

A Study on the Paraplegia Men's Ready-made Pants Pattern and Grading Method

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하반신마비 남성의 기성복 바지원형 및 그레이딩 연구

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Abstract

오늘날 지체장애인의 수는 후천적 원인으로 인하여 점점 증가하는 추세에 있다. 이에 본 연구는 휠체어를 사용하는 하반신마비자 중 성인남성을 중심으로 인체계측을 통해 적합성이 높은 바지를 개발하는데 목적이 있다. 연구 결과는 다음과 같다.

1. 인체계측 결과 하반신마비자들은 정상인과 비교했을 때 허리둘레 및 배둘레에서 유의한 차이를 보여 새로운 치수체계가 필요로 함을 알 수 있었다. 또 자세 변화에 따른 들레항목의 치수 변화와 피부 신축을 위해 허리선의 변화가 고려되어 평상시의 휠체어에 앉은 자세에서 계측한 항목으로 원형이 설계되어야 할 필요가 있다고 분석되었다.
2. 연구원형은 기성복화 하기 위한 방법으로 먼저 기준치수(98-102)를 선정하고, 원형 각 부위는 절대치로 수치화 시켜서 제시하였다. 뒤밑위길이는 허리선에서 8cm 늘이고 앞밑위길이는 허리선에서 6cm 줄여 앉은 자세에서 편안함을 확보할 수 있도록 하였다. 기준치수의 경우 바지길이 107cm, 밑위길이 26cm, 밑위선 28cm, 엉덩이둘레선은 밑위선 위로 8.5cm, 바지부리는 10.5cm이고 외관과 기능성 평가 결과 대부분의 항목에서 우수한 평가를 받았다.
3. 계측 대상자 계측치를 근거로 치수의 출현율을 고려하여 연구 치수체계를 기본 신체부위인 앉은 허리둘레와 앉은 엉덩이둘레의 순으로 적용하여 총 7개의 치수로 설정하였다. 기준치수(98-102)의 연구원형을 마스터 패턴으로 하고 구체적인 원형 부위별 절대치로써 치수 차를 검토하여 연구 그레이딩 룰을 설계하였으며 기준치수 보다 작은 사이즈 88-93과 큰 사이즈 108-111의 적합성을 검증하였다.

Key words: paraplegics, ready-made pants pattern, sizing system, grading rule; 하반신마비자, 기성복 바지 원형, 치수체계, 그레이딩 룰

I. Introduction

It seems that we, the normal people may be the potential disabled men, taken into the consideration the trend of increasing the number of the physically handicapped people resulting from the acquired causes

including a variety of accidents(the Ministry of Health and Welfare, 2000). Under the condition where the clothes for the physically handicapped people have not been developed in Korea compared with those in advanced countries, we should know that the potential consumers or the disabled people have the more

meaningful beings than the niche market in the fashion industry. We can say that it is the main theme in the department of clothing & textiles to improve the poor condition of producing clothes for them and to solve the problem concerning the clothes being put to the practical use.

Especially it is urgent to develop the clothes for the seriously disabled people using wheelchairs with the consideration of the body change in the sedentary posture. Most antecedent studies were for the cerebral palsy children and the handicapped women only, and they included a variety of types of handicaps. Thus, it is necessary to conduct practical studies which can make it possible to commercialize the development of the ready-to-wear by finding the fit commonness for various degrees of handicaps and parts handicaps.

Therefore, This study is to provide the basic material for the clothes to be put to practical by developing the pattern of the suited pants through the anthropometric measurement and by suggesting the size of the clothes fit for the disabled people in reality subsequent to suggested the functional pants design for the disabled men accounting for 67.5% out of the disabled people due to the wars in the past and the high rate of social & economic activity(the Ministry of Health and welfare, 2000), for the paraplegia male adults using wheelchairs who are paralyzed because of the spinal cord(K. I., Kim, 2003).

II. Methods and Procedures

1. Anthropometric measurement

The purposes of the measurement were to conduct a difference examination between the normal and the disabled people, and to select the master size for the construction final pattern as well as to find the features of the lower limbs and the changes of the body shape according to the change of posture.

1) Subjects for measurement

Subjects are among people paraplegics, 30 male adults who have used wheelchairs more than 5 years.

2) Methods and items for anthropometric measurement

Measuring instruments such as Martin's anthropometric instruments and measuring tapes, aids like tapes for indicating the measuring point and rubber band. For consistency and accuracy, the researchers made a measurement themselves and had the subjects wear the light underwear.

Since it is impossible for the subjects to have a standing pose the researchers conducted a measurement in the supine posture and sedentary posture.

The measurement items are 21 for the sedentary posture and 30 for the supine posture. In case of the weight impossible the measurement, the oral questions were conducted.

2. Pattern construction

The purpose of this study was to construct the pattern of ready-made pants, so we constructed the final pattern through the alteration methods using the wearing test based on the result from the anthropometric measurement. The silhouette of the pants is outdoor clothes developed through the survey. It is formal pants with a zipper in front and front pleats and crease(K. I. Kim, 2003).

