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노년층을 위한 스마트 재킷의 개발 및 평가
- 미국 여성을 대상으로 -

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Development and Analysis of Smart Jacket for the Elderly
-Focused on American Women-

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Abstract : 본 연구에서는 시판 중인 디바이스를 활용하여 외관에서는 기성복의 스타일을 유지하면서 기능성을 부여한 노년 여성을 위한 스마트 재킷을 개발하였다. 노년기에 접어들면서 시력은 약화되며 효과적인 체온조절도 저하된다. 이에 열과 빛의 기능을 제공하는 연구재킷을 제작하고 노년층 소비자들의 평가를 실시하여 그 수용가능성을 확인하고자 하였다. 재킷에 대한 만족도 평가는 전문가 외관 평가 및 소비자 착용 평가로 실시되었으며 재킷의 피트성, 활동성, 디바이스의 기능성, 수용 가능성 여부 등을 평가하였다. 그 결과, 전반적으로 높은 만족도를 보였으며 노년층에서도 충분히 미적요소와 기능성이 결합된 스마트 의류가 일상복으로 받아들여질 수 있음을 알 수 있었다. 그러나 여전히 스마트 의류의 문제점 중의 하나인 디바이스의 무게를 경량화 할 수 있는 방법이 모색되어야 할 것으로 나타났으며, 이러한 결과가 노년층을 위한 스마트 의복의 가능성과 만족도 향상을 위한 방안을 제시하는 기초 자료가 되기를 바란다.

Key words : smart jacket, elderly women, fit testing, field testing

1. Introduction

The population worldwide is "graying." According to the United Nations in 2005, the in 2000, the elderly, 65 and over, in the United States constituted approximately 12.3 percent of the total population. By the year 2030, the UN predicts that population of the elderly in the US will increase to 16.2 percent of the population. The proportion of the elderly in all of Europe was 15.9% in 2005, and is expected to grow to 22.6% by 2030. In Japan the proportion was 19.7% in 2005, and is projected to be 30.6% by 2030. In the Republic of Korea, in 2005 the population was relatively low at 9.4% but is expected to grow to 23.45 by 2030 and to 35.1% by 2050 (http://esa.un.org/unpp/index.asp?panel=2). Therefore, it is not surprising that the problems and needs of older people are receiving increased research attention (Lee & Sontag, 2005).

As they become older, people's body shape and body functions change. For example, their back will round, their neck bends forward, and their shoulder point shifts forward, vision becomes less acute, and tactile sensations decrease. Age related changes in the body are of importance to clothing. Height tends to decrease as we age. The loss of bone results in a gradual shape change in the vertebrae of the spine. The vertebrae gradually exhibit an increased end plate concavity. Changes in the malleable discs between each vertebra also have a role in change in height and posture. Vertical body measurements related to stature and the upper torso are affected by these changes. Affected measurements include height, back length and center front length. As height decreases, a shape and posture change also occurs, as the back to waist length decreases. These increased spinal column curves also cause the neck to bend and the head to tilt forward. Weight increases as women get older, and the distribution of body fat over the body changes. Inner fat deposits in the torso and a shifting of the organs due to gravity cause expanding waistlines, increased abdominal extension, increased back width and large hips (Skerlj, B. et al, 1953; Gazzuolo, E. B., 1985 as cited in Kohn, I., 1996). Both muscle tone and laxity of tendons and connective tissue have an impact on posture across the back and in the shoulder area.

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The shoulder slumps and at the same time the shoulder slope increases (Kohn, I., 1996).

Other aspects of age-related change are loss of physiological reserve capacity of homeostatic loss and the sensory mechanisms, perceived as gradual sensory loss. At some point after the age of thirty, a steady decline in reserve capacity of the body begins. There are steady losses of strength, ability to produce and pump blood, and other declines in capability (Koncelik, J. A., 1997). As cited in Koncelik (1997), people in the over-65-age-range are twice as likely to wear glasses (Brotman, 1973); one million people are recorded as functionally blind (National Society for the Prevention of Blindness, 1996). With advancing age, changes in the human eye alter the perception of the environment.

Design for the elderly needs to accommodate a wide range of capabilities, as there is a lot of variation in the rate at which individuals age and in the variety of physical challenges they encounter, resulting in are many individual differences in the changes of body shape and body functions of individuals. This results in a difficult design challenge. But elderly people want products and clothing that will satisfy their needs. Many elderly women are dissatisfied with the clothing available to them. One factor contributing to dissatisfaction of apparel fit is the lack of appropriate styles, which includes well-fitting functional comfort in clothing that meets the active life-style needs of elderly women (Goldsberry & Reich, 1993). One promising strategy for providing clothing that fills the needs of elderly women is the use of new technologies to fill functional needs in well fitting clothing in classic styles that apparel to this age group.

