlation analysis

To verify whether there is a corresponding relationship between the performance and structural rationality of the fabrics in this questionnaire, the necessity of reflecting safety protection functions in infant clothing, and the necessity of using intelligent devices and the demand for anti-fall clothing for infants and young children, a correlation experiment was conducted on the questionnaire.

According to the experimental results in table 4, the correlation coefficients between the per infant clothing, and the necessity of using intelligent devices and the demand for anti-fall clothing for infants and young children are all 1, indicating that the variables in the questionnaire have a certain impact on formance and structural rationality of the fabric, the necessity of incorporating safety protection functions in consumers' purchasing needs.

Summary

This section conducted data analysis on the questionnaire through the SPSS system and provided explanations for the corresponding research results. According to the analysis, the validity, relevance, and credibility of the survey questionnaire are relatively high. At the same time, the performance and structural rationality of the fabrics in the questionnaire, the necessity of incorporating safety protection functions in infant clothing, and the use of intelligent devices can directly reflect consumers' demand for anti-fall functions in infant clothing. This survey provides a certain reference basis for the necessity of combining intelligent Warning devices with anti-fall clothing for infants and young children, and provides data support for subsequent designs.

Table 4

CORRELATION EXPERIMENT RESULTS						
Characteristic	**Indicator**	**Purchase demand**	**Performance of fabric**	**Rationality of structure**	**The necessity of demonstrating safety protection functions**	**Intelligent device usage**
Purchase demand	Correlation coefficient	1				
	P value	-				
Performance of fabric	Correlation coefficient	0.438**	1			
	P value	0.000	-			
Rationality of structure	Correlation coefficient	0.615**	0.566**	1		
	P value	0.000	0.000	-		
The necessity of demonstrating safety protection functions	Correlation coefficient	0.622**	0.459**	0.681**	1	
	P value	0.000	0.000	0.000	-	
Intelligent device usage	Correlation coefficient	0.275**	0.237**	0.208**	0.223**	1
	P value	0.000	0.000	0.000	0.000	-

Note: * p<0.05; ** p<0.01.

ANALYSIS OF ANTI-FALL WARNING DEVICES AND KEY POINTS IN THE DESIGN OF ANTI-FALL CLOTHING FOR INFANTS AND YOUNG CHILDREN

This section mainly focuses on the structural rationality design, fabric performance, functional protection, fall behaviour analysis, and application analysis of fall prevention Warning devices for infant clothing. During infancy and early childhood, it is easy to fall while crawling or just learning to stand. To relieve the pressure of guardianship, it is considered to combine the anti-fall Warning device with infant clothing, which is also the key to implementing the anti-fall Warning device in this project.

Analysis of the rationality of infant clothing structure

Infant and toddler clothing should be designed according to the characteristics of infants and toddlers. To avoid constraints, infant and toddler clothing needs to have sufficient relaxation, and there is no need to pay attention to the structure and style of the clothes. Instead, it is necessary to minimize stitching and avoid waist lines and weight loss; Infants and young children with short necks should preferably have no collar, and attention should be paid to the reasonable use of fastening structures.

Analysis of fabrics for infant and toddler clothing

Infants and young children have delicate skin that is prone to sweating. When choosing fabrics, attention should be paid to meeting the functional requirements of good breathability and moisture absorption, while also meeting the activity range of infants and young children [6]. Clothing fabrics for infants and young children should avoid fabrics with printing, dyeing, and finishing as much as possible to reduce the contact of harmful substances with infants and young children. When infants and young children learn to crawl, they sweat a lot and also need to go outdoors for activities. It is recommended to choose fabrics with good moisture absorption and breathability for their outerwear [7, 8]. Infants aged 10–12 months will gradually crawl and walk, and their range of activities will become wider. The preferred fabric is still sterile and pure cotton.

Functional protection

The most important thing in the growth process of infants and young children is to make fall protection performance a design focus. According to the literature review, currently, fall airbags are commonly used as materials for studying falls. Through AI intelligent calculation, when the speed and angle of a human fall reach a certain threshold, the clothing will automatically inflate the airbag protection material to protect important parts of the human body, such as the head and elbows [9, 10]. This fabric is relatively suitable for adults, but there are certain limitations for infants and young children, mainly because the operation requires a certain amount of gas, such as helium, to be contained in the material, which is not very suitable from a safety perspective. Due to the delicate skin of infants and young children, protective items such as sponge pads can be considered in the design to protect their elbow and knee joints.