1) Experimental pattern

We developed a pattern based on the result of the measurement and K. J. Pack, and J. R. Lee's(2002) pants pattern, which are similar to the silhouette of the pants and suggest the simple drafting method by analyzing various patterns used in ready-made clothes industry. Necessary items for drafting the experimental pattern are 5-sitting waist circumference, sitting hip circumference, crotch length, pants length, and pants hole. In order for the researchers to commercialize, we selected the master size(98cm in sitting waist circumference, and 102cm in sitting hip circumference), and constructed the pattern for the subject corresponding to this size. The experimental clothes were made of actual object material excluded elasticity in order to conduct the accurate identification on the body fitness according to the change in the pattern.

2) Wearing test of experimental pattern

The evaluations methods of the wearing test consist of two-external appearance evaluation and functional evaluation. In the external appearance evaluation, 3 subjects corresponding to the master size were evaluated by two evaluating groups (total 8 persons)-Group A: 5 persons majoring in clothing & textiles, Group B: 3 persons of paraplegics. These evaluators used the five-point rating scale according to each inspection item. In the functional evaluation in accordance with wear comfort, 3 subjects corresponding to the master size became the evaluators to evaluate in the five-point rating scale according to the items as to the parts and motions.

3) Final pattern

By finding out the part with low satisfaction in the wearing test and by revising it, we suggested the pattern of the pants with high fitness. Necessary items for final pattern construction 5, which was same as the experimental pattern. The pattern was constructed in the master size of the actual object material used in making the experimental clothes.

4) Wearing test of final pattern

In order to evaluate the fitness of the final pattern, other 3 subjects (excluded the subjects who participated in the wearing test) corresponding to the master size were selected. The wearing evaluation methods were same as those of the experimental pattern

5) An actual object production

We produced clothes that make use of subsidiary materials which are similar to the ready-made pants, then selected one subject among 6 subjects who were close to the master size, and had him wear the clothes.

3. Grading

The system for the normal people is unfit for the disabled people because of the low fitness. Therefore, with the consideration of the features of the disabled persons body, we set up new sizing system and the grading rules.

1) Sizing system

Under the present condition which neither special clothes nor the sizing system is not developed, we would like to give a suggestion which is easily able to apply in the apparel industry. So we analyzed the data from the result of the anthropometric measurement, then established the grading increment and finally set up 7 different sizes.

2) Grading rule

The grading, the YUKA CAD system, used the shift method. Drafting 7 different sizes respectively and calculating the difference of the enlarged and the reduced part, we made a chart according to the grading point. With the amount of the maximal adjusted-increase and decrease in each size, we applied the master pattern to the grading rule in order to conduct grading in all sizes.

3) Wearing test

For the fitness of the grading rule, we selected each subject corresponding to the size 108-110, and the size 88-92 respectively, which were a little larger or smaller than the master size 98-102. The evaluators and the evaluation methods were same as those of the wearing test of experimental pattern.

III. Results & Discussion

1. A analysis of the anthropometric measurement

1) Descriptive statistics of the measurement

Except the inaccurate measuring values, the values of 30 subjects were used in the statistical process. The mean age of the subjects are full 42 years old. Table 1 shows the mean and the standard deviation of the values.

Table 2 indicates the change in the circumference and the length dimension in order to understand the posture change in the sedentary posture. Among the dimensions of the measurement, some of the length dimensions to understand the degree how to expand and contract were impossible to measure. In this case, we calculated the elasticity (%), indicated "cm" unit, by using contraction (-) and expansion (+). According to Table 2, the

Table 1. Descriptive statistics anthropometric measurement

(unit : cm)

posture	measurement items			M	S.D.	measurement items			M	S.D.
supine posture	front	breadth	waist breadth	31.0	3.23	circumference	waist circumference	92.1	7.98	
			abdominal breadth	32.1	2.97		abdominal circumference	95.0	7.91	
			hip breadth	34.5	2.54		hip circumference	96.9	4.67	
			thigh breadth	12.2	2.35		thigh circumference	43.9	6.03	
			knee breadth	9.2	1.78		knee circumference	36.5	2.72	
			calf breadth	8.4	1.99		calf circumference	32.6	1.89	
			ankle breadth	4.8	1.57		ankle circumference	23.9	3.06	
	side	height	heigh	168.4	5.56	depth	waist depth	24.2	4.93	
			waist height	101.5	6.18		abdominal depth	26.0	4.74	
			abdominal height	96.7	6.65		knee depth	7.6	1.31	
		length	pants length	97.4	4.56		ankle depth	4.3	0.98	
	back	depth	hip depth	16.1	4.09	length	leg length	68.8	13.1	
			thigh depth	8.9	1.26					
			calf depth	6.9	1.10					
	sedentary posture	front	circumference	waist circumference	96.7	8.26	breadth	waist breadth	30.9	2.70
abdominal circumference				99.6	8.20	abdominal breadth		32.0	2.64	
hip circumference				101.4	5.08	thigh breadth		11.9	2.09	
thigh circumference				42.9	5.14	knee breadth		9.31	1.84	
knee circumference				37.7	2.97	length		front interscye length	39.0	3.71
chest circumference				97.6	6.06					
side		depth	waist depth	25.7	4.04	length	crotch length	26.2	0.87	
			abdominal depth	27.7	4.04					
			hip depth	27.8	2.70					
back		breadth	hip breadth	35.6	2.45	length	waist back length	44.9	1.21	
the rest		weight	63.7	6.64						