Currently the field of wearable technology, especially that of garment-integrated wearable technology, is primarily limited to academic research, as new materials and technologies are being developed and tested (Dunne et al., 2004). A specific category of wearable technology is emerging that of intelligent clothing. Intelligent or "Smart" clothing has augmented functions that are derived from new technology, characterized by its emphasis on the integration of technology into ordinary garments, so that the technology is added to the functions already provided by the clothing, and becomes part of a garment or garment system (Dunne et al., 2002). Functionality is not provided in a separate device, but is donned and doffed with the garment, reducing the need to remember or keep track of multiple objects. Therefore the basis for smart clothes is ordinary clothing, which is often augmented with electrical or non-electrical functional components. The fabric of the clothing may also be intelligent, i. e., it may provide functions not ordinarily associated with fabric. Based on these modifications, an intelligent garment that can better fulfill its primary function as clothing, and also give some added value to a user is created (Rantanen et al., 2002).

Smart clothing has become a potential alternative for a wide range of personal applications, including safety and entertainment as well as applications requiring privacy. Items already on the market include socks that prevent smelly feet by inhibiting bacteria growth; snow suits embedded with adjustable heating systems, emergency alarms, and GPS (global positioning system) receivers to track the wearer's location; clothing that can wick away liquids without staining; and even aromatherapy business suits (www.news.cornell.edu/Chronicle/03/1.16.).

1.1. Objectives

The purpose of this study was to develop a prototype smart jacket for elderly women and to study the acceptability of smart wear for this generation. Two new functionalities were chosen for elderly women's clothing based on areas of interest of this age group. These interests were identified from interviews of 13 women and a focus group meeting of 10 women aged 56 and older. As we age, vision becomes less acute and thermoregulation of body temperatures can decrease. We used modified electronic devices in a prototype garment to provide augmented lighting and heating. The style of the garment was also chosen from styles preferred by the women in the interviews and the focus group meeting. Performance of the prototype was evaluated through expert fit testing and user field testing. Tests evaluated fitting, comfort, mobility, functionality and acceptability of the prototype by the specific target group.

The specific objectives of this study were 1) To develop a pattern for a jacket prototype for elderly women aged 56 and older, providing a good fit and appearance; 2) To develop the prototype smart jacket based on the architectural requirements and the profile of the target users; 3) To evaluate the prototype through fit testing and user field testing for the functionality of the device and wearability.

1.2. Problem Statement

As people age, their body shape and body functions change. For example, their body proportions change, their back will round, their neck bend forward, and their shoulder point shifts forward, their vision becomes less acute, tactile sensations decrease, and body responses to variations in thermal conditions become inconsistent. Elderly people demand clothing that will satisfy their needs by providing not only appropriate stylish design and good fit but also functional comfort that meets their life-style needs. There is a necessity to develop and test clothing to fill these needs.

2. Methods and Procedures

2.1. 3D Body Measurements

Data from three-dimensional body scans of American women aged 56 and older provided the body measurements needed to develop the jacket. Two sources of data were used in this study; an anthropometric study of the US population (SizeUSA, 2004) and body scan data from 54 subjects who were scanned from June to August 2007 in New York State using the Human Solutions scanner. Anthroscan and Polyworks software were used for analysis and measurement. Two groups of participants were used in developing the pattern. 13 women were fitted into the first prototype jacket that was then modified based on the results of this test. 4 women then participated in a fit of the final prototype. Participants in the original scan group and the fit tests were chosen that did not have any body variations or postural problems caused by neurological or musculoskeletal diseases, as the goal was to develop a jacket for women who could be well fitted in ready-to-wear clothing.

2.2. Jacket pattern for older women

2.2.1. Jacket pattern

To propose an appropriate jacket pattern for elderly women, providing a good fit and appearance, a pattern developed by Bae & Kim (2007) for Korean women over 60 years old was adjusted to fit the US target market of women 56 and older based on SizeUSA data and on data from the scan analysis of 54 women.

Jacket sizing and proportions were chosen on the ISO body type recommendations and using body measurements of scanned subjects and SizeUSA data. Sizing systems from 5 women's apparel companies were also compared and analyzed for additional sizing data.

2.2.2. Fit testing

A set of prototype patterns was developed through a series of fit tests. Unlined jackets were made from a stable medium weight cotton twill fabric in a neutral color. Subjects recruited as fit model for the jackets were asked to respond to questions about the jacket fit. Jackets were modified based on these comments and on expert analysis of misfit. The suitability of the final jacket prototype for elderly women was demonstrated by fit ratings of subjects who participated in the fit study and fit rating of two experts. Experts analyzed the fit of the jackets using 3D scan images. A 5-point response scale was used to answer the items. The criteria for establishing good fit were those described by Leichy et al. (1992) and by Erwin et al. (1979).