Analysis of falling behaviour

The direction of human falls generally includes forward and backward falls and lateral falls [11]. When the human body is hit by a collision object, there is usually a reaction stage, during which the body will go through several stages of tilting, imbalance, and landing in sequence [12]. Taking a lateral fall as an example, the most obvious feature of the human body when about to fall is that the body tends to tilt. Generally, the line connecting the centre point S0 ‘of the two ankle support points and the centre point (S0) of the head when standing is taken as the centre line.

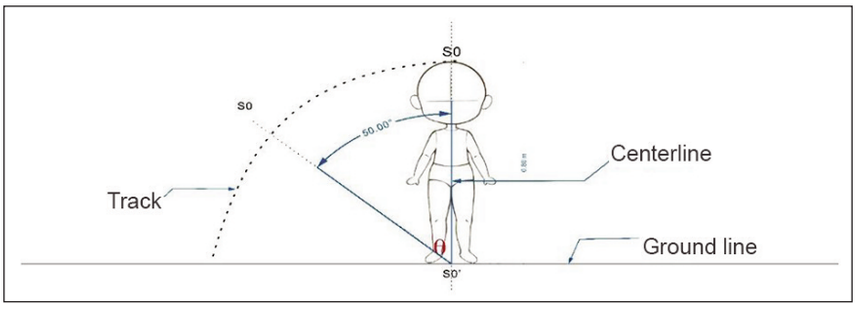

Fig. 1. Schematic diagram of the human body tilt trajectory

The angle (θ) between the centre line and the body tilt line is used as the standard for whether the human body is tilted. When θ reaches the set angle, it can be judged as a signal of imminent fall, as shown in figure 1.

Analysis of anti-fall warning device

The Warning device is developed based on the original IM948 series module, using Qt Creator integrated software combined with MSVC2019 compiler and C++ language. The developed page display is more specific and intuitive, and the main functions include Bluetooth connection, data display, 3D stereo, and dynamic curve.

Bluetooth function

By clicking on "Bluetooth Connection" to enter the Bluetooth page, click on "Search" to start searching for Bluetooth devices. If a gyroscope Bluetooth device is found, it will automatically connect and display the name and address of the gyroscope Bluetooth in the first blank area. The second blank area will display the progress and logs of the Bluetooth connection. Clicking 'disconnect' will disconnect from the Bluetooth of the connected gyroscope. If the Bluetooth connection is successful, the "Not Connected" label will become the name of the device connected to Bluetooth.

Data display

After receiving and parsing the data packet, the program will display the parsed data on the data page, such as angular velocity, magnetic field, etc. Whenever the state of the gyroscope changes (the content of the data packet changes), a data packet will be sent, and the program will parse it. At this time, the content of the data page will be refreshed.

The battery status is unique, and its information is not in the same data packet as other information. Here, a timer is used to send instructions to the gyroscope every five seconds to read the gyroscope's battery level and charging status. When the gyroscope battery level drops below 5%, a battery alarm will be triggered.

Three-dimensional solid

Enter the 3D view page through "3D View". Among them, x, y, and z respectively display the three values of the Euler angle of the gyroscope, and angle displays the angle between the gyroscope and the Z-axis (vertical direction). The middle is a cube made with OpenGL.

At the Bluetooth connection, the rotation axis coordinates and rotation angle of the gyroscope are calculated. Here, these two data points are passed as parameters to OpenGL's rotation function to achieve the rotation of the cube graph, which is synchronized with the gyroscope's motion.

Fig. 2. *3D Page*

Dynamic curve

This function adds angle lines and call lines based on the original module parameters. Based on this, the changes in human activity can be visually observed. The vertical axis of the curve represents the angle, and the horizontal axis has no meaning, only to better display the progress. The graph contains two curves; the black line is the threshold line, and the green line reflects the change in the angle between the gyroscope and the Z-axis.