Table 2. Size variation according to posture change

items	measurement regions		M (cm)	S.D.(cm)
circumference	sitting waist circumference – laying waist circumference		4.60	0.99
	sitting abdominal circumference – laying abdominal circumference		4.42	0.92
	sitting hip circumference – laying hip circumference		4.68	1.18
items	measurement regions		elasticity(%)	cm
length*	front	waist circumference line ~ hip circumference line ~ thigh circumference line	-23.17	68
		thigh circumference line ~ knee circumference line ~ calf circumference line	+ 7.97	35
	back	waist circumference line ~ hip circumference line ~ thigh circumference line	+30.51	810
		thigh circumference line ~ knee circumference line ~ calf circumference line	- 5.97	12

*means the dimension which shows the amount of change in measuring along with the body surface after marking the standard line by rubber band both in the sedentary posture and in the supine posture.

variances in circumference and length are very big. Thus, we should construct the clothes for the paraplegics whose main posture is the sedentary posture, with considering the dimensions about the sedentary posture.

2) Identification the difference from the normal people

We studied the shape of the lower limbs by comparing with the values and indices for the 40s people in "National Antropometric Survey of Korea(1997)" and in the study by K. S. Kim(1993).

According to the results of Table 3 and Table 4,

compared with the normal people, paraplegics have similar heights, bigger chest circumference and front interscye breadth, but outstandingly smaller thigh circumference and calf circumference. On the other hand, their waist and abdominal circumference are much bigger than those of the normal people studied at National Antropometric Survey of Korea There is also a big gap in both circumference and breadth of waist and hip. The first reason is that the abdominal and the waist circumference become bigger due to the lack of exercise resulting from being paralyzed from waist down, and the circumference of the upper half of the

Table 3. A comparison of measurement result in National Antropometric Survey of Korea (unit: cm)

comparison items		the normal people	paraplegics	t-value
		M	M	
height	height	167.9	168.5	0.578
	waist height	100.5	101.5	0.958
breadth	waist breadth	29.5	31.0	2.531*
	hip breadth	32.7	32.1	-4.104***
depth	waist depth	22.7	24.3	1.728
	abdominal depth	23.3	26.0	3.102**
circumference	waist circumference	85.1	92.1	4.729***
	abdominal circumference	87.3	95.0	5.263***
	hip circumference	93.5	96.9	4.021***
	thigh circumference	54.4	43.96	-9.360***
	knee circumference	35.8	36.5	1.600
	calf circumference	36.6	32.6	-11.36***
length	chest circumference	94.9	97.6	4.218***
	front interscye breadth	35.9	39.0	4.524***
	waist back length	43.9	44.9	4.950***
the rest	weight	69.0	63.7	-4.255***
	Rohrer's index	146.0	134.1	3.138**

* $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$ **Table 4. A comparison of size measurement result in the study by Kye-sun, Kim(1993) (unit: cm)**

items	object	the study of Kim		the paraplegics		t-value
		M	S.D.	M	S.D.	
chest circumference - waist circumference		7.82	5.54	7.66	5.24	-0.165
hip circumference - waist circumference		9.95	4.48	4.88	4.16	-6.581***
hip breadth - waist breadth		4.78	-	3.26	2.68	-3.063**

** $p \leq .01$, *** $p \leq .001$

body is increasing as well because of the activity of exercise. Secondly, because of being paralyzed from the abdominal muscle, it cant grab tightly the internal organs, so the abdominal circumference is getting bigger. Simultaneously, as the paralysis and the stiffness of the low limbs come with, the contraction of the muscle of the low limbs occurs(S. H., Ahn, 2001). In this way, as the waist circumference of the paraplegics is getting bigger, the present size of the ready-to-wear is unable to apply to them. Therefore, we need new sizing system.

2. Pattern construction

The main posture of the paraplegics using wheelchairs is the sedentary posture. So we tried to make sure that the parts of the body in the sedentary posture which are easy to be measured can be applied to the pattern. Also we used the analysis of the skin elasticity in accordance with the posture change in making the pattern.

1) Experimental pattern

As the result of the anthropometric measurement on 30 subjects paraplegics, we chose 98cm of sitting waist circumference and 102cm of sitting hip circumference as the master size since it is close to the average as well as it is in high frequency. With this, we constructed a experimental pattern which is 26cm of crotch length, 107cm of pants length, and 22cm of pants hole. Since the waist circumference of paraplegics is expected to be bigger, the waist circumference of the pattern was made to cover 5cm. To make it possible, we used the rubber material for the back waist part so as to adjust the measurement. We think that it is the feature of the functional clothes which the disabled people need. Also it seems to be good that it relieves the pressure on the waist. The drafting procedure is as follows.

(1) Waist circumference line

This line seems to have ease-amount due to the usage of the sitting waist circumference, we added 0.5cm as

ease-amount and 1.5cm to cover the measurement of the waist circumference, so the line became $W/4+9.5\text{cm}$.