2.3. Wearable devices and integration

2.3.1. The structure of the device

Carbon fibers, wires, controller and other components were removed from a commercially available winter vest and were fitted to produce the current jacket. An expert was consulted to modify the length and the orientations of the wires were appropriate for the current jacket. The material used for heat generation was carbon fiber. The controller could be manipulated to three different levels including high, medium and low, and the lithium battery was rechargeable. In addition, a commercially available portable LED light was modified and integrated into the current jacket.

2.3.2. The location of the devices and integration procedure

The heating device needed to be incorporated to an area where it would be least invasive but generate maximum benefits. The location was chosen according to the elderly women's feedback. It was determined that the device should be inserted around the shoulders and the back. The controller, which can be easily reached, was located inside the inseam pocket of the princess line so that it would invisible from the outside. An inner pocket was created to store the batteries. The current jacket did not bear any difference to other regular jackets in appearance. A detachable facing was produced to fasten the carbon fibers onto the original fabric, and the wires were locked into the place by enclosing them with bias tape. Velcro was used so that it could be attached to the back of the neck, the sides of the neck, the tip of the shoulders, the center front, and the right side of the waist area. To integrate the LED light, considering the characteristics of the elderly population, the hem of the sleeves providing for easy attaching and detaching were determined optimal. Also, to prevent the device from becoming loose, a snap was integrated to inside of the seam.

2.4. Prototype smart jacket

2.4.1. Prototype smart jacket

The user was defined as a woman aged 56 and older and selected for her interest in design, fit, and functional needs, and her likelihood of being interested in buying and wearing a well-fitted, functional garment. User needs were defined as augmented visibility and temperature control for activities of daily life.

Architectural requirements for the entire system were chosen from the categories of daily activities, environmental situations, problems and user wants identified in the personal interviews and a focus group meeting. These architectural requirements were determined and a jacket design was developed for the prototype.

The prototype jacket was made from 55% linen/45% rayon fabric in navy color with embedded heating system and lighting system. Figure 1 is a diagram of the smart jacket. The light and heat systems used in the prototype jacket were modified devices that were available in the marketplace. The heating fabric was placed inside the jacket at upper back and shoulder area and LED light was installed at the hem of the sleeve. The power and control units for the heat system were placed in locations close to the center front of the garment and those of the lighting system at sleeve for ease of use.

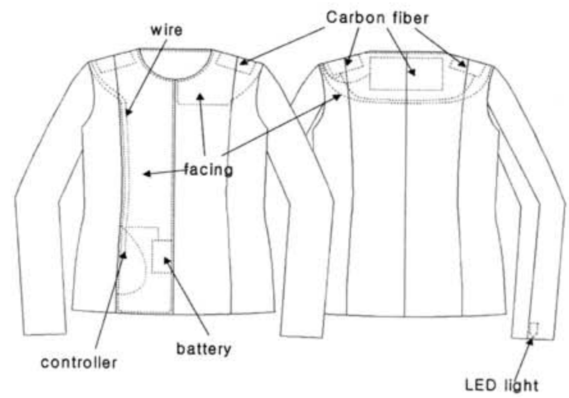

Fig. 1. Diagram of the smart jacket

2.4.2. Fit testing

4 participants rated the satisfaction of the fit of the prototype smart jacket and 2 experts conducted assessment the fit of the jacket using 3D scan images. A 5-point response scale was used to answer the items. The criteria for establishing good fit were those described by Leichy et al. (1992) and by Erwin et al. (1979).

2.4.3. Field testing

Then the prototype garment was given to 4 participants for field testing for 3~10 days along with a form to complete during the evaluation period. The form covered topics such as the general functioning and usability of the electronic systems, the comfort of the garment, the social acceptability of the garment, and general reactions to the garment and its functions. The final design can be seen in Figure 1.

3. Results

3.1. Subjects and Size

We analyzed the sizing system of 5 American apparel companies which target group included women aged 56 and older as a basis for standard body measurements and appropriate size designation for the prototype jacket. In Table 1 it can be seen that these companies provide sizing systems with 7~10 steps from size 2 to 20 based on bust, waist, and hip. Table 2 provides information on frequencies according to bust size based on body measurements based on SizeUSA data and from our research data.

We chose the bust size 39~40 group as a basic size for a prototype jacket based on the high frequencies of the sizes in this category, both from companies' sizing systems and body measurement data.