When the program starts receiving data, start a timer and read the value of the angle every 50 ms, forming coordinates and connecting them into a curve in the table.

When the angle exceeds the threshold, the program will sound an alarm and send instructions to the gyroscope to raise one pin of the gyroscope, which is connected to a buzzer. When the angle exceeds the threshold, the program will sound an alarm, and the gyroscope buzzer will also sound an alarm. In addition, the angle curve will turn red, and the "unconnected" label on the Bluetooth interface will also turn red.

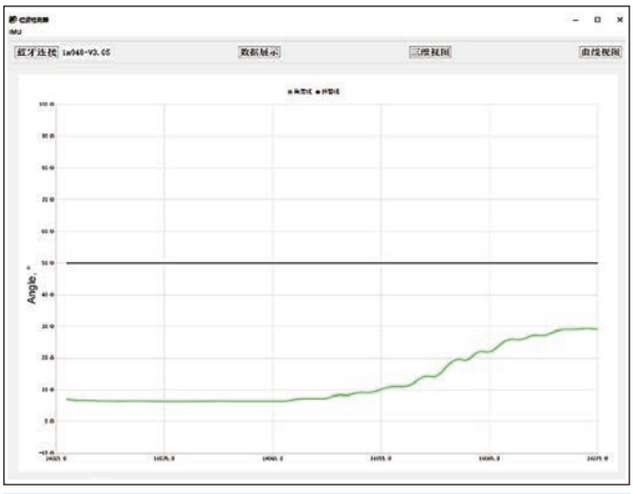

Fig. 3. Curve page when the angle does not exceed the threshold

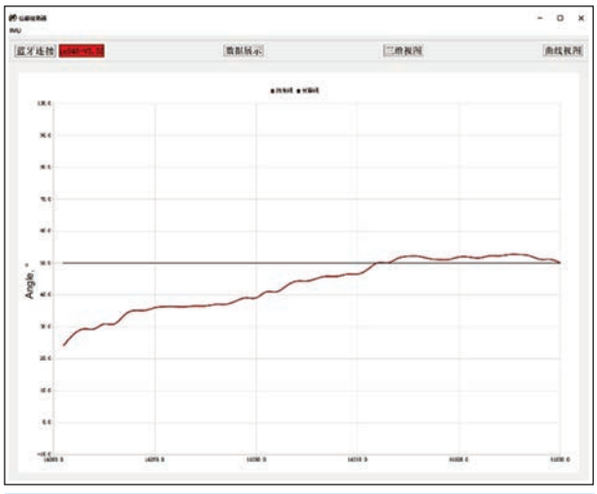

Fig. 4. Curve page when the angle exceeds the threshold

Program logic

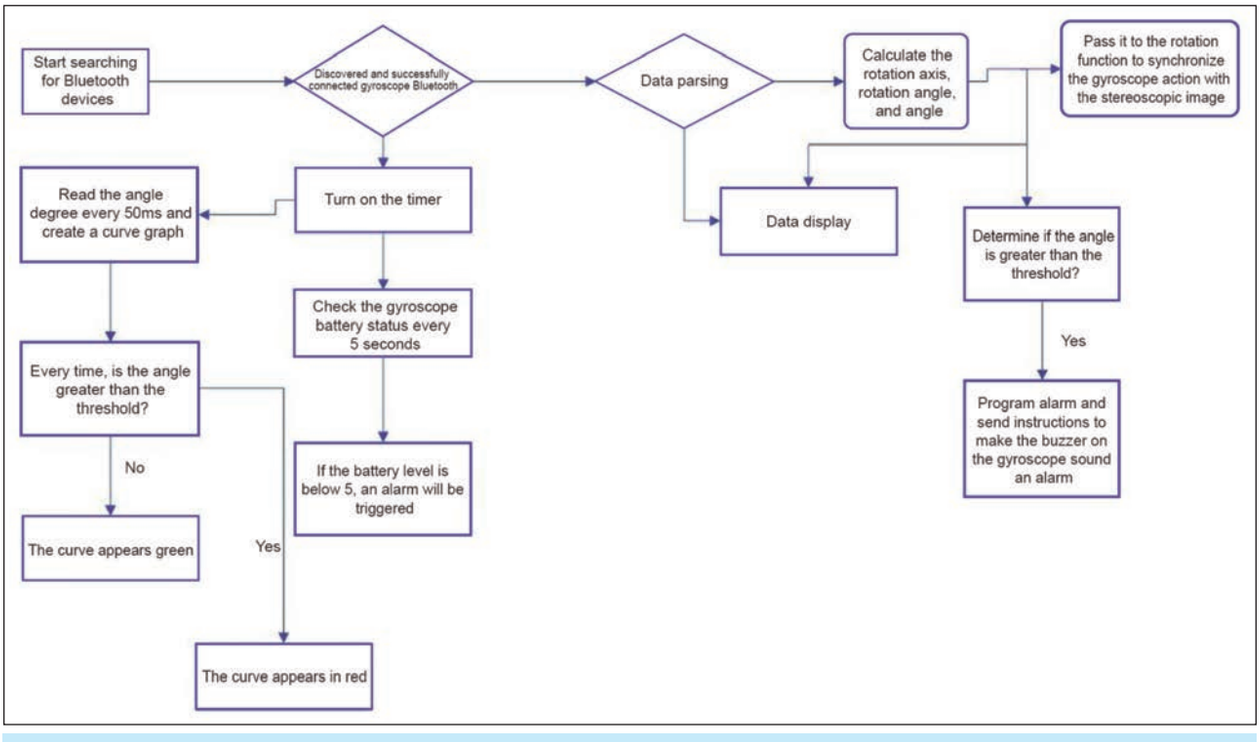

Fig. 5. *Flow chart*

Physical production and display of Warning devices

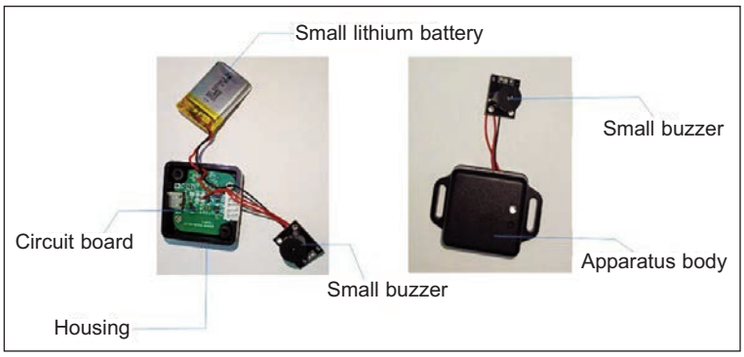

Fig. 6. Overall composition of the Warning device

Summary of this section

Infants and young children cannot take care of themselves, and to facilitate the care of guardians, the structural design of clothing needs to consider factors such as loose size and ease of wearing and taking off; During infancy and early childhood, the skin is delicate and prone to sweating, with weak resistance, and infants and young children are unable to express their body's discomfort to heat and cold. Therefore, when designing, the first step is to choose fabrics that have protective and safe properties for the skin of infants and young children. At the same time, sponge pads designed to prevent falls and impacts on joints such as elbows and knees can meet the needs of functional protection.

Secondly, the anti-fall Warning device is an important component in achieving the function of preventing falls in infants and young children. By detecting the physical activity status of infants and young children through the anti-fall Warning device, the possibility of falling can be determined. Allowing guardians of infants and young children to be informed of their child's condition promptly effectively avoids dangerous situations such as bumps and falls.

PRACTICE OF INFANT CLOTHING DESIGN BASED ON ANTI-FALL REQUIREMENTS

Based on the analysis of the design points of anti-fall clothing for infants and young children, two physical design schemes are proposed for the research topic, and one scheme is selected for physical production.

Design description

Taking childhood as the theme, searching for the innocence and carefree nature of childhood. In terms of design elements, starting from abstract letters, geometric elements such as straight lines are integrated into the design of clothing. The overall structure of the clothing adopts a jumpsuit style, which is convenient to put on and take off. In terms of style details, a round neck design is made, with straight access control; Sponge pads and other protective measures should be used at the joints to ensure the safety of infants and young children; The overall colour scheme is mainly blue and white, and the anti-fall Warning device weighs about 10 g. The device is lightweight and designed to be worn on the chest of clothing for easy disassembly by guardians.