(2) Hip circumference line

This line also has ease-amount, but we added 2.5cm ($H/4+5\text{cm}$) because of the users sitting all day and the consideration of using a urine bag.

(3) Total crotch length

In the front part, the value measured from waist line to hip line to thigh line in the supine posture is smaller than one measured in the sedentary posture, so there occur pleats. The calculated elasticity is 68cm, so we gave 6cm to the front waist circumference in order to have enough waist line, which make comfortable. In the back part, the value measured from waist line to hip line to thigh line becomes bigger so the back waist line goes down. Thus, the calculated elasticity is 810cm, so we gave 8cm to the back waist line so as to balance the waist line.

(4) Pants length

When taking a measurement of the length from thigh to knee to calf in the front and the back part respectively, the front part goes 35cm long in the sedentary posture and the back part goes 12cm short. Therefore, we added 3cm of pants length in order to prevent the climb of pants hem when users sitting at wheelchairs.

(5) Position of pockets

We suggested two types of pockets in the front based on the result of the survey(K. I., Kim, 2003), and checked which part of the pocket is more convenient in the wearing test. The back pocket was made at the point of 5cm below the knee line on the side(within) line parts of pants(the left part), and size of pocket was made hang up a half respectively in the front and back.

2) Wearing test of experimental pattern

(1) External appearance evaluation

In the wearing test, we corrected some problems shown on the calculated evaluations of two evaluation groups. The dissatisfying dimensions in the appearance are ease-amount and the crotch curved line in hip circumference line, and pleats in the abdominal part. So we had to consider the ease-amount in the abdominal and the hip region. When selecting the front pocket, we gave a higher score to the welt pocket positioned on the calf

circumference line rather than to the inseam pocket on the side line. Instead, we lessened 2cm of the pocket size in order to prevent the pocket entrance from widening. With ease in the knee part, we added 2cm. Most subjects were satisfied with our making the length of the zipper long for the urine bag. The back pocket(bound pocket) positioned on the inner side seam of pants was attached too low below the knee line. So we drew the center of the pocket 3.5cm below the knee line.

(2) Functional evaluation

The subjects personally conducted the functional evaluation on how they felt their clothes while taking simple motions. The items of each part got relatively high scores because each part had spacious ease-amount. In the dimensions regarding motion, the region for belt and the length of zipper received a high score, which meant they satisfied the subjects. In case of the pocket, they gave a high score to the welt pocket positioned on the calf circumference line. The back pocket received a comparatively low score because of the inconvenience of the usage. However, this study focused on the pants for going-out only and the paraplegics who activity of upper half of the body possible, so we excluded the evaluation dimension regarding easiness of put on and take off.

3) Construction of final pattern

We completed the final pattern for the master size after revising the regions pointed out as problems in the wearing test. Instead of showing some formulae in accordance with the size of the pattern as the existing studies did, we made every part calculated the absolute value in order for everyone to design the drafting method easily(Fig. 1).

(1) Dimensions of needed measurement

The master size in the dimension of the anthropometric measurement is 98cm of sitting waist circumference, 102cm of sitting hip circumference, 107cm of pants length, 26cm of crotch length, and 21cm of pants hole breadth.

(2) Drafting method

<Drafting the basic line>

① Draw the crotch line on the pants length and the

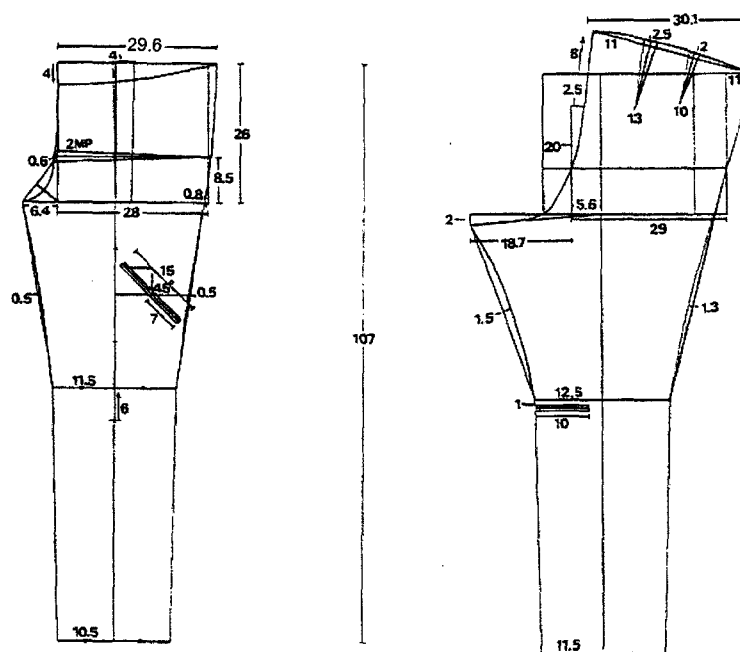


Fig. 1. Final pattern of pants

crotch length, and set the hip circumference line at $H/12$ cm above the crotch line.

- ② Set the knee line at 6cm above the half point between the pants length and the crotch length.