The ISO sizing system specifies sizing categories for women's body types based on drop values between bust girth and hip girth: A type, M type, and H type. The A body type has high percentage in research data, 2007 otherwise H type in SizeUSA data, 2004 (see Table 3).

Table 1. Sizing System (Units: inch)

N.company	size	-	-	6	8	10	12	**14**	16	18	-
	bust			34½	35½	36½	38	**39½**	41	43	
	waist			26	27	28	29½	**31**	32½	34½	
	hip			36½	37½	38½	40	**41½**	43	45	
C.company	size	-	4	6-8		10-12		14-16		18	20
	bust		34	35-36		37-38½		40-41½		43½	46½
	waist		26½	27½-28½		29½-31		32½-34		36	39
	high hip		34	35-36		37-38½		40-41½		43½	46½
	low hip		36	37-38		39-40½		42-43½		45½	48½

Table 1. Sizing System(continued) (Units: inch)

W.company	size	2	4	6	8	10	12	**14**	16	18	20
	bust	32½	33½	34½	35½	36½	38	**39½**	41	43	45
	waist	24	25	26	27	28	29½	**31**	32½	34½	36½
	hip	34½	35½	36½	37½	38½	40	**41½**	43	45	47
Ch.company	size	-	4	6	8	10	**12**	14	16	18	-
	bust		33½		36½		**39½**		42½		
	waist		25¼	26¾	28¼	29¾	**31¼**	32¾	33¼	33¾	
	hip		36	37½	39	40½	**42**	43½	45	46½	
T.company	size	2	4	6	8	10	12	**14**	16	18	20
	bust	33	34	34	35	36	37½	**39**	40½	42½	44½
	waist	24	25	26	27	28	29½	**31**	32½	34½	36½
	hip	34½	35½	36	37	38	39½	**41**	42½	44½	46½

Table 2. Frequency according to Bust size (Units: inch)

Bust Size		…	33	34	35	36	37	38	**39**	**40**	41	42	43	44	45	46	…
Research Data (Paek, 2007)	N/54 (%)	…	0 (0)	4 (7.4)	4 (7.4)	4 (7.4)	5 (9.3)	4 (7.4)	**10 (18.5)**	**7 (13.0)**	3 (6.0)	0 (0)	2 (4.0)	1 (1.9)	1 (1.9)	2 (3.7)	…
Size USA (2004)	N/606 (%)	…	4 (0.7)	7 (1.2)	14 (2.3)	30 (5.0)	21 (3.5)	35 (5.8)	**65 (10.7)**	**59 (9.7)**	58 (9.6)	53 (8.7)	54 (8.9)	35 (5.8)	38 (6.3)	34 (5.6)	…
Total	N/660 (%)	…	4 (0.6)	11 (1.7)	18 (2.7)	34 (5.2)	26 (3.9)	39 (5.9)	**75 (11.4)**	**66 (10.0)**	61 (9.2)	53 (8.0)	56 (8.5)	36 (5.5)	39 (5.9)	36 (5.5)	…

Table 3. Frequency according to ISO body type

Body Type	Drop value	Research Data, 2007 (N=54)	Size USA, 2004 (N=606)	Total (N=660)
A	12 cm(9 cm over)	**26 (48%)**	170 (28%)	196 (29.7%)
M	6 cm(4~8 cm)	13 (24%)	162 (27%)	175 (26.5%)
H	0 cm(~4 cm)	15 (28%)	**274 (45%)**	289 (43.8%)
Total		54 (100%)	606 (100%)	660 (100%)

To identify if any significant differences in among patterns for different body types, we compared body measurement that are items for a pattern making. The result of Duncan showed that there was no significant differences were found except hip girth and sleeve length. Table 4 shows these results and Figure 2 is images according to ISO body type.

3.2. Jacket for elderly women

3.2.1. Jacket pattern

Among the 54 subjects who scanned, 13 subjects who are A or H Body Type, as indicated by the ISO, with a bust size of 39~40 were chosen for developing a set of prototype jacket patterns. Based on the fit evaluation of the subjects, the pattern was modified and improved through a series. The basic numerical formula for the jacket pattern is as follows:

B/4±0.5 cm+2.5~3.0 cm (difference of front and back), W/4±0.5 cm+1.5 cm+dart amount (difference of front and back), H/4±0.5 cm+3.0~4.5 cm (difference of front and back), armhole depth B/4, and back neck width B/12+0.5 cm. The waist