Design renderings and style drawings, and detail production display

Application analysis

Evaluate and test the use of anti-fall warning devices on infant clothing, evaluate the appearance, functionality, and whether the use of anti-fall warning devices effectively alleviates guardian anxiety in the production of infant clothing, and analyze and summarize the results.

Evaluation of testing personnel

Five 1–2 year old infants and their guardians in the community were randomly selected as subjects for evaluation testing. The average weight of 5 infants

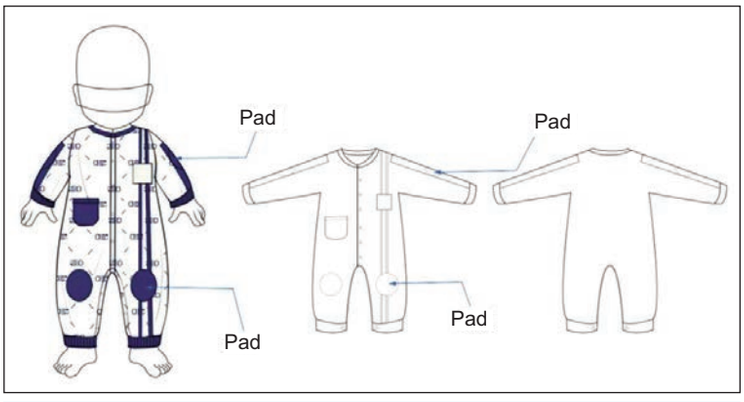

Fig. 7. Design proposal

Fig. 8. Finished product detail display – combination of a warning device and clothing

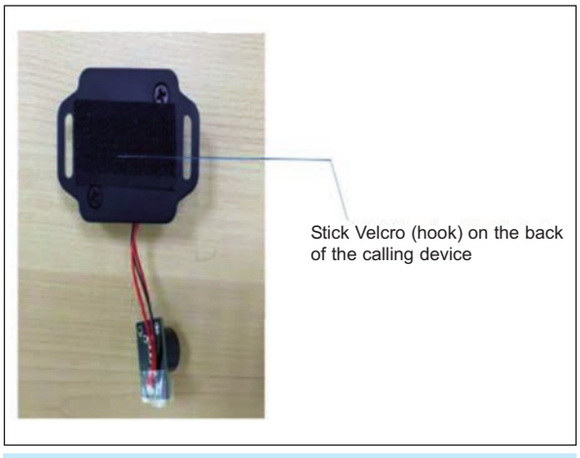

Fig. 9. Finished product detail display – Velcro (hook surface) pasted on the back of the Warning device

Table 5

SCORING RULES TABLE			
Evaluating indicator	**Evaluation content**	**Evaluation method**	**Evaluation level**
Appearance	Style aesthetics	Try on and observe	Very satisfied 3 satisfied 2 general satisfaction 1
	Comfort of wearing	Touch sensation	
Functional evaluation	Add protective design to the anti-fall parts	Feedback effect	Very satisfied 3 satisfied 2 general satisfaction 1
Evaluation of the combination of infant clothing and anti-fall warning equipment	The effect of combining anti-fall warning equipment with clothing	Relieve anxiety	Very anxious 3 Anxiety 2 General anxiety 1

and young children is between 10 kg and 12 kg, and their height is between 75 cm and 80 cm. The difference is small and can be used as a reference. Because infants and young children do not yet have good language expression abilities, guardians need to make evaluations on their behalf, and guardians also need to evaluate whether it effectively alleviates anxiety.

Evaluation testing using clothing

The infant clothing produced in this project is named Style "E" as the testing clothing. To better compare and verify with infant clothing on the market, we selected clothing styles with high praise rates for comparison. The infant clothing on the market is named Style "F".

Evaluation and testing methods

This evaluation mainly tests the appearance, functionality, and effectiveness of the baby clothing made, as well as whether it can effectively alleviate the anxiety of guardians when used in conjunction with anti-fall warning devices. Participants need to score based on their feelings, with high or low scores representing high or low satisfaction. The detailed rules for setting scores are shown in table 5.