<Drafting the front part>

- ① Draw a perpendicular line at the point of $H/4 + 2.5$ cm moved 0.8cm from the crotch line. The bisector line of $H/4 + 2.5$ cm is the front center-line.
- ② At the crossing point between the waist circumference line and line $W/4 + 5.1$ cm is the measurement including the pleats (4cm).
- ③ Extent $H/16$ cm of the front crotch extension line connect by curve.
- ④ Let the pants holes be 10.5cm from the front center-line respectively.
- ⑤ Let the width of the knee line be 11.5cm from the front center-line.
- ⑥ The big pleats line begins at the point of 0.5cm left from the center-line, and its length is 4cm.
- ⑦ Draw the side line of the pants naturally.
- ⑧ Down 4cm from the front waist circumference, let M.P be 2cm from hip circumference line to crotch curve.

- ⑨ The pocket is positioned at the point which the half point between the knee line and the crotch line meets the half point between the knee line and thigh line. At this point, turn it at the angle of 45 degree from left, then draw the center-line of the pocket. Draw up 8cm and draw down 7cm from the center-line respectively.

- ⑩ The waist line starts at a right angle. The width of the belt is 3.7cm in consideration of the measurement change in the sewing procedure. With the waist shape remained, fold the part corresponding to the big pleats in order to improve the fitness around the waist.

<Drafting the back part>

- ① Set 11.5cm of pants hole and 12.5cm of the knee line width, which are 1 cm longer than those of the front part.
- ② At the point of $H/16 - 0.8$ cm from left from the center-line of the crotch line, draw up 20cm of a perpendicular line. Let the degrees of an angle 2.5cm.
- ③ The hip circumference is $H/4 + 5.6$ cm at point of the crotch line.
- ④ Connect the waist line with the point which the

extension line from the seam line of the hip meets the line of $w/4+5.6\text{cm}$.

- ⑤ Extend $H/6+1.7\text{cm}$ of the rear crotch extension line, set the line 2cm below.
- ⑥ Attach a long dart at 11cm right from the back waist center-line, whose size is 2.5cm and whose length is 13cm. And attach a short dart at 11cm left from the side waist point, whose size is 2cm and whose length is 10cm.
- ⑦ The position of the pocket is on the inner side seam of pants. Draw the center-line of the pocket at 1.5cm below the knee line. And draw 10cm in the front and 5cm in the back respectively.

4) Wearing evaluation

(1) external appearance evaluation

Table 5 indicates the result of the wearing evaluation on the appearance of the final pattern. All the dimensions

received excellent scores over grad of 4.0, and showed 93% of confidence. Among them, the position of the waist line and its ease-amount received the high score grade of 4.45 and 4.41 each. The ease-amount in the hip circumference also received a high score(4.41). The pleats on the abdominal part gained a relatively high score (4.50), which was a problem in the experimental pattern. The pants hole and the pants hem received excellent scores(4.50 each), especially they received high points in the position and the size of the pocket.

(2) Functional evaluation

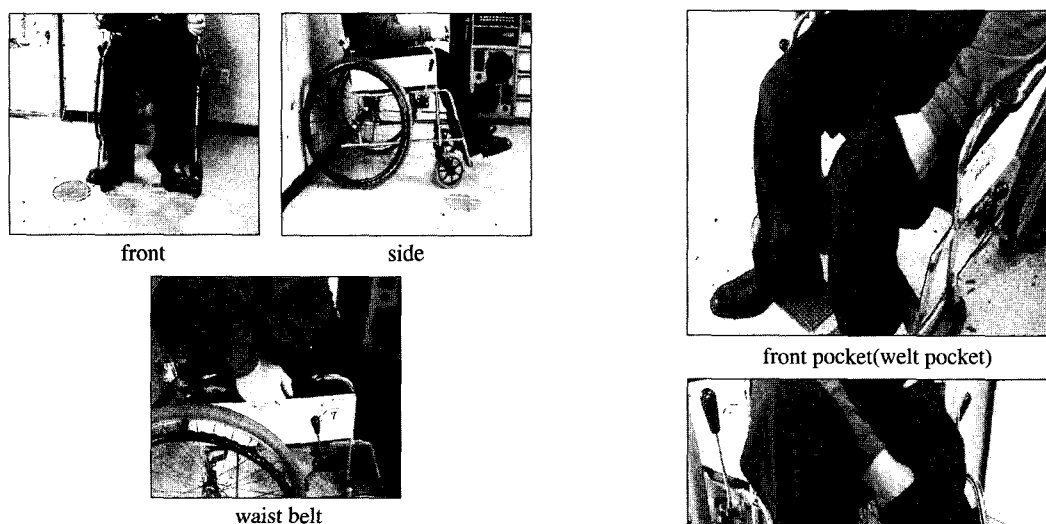
Table 6 shows the result of the functional evaluation according to the degree to feel while wearing clothes. In spite of lessening the ease-amount in the experimental pattern, all the dimensions received grades over 4.0, and showed 87% of confidence. Especially, the convenience of the waist circumference and the position of the pocket received high scores over 4.6.