Table 4. The result of Duncan test

Items	Body Type by ISO			
	H	M	A	
Bust girth	39.28	39.78	39.33	
Waist girth	35.00	35.34	35.71	
Hip girth	40.54	42.10	44.84	***
Cross shoulder	18.03	17.79	18.54	
Across front width	14.55	14.96	15.45	
Bust pts width	7.78	7.64	7.88	
Bust pt to neck right	11.88	11.97	11.91	
Neck right to waist over bust	17.32	17.44	17.62	
Across back width	15.45	14.73	15.58	
Neck to waist center back	15.33	15.19	15.53	
Waist to buttock	7.10	7.04	7.28	
Belly circumference	36.57	36.73	37.86	
Maximum belly circumference	36.98	37.24	38.58	
Arm length right	22.43	21.75	22.31	*
Upper arm girth right	11.40	11.46	12.31	

*: $p<0.05$, **: $p<0.01$, ***: $p<0.001$

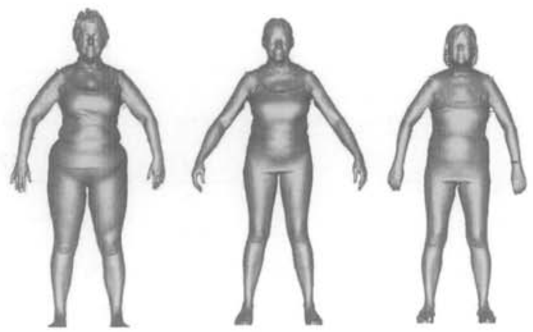

Fig. 2. 3D Images from illustrating ISO Body Types

back length was made 1.7 cm longer than the actual size of the waist back length. Waist dart was calculated according to the body type from drafted line between bust line and hip line and bust dart was set to 3.5 cm. Accordingly, the pattern making for the sleeve was drafted in the same way, but due to the change in armhole, more width in the sleeves was added, and the sleeves were shortened to an appropriate length.

3.2.2. Fit testing

A final jacket was constructed for fit testing. Three H type subjects and one A type subjects were tested for fitting, and the average scores for each category and the standard deviation were calculated to examine fit. The results showed overall satisfaction with a score of 2.5~3.5 in most of the categories (see Table 5).

3.3. Integration of wearable devices and jacket

3.3.1. Heating device

The carbon fibers, the wires, the controller and other com-

Table 5. The results of fit test of jacket

Categories		A type(N=2)		H Type(N=6)	
		Mean	S.D.	Mean	S.D.
Bust level too loose 5--4--3--2--1 too tight	Front	3.50	0.71	3.33	0.52
	Side	3.50	0.71	3.50	0.55
	Back	3.50	0.71	3.67	0.52
Waist level too loose 5--4--3--2--1 too tight	Front	3.50	0.71	3.33	0.52
	Side	3.00	1.41	3.17	0.41
	Back	4.50	0.71	3.67	0.52
Hip level too loose 5--4--3--2--1 too tight	Front	3.50	0.71	3.17	0.41
	Side	3.00	1.41	2.83	0.41
	Back	3.00	1.41	2.83	0.75
Bottom of the Jacket too loose 5--4--3--2--1 too tight	Front	3.50	0.71	3.17	0.41
	Side	3.00	1.41	2.83	0.41
	Back	3.00	1.41	2.67	0.52
Cross chest/cross back too loose 5--4--3--2--1 too tight	Front	4.50	0.71	3.50	0.55
	Back	3.00	1.41	3.50	0.55
Underarm(armscye)	too loose 5--4--3--2--1 too tight	3.50	0.71	3.50	0.55
Sleeve too wide 5--4--3--2--1 too narrow too long 5--4--3--2--1 too short	Bicep level width	3.00	0.00	2.83	0.41
	Elbow level width	3.00	0.00	3.33	0.52
	Wrist level width	3.00	0.00	3.17	0.41
	length	2.00	0.00	3.17	0.52
Neckline too high 5--4--3--2--1 too low too far 5--4--3--2--1 too close too high 5--4--3--2--1 too low	Front Neck Point	3.00	0.00	3.17	0.41
	Side Neck Point	3.00	0.00	3.00	0.00
	Back Neck Point	3.50	0.71	2.83	0.41
Shoulder too long 5--4--3--2--1 too short too sloped 5--4--3--2--1 too square too backward 5--4--3--2--1 too forward	Length	2.50	0.71	3.00	0.00
	Slope	3.00	0.00	3.00	0.00
	Seam	3.50	0.71	3.00	0.00
Jacket length	too long 5--4--3--2--1 too short	3.00	0.00	3.17	0.41