Evaluation of Test Results

Appearance evaluation score

Table 6

APPEARANCE EVALUATION SCORE		
Subject	**Style E**	**Style F**
Subject 1	2.5	2
Subject 2	2.6	1.8
Subject 3	2.3	2.1
Subject 4	1.9	1.6
Subject 5	2.2	2.1

According to table 6, the evaluation scores of the five subjects for style E and wearing comfort are significantly higher than those for style F, indicating that the infant clothing produced in this study can win the Favor of consumers in terms of appearance design.

Functional evaluation score

Table 7

FUNCTIONAL EVALUATION SCORE		
Subject	**Style E**	**Style F**
Subject 1	2.3	2
Subject 2	2.1	1.5
Subject 3	2.6	1.8
Subject 4	2.4	2.2
Subject 5	2.8	2.1

According to table 7, the functional evaluation of style E by 5 subjects is higher than that of style F, indicating a high level of satisfaction with the functionality of the infant clothing designed in this study.

Effective evaluation score for alleviating anxiety

To effectively evaluate the level of anxiety of the guardians when the subjects were wearing and not wearing anti-fall warning devices, the experiment lasted for 2 days, and the records are as follows:

On the first day, 5 subjects did not wear clothing with fall warning devices, and the total number of falls recorded within 8 hours during the day was 25; On the second day, 5 participants wore clothing with fall warning devices, and the total number of falls recorded within 8 hours during the day was 18. When infants and young children are not wearing clothing with anti-fall warning devices, guardians need to take care of them without leaving within 8 hours. When

infants and young children wear clothing with anti-fall warning devices, if their physical activity is about to fall, the anti-fall warning device will send a beep alarm reminder to the caregiver, and the guardian will pay attention to the infant's condition promptly. The guardian does not need to constantly monitor the infant's activity. A study on the level of anxiety among caregivers found that they were most anxious when they were not wearing fall warning devices; When infants and young children wear anti-fall warning devices, caregivers' anxiety is significantly lower, mainly due to the alarm reminder function of the anti-fall warning device, which relaxes the caregiver's mood. For this purpose, an evaluation score was also collected from the guardians regarding the alleviation of anxiety.

Table 8

EFFECTIVE EVALUATION SCORE FOR ALLEVIATING ANXIETY

Subject	Anxiety when wearing anti-fall warning devices	Anxiety when not wearing anti-fall warning equipment
Subject 1	1.1	2.3
Subject 2	1.5	1.8
Subject 3	1.2	2.2
Subject 4	1.3	2.6
Subject 5	1.2	1.9

According to table 8, when infants and young children were wearing clothing with anti-fall warning devices, the anxiety of the five guardian subjects was significantly lower than when infants and young children were not wearing clothing with anti-fall warning devices. This indicates that the application of the anti-fall warning device in infant and young children's clothing studied in this project is feasible.

CONCLUSIONS

Through literature review and analysis, the harmfulness of accidental falls in infants and young children was identified. Combined with the analysis of research questionnaires, the necessity of using devices with anti-fall warning functions on infant clothing in the market was concluded. Based on previous infant and toddler protective clothing research, research has been conducted on incorporating anti-fall warning equipment. The anti-fall warning equipment has been developed based on the original IM948 series module, using Qt Creator integrated software, MSVC2019 compiler, and C++ language for development. The developed page can be used more intuitively to see the activity status of infants and toddlers. The anti-fall warning equipment has the function of setting tilt angles and prompts, which has a certain application reference value for improving child safety and facilitating the care of young children. At the end of the project, an evaluation test was conducted on the use of anti-fall warning devices in infant and toddler clothing. The appearance, functionality, and effectiveness of the produced infant and toddler clothing in alleviating guardian anxiety were evaluated in three aspects. Based on the feedback provided by the evaluators, it was concluded that the infant and toddler clothing produced in this project can be loved by consumers in terms of appearance, design, and functionality. At the same time, when infants and young children were wearing clothing with anti-fall warning devices, the subjects' anxiety was significantly lower than when infants and young children were not wearing clothing with anti-fall warning devices. This indicates that the application of the anti-fall warning device studied in this project on infant and young children's clothing is feasible.