Table 5. The result of wearing evaluation about external appearance in final pattern

questions of evaluation		M	S.D.
front	1. Is the position of the waist line good and well-balanced?	4.45	0.50
	2. Is the ease-amount of the waist circumference suitable?	4.41	0.58
	3. Is the ease-amount of the hip circumference suitable?	4.41	0.50
	4. Is the ease-amount of the crotch curved line suitable?	4.04	0.35
	5. Is the pleats in the abdominal region suitable?	4.50	0.51
	6. Is the front center-line straight?	4.50	0.51
	7. Is the position of the front pleats suitable?	4.41	0.50
	8. Are the position and the size of the pocket suitable?	4.16	0.38
	9. Is the crease of the pants vertical?	4.58	0.58
	10. Is the length of the zipper suitable?	4.00	0.51
	11. Is the ease-amount of the thigh circumference line suitable?	4.50	0.51
	12. Is the ease-amount of the knee region suitable?	4.58	0.50
	13. Is the breadth of the pants hole suitable?	4.50	0.51
	14. Is the pants hem horizontal?	4.50	0.51
	15. Is the pants length suitable?	4.12	0.33
	16. Is the width of the belt suitable?	4.66	0.48
side	1. Is the position of the waist line good and well-balanced?	4.58	0.50
	2. Is the position of the side line suitable?	4.58	0.50
back	1. Is the position of the waist line good and well-balanced?	4.50	0.51
	2. Is the position and the length of the back dart suitable?	4.37	0.49
	3. Is there any pleats in the hip region?	4.66	0.48
	4. Is the position and the size of the pocket suitable?	4.12	0.33
	5. Is the back center-line straight?	4.58	0.50
whole	1. Is the whole ease-amount suitable?	4.58	0.48
	2. Is the whole external appearance good?	4.33	0.48
	3. How is compared with other clothes?	4.33	0.28
total	How is the general evaluation?	4.33	0.48
calculation of Cronbach Alpha		0.9309	

Table 6. The result of wearing evaluation about functional in final pattern

questions of evaluation		M	S.D.
rignon evaluation	1. Is the waist circumference convenient?	4.66	0.57
	2. Is the abdominal circumference is convenient?	4.33	0.57
	3. Is the hip circumference is convenient?	4.67	0.57
	4. Is the crotch part in the pants convenient?	4.34	0.57
	5. Is the side line convenient?	4.00	0
	6. Is the knee part convenient?	4.33	0.57
	7. Is the thigh part convenient?	4.66	0.57
motion evaluation	1. When bending the waist, is the belt convenient?	4.60	1.15
	2. Is the position of the front pocket good?	4.33	0.56
	3. Is the position of the rear pocket good?	4.00	0
whole	In general, Are the ease-amount and the external appearance suitable?	4.67	0.57
total	When wearing the pants, is it easy to move and convenient?	4.66	0.57
calculation of Cronbach Alpha		0.8756	



Photograph 1. The features of wear pant.

5) An actual object production

Photograph 1 and Photograph 2 shows the subjects wearing the clothes and using the pocket after making a real one of the master size.



Photograph 2. The features of pocket use.

3. Grading

1) Sizing system

Taking into consideration that paraplegics have big waist circumferences, we considered the waist circumference as the main item in setting the sizing system. As of the marking method of the measurement, we set the body measurements that were the sitting waist circumference, the

Table 7. Sizing system for paraplegics

sitting waist circumference – sitting hip circumference	
size (cm)	83-90
	88-93
	93-97
	98-102(master size)
	103-107
	108-111
	113-114

(unit: cm)

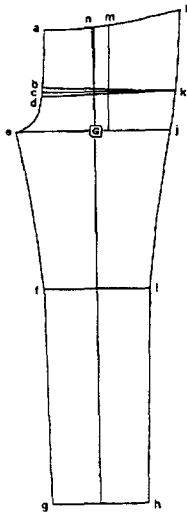


Fig. 2. Grading rule (front)

point	axis	grading rule of each size						
		83-90	88-93	93-97	98-102	103-107	108-111	113-114
a	X	+0.9	+0.6	+0.3	0	-0.3	-0.6	-0.9
	Y	-0.6	-0.4	-0.2	0	+0.2	+0.4	+0.6
b	X	+0.9	+0.7	+0.4	0	-0.4	-0.7	-0.9
	Y	-0.9	-0.6	-0.3	0	+0.3	+0.6	+0.9
c	X	+0.9	+0.7	+0.4	0	-0.4	-0.7	-0.9
	Y	-0.9	-0.6	-0.3	0	+0.3	+0.6	+0.9
d	X	+0.9	+0.7	+0.4	0	-0.4	-0.7	-0.9
	Y	-0.9	-0.6	-0.3	0	+0.3	+0.6	+0.9
e	X	+2.1	+1.5	+0.8	0	-0.8	-1.5	-2.1
f	X	+0.45	+0.3	+0.15	0	-0.15	-0.3	-0.45
g	X	+0.45	+0.3	+0.15	0	-0.15	-0.3	-0.45
h	X	-0.45	-0.3	-0.15	0	0.15	0.3	0.45
i	X	-0.45	-0.3	-0.15	0	0.15	0.3	0.45
j	X	-2.1	-1.4	-0.6	0	+0.6	+1.4	+2.1
	Y	-2.1	-1.4	-0.6	0	+0.6	+1.4	+2.1
k	X	-2.1	-1.4	-0.6	0	+0.6	+1.4	+2.1
	Y	-0.9	-0.6	-0.3	0	+0.3	+0.6	+0.9
l	X	-2.1	-1.4	-0.6	0	+0.6	+1.4	+2.1
	Y	-0.9	-0.6	-0.3	0	+0.3	+0.6	+0.9
m	Y	-0.6	-0.4	-0.2	0	+0.2	+0.4	+0.6
n	Y	-0.6	-0.4	-0.2	0	+0.2	+0.4	+0.6