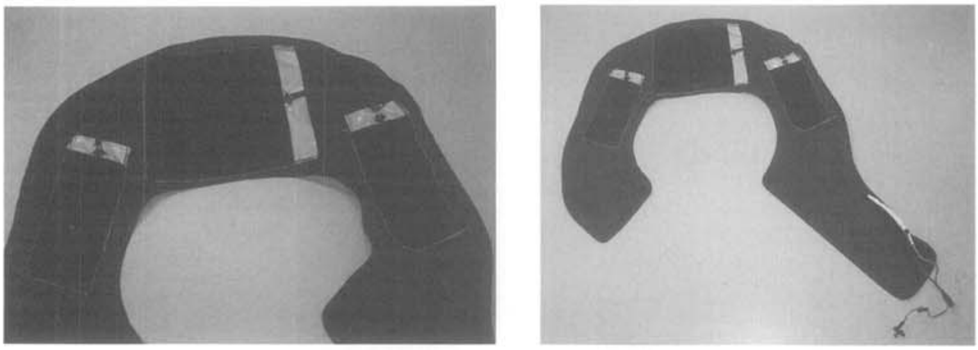

Fig. 3. Additional facing attached the carbon fibers and wires

ponents embedded in a commercially available winter vest were used to construct the jacket. An additional attachable facing was made to be inserted between the completed jacket and its facing. It was then fastened onto the original fabric using carbon fibers, and the wires were secured with bias tape (see Figure 3).

3.3.2. Light device

To attach the LED light to the inner surface of the jacket sleeves, fabric was first used to enclose the device, and a snap was placed; this process is described in Figure 9, 10. Snaps were placed inside both cuffs so that a user would be able to position the device according to her convenience. Figure 11 shows the smart jacket with all the devices in place in the body size 18.

3.4. The results of user satisfaction of the smart jacket

The results from the tests conducted to investigate user satisfaction regarding the look of the smart jacket and its ability to support activity, and its heating and lighting abilities are provided below.

3.4.1. Participants

The test for investigating user satisfaction of the smart jacket was administered to four women. Their average body size is same as that of Table 6 and Table 7 shows general information of them.

3.4.2. Appearance assessment results

Body scans were conducted on four subjects while wearing the smart jacket for experts' fit assessments and the subjects conducted direct assessment to generate average scores and standard deviation for each category, which were ultimately used to determine fitting. With that, a satisfaction score of 2.33~3.50 was observed in every category (see Table

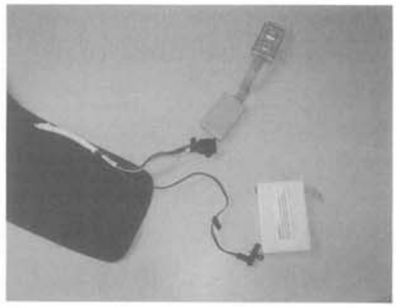

Fig. 4. Controller and battery

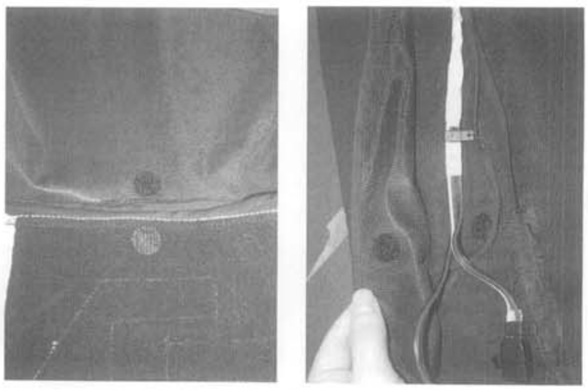

Fig. 5. Attachment of heating device using velcro in back neck area(left) and center front area (right)

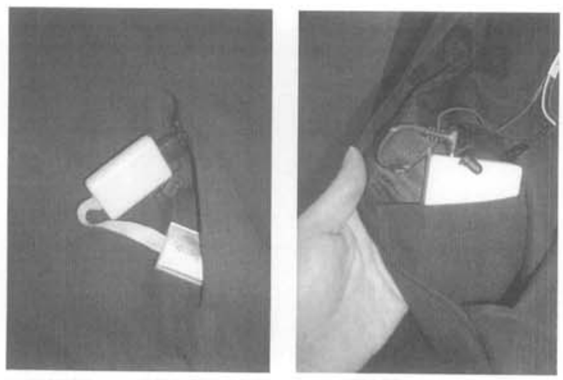

Fig. 6. Controller in inseam pocket(left) and battery in inside pocket(right)