The significance of this research is mainly based on the safety of infant and young child growth, combining infant and young child clothing with anti-fall warning devices, and designing and considering the anti-fall performance of daily infant and young child clothing to minimize secondary injuries. Improve the injuries caused by accidental falls in infants and young children, and provide new ideas for the functional design of infant clothing. At the same time, it provides a certain reference value for the research on human body protection design of other functional clothing.

There are still some shortcomings in the research of this topic, and further supplements can be made in the following aspects:

1. Due to the constantly changing tilt posture of the human body, especially for infants and young children who are not yet independent in their daily lives, sometimes their movement posture may not necessarily be in a state of imminent fall. After the Warning device emits a prompt sound, it will increase the time for guardians to judge and recognize.
2. Currently, the project can only display the dynamic curve of the anti-fall Warning device on the computer. In the future, it is hoped that relevant technologies can be combined to achieve display on mobile apps or more convenient devices, making it easier to view data.

EXPECTATION

The research on fall prevention for infants and young children in this project is not yet very comprehensive. I look forward to the future development of infant and toddler protective clothing from the perspective of protective fabrics and related technologies.

1. The design of infant clothing needs to be combined with the growth characteristics of infants and young children. There are not many fabric materials available for use on infants and young children, and it is hoped that future research can develop a variety of protective fabrics suitable for infants and young children.
2. The use of intelligent products in the future will cover various fields, and infant protective clothing

is no exception. It involves interdisciplinary collaboration, and innovation and protective design alone are no longer sufficient to promote research on functional clothing for infant protection. I hope that in the future, more fields can pay attention to the infant and toddler population, providing them with a safe and reliable environment for their growth, while also reducing the caregiving pressure on guardians and enhancing their sense of happiness.

REFERENCES

[1] Wei, D., Nagai, Y., Jing, L., et al., *Designing comfortable smart clothing: for infants' health monitoring*, In: International Journal of Design Creativity & Innovation, 2019, 17, 1/2, 116–128

[2] Tang, Q., Zhang, B., Zheng, X., *Design of Wearable Intelligent Monitoring Clothing for Infants and Young Children*, In: Journal of Textiles, 2021, 42, 08, 156–160

[3] Ni, R., Xu, Q., *Evolution and Response of Infant Clothing Design in the New Era*, In: Popular Literature and Art, 2019, 19, 147–148

[4] Zhang, Y., Liu, D., Wang, Y., *Research Progress on Accidental Injuries and Protection Status of Infants and Young Children in Chinese Families*, In: China Maternal and Child Health Care, 2019, 34, 07, 1687–1689

[5] Huang, Z., *Analysis of Child Injury Monitoring Results,* In: China Maternal and Child Health Care, 2010, 25, 22, 3136–3137

[6] Yuan, B., *Exploration of Fabric Selection for Baby Clothing Based on Market Demand*, In: Modern Marketing (Academic Edition), 2013, 11, 46–47

[7] Qian, J., Zhang, H., *Study on the Breathability of Wetted Fabrics*, In: Journal of Beijing Institute of Fashion Technology, 2008, 28, 02, 31–35

[8] Zhao, L., Wu, J., Li, C., *Research on the Performance of PTT Moisture wicking Weft Knitted Fabric*, In: Knitting Industry, 2011, 01, 11–12

[9] Zhang, L., Weng, C., Wang, Q., et al., *Research progress on assessment and intervention strategies for falls in elderly people*, In: Chinese Rehabilitation Theory and Practice, 2010, 1, 11–13

[10] Yu, Z., Zhang, B., Sun, J., *Application of Functional Material Innovation in the Development of Intelligent Clothing*, In: Journal of Xi'an Engineering University, 2019, 32, 2, 129–135

[11] Xie, L., *Research on Knee Protection Performance and Product Development Based on Inverse Dynamics Analysis,* Zhejiang University of Technology, 2018

[12] Li, C., *Research on Human Fall Model and Its Recognition Technology*, Hebei Agricultural University, 2018

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