(unit: cm)

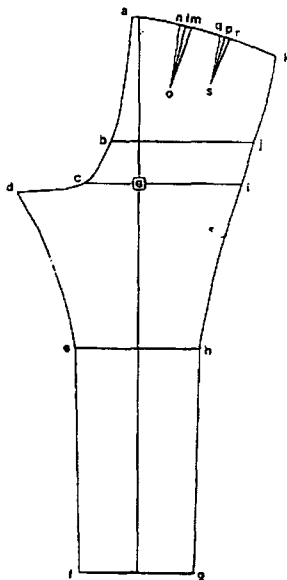


Fig. 3. Grading rule (back)

point	axis	grading rule of each size						
		83-90	88-93	93-97	98-102	103-107	108-111	113-114
a	X	+1.3	+1.0	+0.6	0	-0.6	-1.0	-1.3
	Y	-0.6	-0.4	-0.2	0	+0.2	+0.4	+0.6
b	X	+0.9	+0.7	+0.4	0	-0.4	-0.7	-0.9
	Y	-0.6	-0.4	-0.2	0	+0.2	+0.4	+0.6
c	X	+1.2	+0.9	+0.5	0	-0.5	-0.9	-1.2
d	X	+2.4	+1.8	+1.0	0	-1.0	-1.8	-2.4
e	X	+0.45	+0.3	+0.15	0	-0.15	-0.3	-0.45
f	X	+0.45	+0.3	+0.15	0	-0.15	-0.3	-0.45
g	X	-0.45	-0.3	-0.15	0	+0.15	+0.3	+0.45
h	X	-0.45	-0.3	-0.15	0	+0.15	+0.3	+0.45
i	X	-1.8	-1.4	-0.8	0	+0.8	+1.4	+1.8
j	X	-2.4	-1.8	-1.0	0	+1.0	+1.8	+2.4
	Y	-0.9	-0.6	-0.3	0	+0.3	+0.6	+0.9
k	X	-2.4	-1.8	-1.0	0	+1.0	+1.8	+2.4
	Y	-0.6	-0.4	-0.2	0	+0.2	+0.4	+0.6
l	X	+1.3	+1.0	+0.6	0	-0.6	-1.0	-1.3
	Y	-0.6	-0.4	-0.2	0	+0.2	+0.4	+0.6
m	X	+1.3	+1.0	+0.6	0	-0.6	-1.0	-1.3
	Y	-0.6	-0.4	-0.2	0	+0.2	+0.4	+0.6
n	X	+1.3	+0.1	+0.6	0	-0.6	-1.0	-1.3
	Y	-0.6	-0.4	-0.2	0	+0.2	+0.4	+0.6
o	X	+1.3	+1.0	+0.6	0	-0.6	-1.0	-1.3
	Y	-0.6	-0.4	-0.2	0	+0.2	+0.4	+0.6
p	X	-2.4	-1.8	-1.0	0	+1.0	+1.8	+2.4
	Y	-0.6	-0.4	-0.2	0	+0.2	+0.4	+0.6
q	X	-2.4	-1.8	-1.0	0	+1.0	+1.8	+2.4
	Y	-0.6	-0.4	-0.2	0	+0.2	+0.4	+0.6
r	X	-2.4	-1.8	-1.0	0	+1.0	+1.8	+2.4
	Y	-0.6	-0.4	-0.2	0	+0.2	+0.4	+0.6
s	X	-2.4	-1.8	-1.0	0	+1.0	+1.8	+2.4
	Y	-0.6	-0.4	-0.2	0	+0.2	+0.4	+0.6

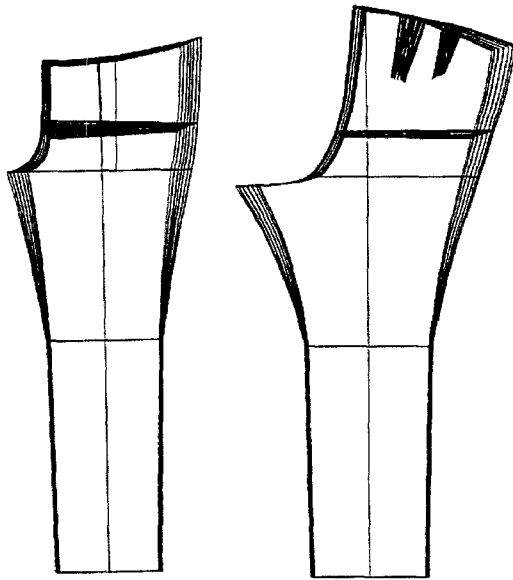


Fig. 4. The result of the grading

sitting hip circumference in that order. Table 7 shows 7 size that we set.