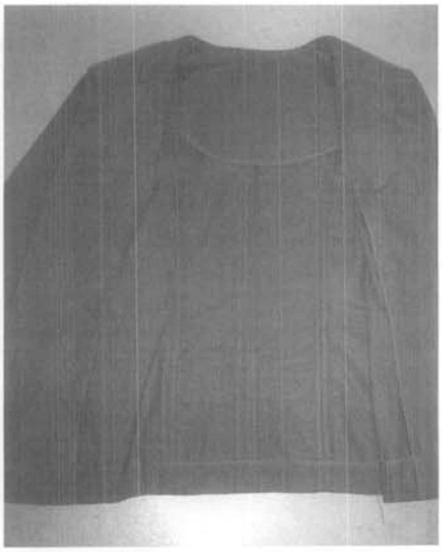

Fig. 7. Inside jacket attached the heating device

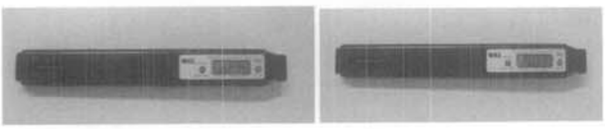

Fig. 8. Thermometer for measure the temperature of the jacket

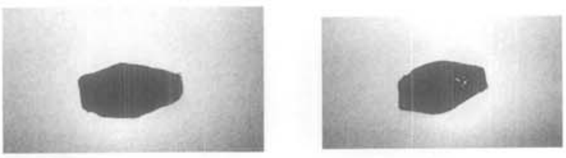

Fig. 9. LED light

Table 6. Body measurement of the participants (Units: inch)

	Height	Bust girth	Waist girth	Hip girth
H Type(N=4)	66.85	39.28	35.00	40.54

8). Especially, it was gathered that the heating device was naturally incorporated to a strategic location and did not show from the outside. Regarding overall fit, the scores from the direct assessments were higher than those from the expert's 3D assessments; this may be due to the fact that the folds formed due to the nature of the fabric, which is usually for summer wear, were not regarded as highly on the 3D display.

3.4.3. Wearing assessment results

The three subjects who conducted assessment on the looks of the smart jacket were asked to wear the jacket and assess its fit and usability while they were doing everyday tasks. Satisfaction regarding the sufficient amount of available space within the jacket even after having incorporated the heating and lighting devices was noted. In terms of the weight of the devices inside the jacket, the battery for the heating device was found to be heavy, but overall, the jacket did not restrict the wearer's activities, and the mechanical features were determined to be easy to use.

3.4.4. Device satisfaction assessment results

Table 10 contains the results from the satisfaction assess-

Fig. 10. Attachment of LED light using snap

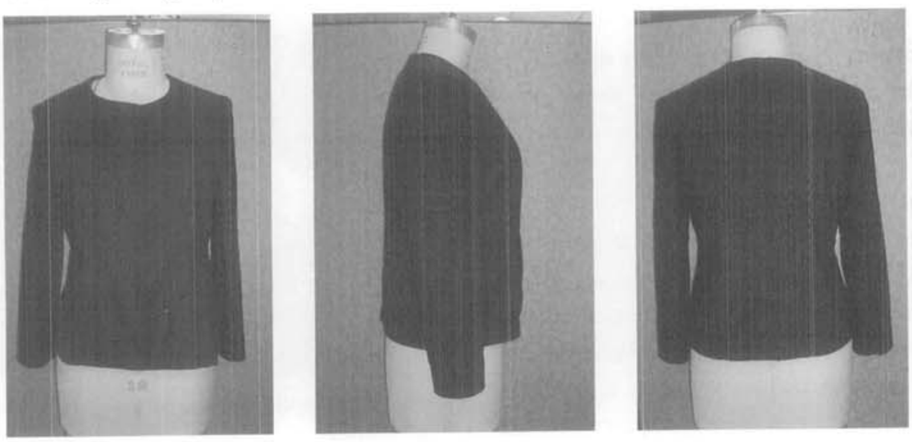

Fig. 11. The smart jacket with the devices

Table 7. Field testing information

Age	Occupation	Times and where she wore the jacket	Temperature encountered	Length of time to use heating device	Use of lighting device
Subject 1 (58)	Librarian	5:30-9:10pm/restaurant	20.6°C	20 min.	Used
		7am-3pm/library	-	30 min.	-
Subject 2 (58)	Librarian	1-4pm/office	23.6°C	30 min.	-
		6-7pm/home	21.4°C	30 min.	Used
		7-7:40/mall	-	40 min.	Used
		8:30-10am/office	22.8°C	-	-
Subject 3 (60)	Administrative Assistant	9:30-11pm/river	20.0°C	90 min.	Used
		7:30-8am/office	21.7°C	-	-
		9:30-10:30pm/ outside in neighborhood	18.3°C	120 min.	Used
Subject 4 (57)	Lecture	10-11pm/home	21.1°C	60 min.	Used
		9-10am/home	19.4°C	60 min.	-
		9:30-11:30/theater	18.9-20.0°C	120 min.	Used

Table 8. The results of the appearance assessment of the smart jacket

Categories		Expert (N=8)		Subject (N=4)	
		Mean	S.D.	Mean	S.D.
Bust level too loose 5--4--3--2--1 too tight	Front	3.33	0.52	3.00	0.00
	Side	3.17	0.41	3.00	0.00
	Back	3.50	0.84	3.00	0.00
Waist level too loose 5--4--3--2--1 too tight	Front	3.00	0.63	3.00	0.00
	Side	2.83	0.41	3.00	0.00
	Back	3.00	0.00	3.00	0.00
Hip level too loose 5--4--3--2--1 too tight	Front	3.33	1.03	3.00	0.00
	Side	3.00	0.63	3.00	0.00
	Back	2.33	0.82	3.00	0.00
Cross chest/cross back too loose 5--4--3--2--1 too tight	Front	3.50	0.55	3.00	0.00
	Back	3.00	0.89	3.00	0.00
Underarm(armscye) too loose 5--4--3--2--1 too tight	Front	3.17	0.41	3.00	0.00
	Back	3.17	0.41	3.00	0.00
Sleeve too wide 5--4--3--2--1 too narrow	Width	3.00	0.00	3.00	0.00
too long 5--4--3--2--1 too short	length	3.33	0.52	3.33	0.58
Neckline too high 5--4--3--2--1 too low	Front Neck Point	2.83	0.41	3.00	0.00
too far 5--4--3--2--1 too close	Side Neck Point	3.33	0.52	3.00	0.00
too high 5--4--3--2--1 too low	Back Neck Point	3.00	0.00	3.00	0.00
Shoulder too long 5--4--3--2--1 too short	Length	3.33	0.52	3.33	0.58
too sloped 5--4--3--2--1 too square	Slope	3.00	0.00	3.00	0.00
too backward 5--4--3--2--1 too forward	Seam	2.83	0.41	3.00	0.00
Jacket Length	too long 5--4--3--2--1 too short	2.83	0.41	3.00	0.00
Overall Jacket Look very good 5--4--3--2--1 too bad	Front	3.67	1.03	4.00	1.00
	Side	3.67	0.82	4.33	0.58
	Back	3.00	1.10	4.67	0.58

Table 9. The results of the wearing assessment of the smart jacket

Categories		Subject (N=4)	
		Mean	S.D.
Ease of moving too loose 5--4--3--2--1 too tight	Bust level	3.00	0.00
	Waist level	3.00	0.00
	Hip level	3.00	0.00
	Underarm(armscye)	3.00	0.00
	Sleeve	3.00	0.00
	Shoulder	3.00	0.00
Heating system	Soft 3--2--1 Stiff	2.67	0.58
	Comfortable 3--2--1 Uncomfortable	3.00	0.00
	Light 3--2--1 Heavy	1.33	0.58
Lighting system	Soft 3--2--1 Stiff	2.33	0.58
	Comfortable 3--2--1 Uncomfortable	2.67	0.58
	Light 3--2--1 Heavy	2.67	0.58
Overall jacket	Comfortable 3--2--1 Uncomfortable	3.00	0.00
	Acceptable 3--2--1 Unacceptable	3.00	0.00
	Like 3--2--1 Dislike	3.00	0.00

ment on the functionality of the devices. A score of 2.89 for the heating device and 2.96 for the lighting device showed overall satisfaction.

3.5. Potential for a smart jacket for the elderly

The current research, focusing on the elderly population on which there is a lack of research, supports for high potential in utilizing wearable devices to produce an aesthetically pleasing smart jacket that can be worn daily by the elderly. The concern regarding the weight of the device, however, needs to be addressed. We expect to see more development of high-functionality and more efficient smart clothing in the future.

Acknowledgement

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Table 10. The results of the devices satisfaction assessment of the smart jacket

Satisfied **3--2--1** Unsatisfied	Subject(N=4)			
	Heating system		Lighting system	
	Mean	S.D.	Mean	S.D.
Position of device	2.67	0.58	2.67	0.60
Easy to put the jacket on/off	3.00	0.00	3.00	0.00
Easy to operate	2.67	0.58	3.00	0.00
Easy to change the battery	3.00	0.00	-	-
Usability	3.00	0.00	3.00	0.00
Performed as expected	3.00	0.00	3.00	0.00
Jacket is acceptable, not too eccentric	3.00	0.00	3.00	0.00
Method of removal of device for laundry is acceptable	3.00	0.00	3.00	0.00
Physical comfort	2.67	0.58	3.00	0.00
Total	2.89	0.19	2.96	0.07

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