The variance of the waist circumference was 5cm, while those of the hip circumference were 3, 4, and 5cm. As feature of paraplegics, their waist circumferences are very big but the gap with the hip circumference is small. That's why there occur irregular variances in the hip circumference.

2) Grading rule

In consideration of the body shape and the form of the human body, we enlarged or contracted in the proper rate to the pattern in order not to make damage to silhouette. So we conducted grading with the pattern 98-102 as the standard. Fig. 2 and Fig. 3 shows the study grading rule on 3 large and 3 small measurement respectively. The result of the grading is shown on Fig. 4.

Table 8. The result of external appearance evaluation of grading pattern

questions of evaluation		88-93			108-111		
		M	S.D.	t-value	M	S.D.	t-value
front	1. Is the position of the waist line good and well-balanced?	4.50	0.53	0.04	4.25	0.46	10.5
	2. Is the ease-amount of the waist circumference suitable?	4.63	0.51	0.80	4.12	0.64	1.43
	3. Is the ease-amount of the hip circumference suitable?	4.38	0.51	0.04	4.25	0.46	0.68
	4. Is the ease-amount of the crotch curved line suitable?	4.00	0	0.11	4.00	0	0.11
	5. Is the pleats in the abdominal region suitable?	4.38	0.51	0.36	4.12	0.35	3.68
	6. Is the front center-line straight?	4.50	0.53	0.00	4.37	0.51	0.36
	7. Is the position of the front pleats suitable?	4.13	0.35	2.28	4.12	0.35	2.28
	8. Are the position and the size of the pocket suitable?	4.00	0	1.50	4.00	0.75	0.68
	9. Is the crease of the pants vertical?	4.13	0.35	4.34*	4.00	0	0.82
	10. Is the length of the zipper suitable?	4.13	0.35	0.41	4.12	0.35	0.41
	11. Is the ease-amount of the thigh circumference line suitable?	4.63	0.51	0.36	4.37	0.51	0.36
	12. Is the ease-amount of the knee region suitable?	4.63	0.51	0.04	4.50	0.53	0.16
	13. Is the breadth of the pants hole suitable?	4.75	0.46	1.50	4.37	0.51	0.36
	14. Is the pants hem horizontal?	4.38	0.51	0.36	4.25	0.46	1.50
	15. Is the pants length suitable?	4.13	0.35	0.00	4.00	0	1.07
	16. Is the width of the belt suitable?	4.38	0.51	2.12	4.37	0.51	2.12
side	1. Is the position of the waist line good and well-balanced?	4.25	0.46	2.73	4.25	0.46	2.73
	2. Is the position of the side line suitable?	4.13	0.35	5.64*	4.12	0.35	2.64
back	1. Is the position of the waist line good and well-balanced?	4.25	0.46	1.50	4.00	0	0.75
	2. Is the position and the length of the back dart suitable?	4.13	0.35	1.73	4.00	0	0.45
	3. Is there any pleats in the hip region?	4.25	0.46	4.57*	4.00	0	0.51
	4. Is the position and the size of the pocket suitable?	4.63	0.51	0.03	4.37	0.51	2.50
	5. Is the back center-line straight?	4.13	0.35	5.64*	4.25	0.46	2.73
whole	1. Is the whole ease-amount suitable?	4.38	0.51	0.04	4.25	0.46	0.18
	2. Is the whole external appearance good?	4.25	0.46	0.48	4.12	0.35	1.26
	3. How is compared with other clothes?	4.00	0	0.68	4.00	0	0.68
total	How is the general evaluation?	4.00	0	3.75	4.00	0	3.75
calculation of Cronbach Alpha		0.7931			0.8538		

Table 9. The result of functional evaluation of grading pattern

questions of evaluation		88-93		108-111	
		score	t-value	score	t-value
rignon evaluation	1. Is the waist circumference convenient?	4.00	1.00	4.00	1.00
	2. Is the abdominal circumference is convenient?	4.00	0.25	4.00	0.25
	3. Is the hip circumference is convenient?	4.00	1.00	4.00	1.00
	4. Is the crotch part in the pants convenient?	4.00	0.25	4.00	0.25
	5. Is the side line convenient?	4.00	0.00	5.00	0.00
	6. Is the knee part convenient?	4.00	0.25	5.00	1.00
	7. Is the thigh part convenient?	4.00	1.00	5.00	0.25
motion evaluation	1. When bending the waist, is the belt convenient?	4.00	0.25	4.00	0.25
	2. Is the position of the front pocket good?	4.00	0.06	4.00	0.06
	3. Is the position of the back pocket good?	5.00	1.00	4.00	0.25
whole	In general, Are the ease-amount and the external appearance suitable?	4.00	0.00	5.00	0.25
total	When wearing the pants, is it easy to move and convenient?	4.00	1.00	4.00	1.00

3) Wearing test

For the fitness of the grading rule, we made smaller and bigger pants, and conduct the wearing evaluation on each subject corresponding to each size. Table 8 and Table 9 show the result of the external appearance evaluation and the functional evaluation between the master pattern and the grading prototype. Both the size of 83-93 and the size of 108-111 received the satisfying scores over 4.00. In the significance examination for each dimension, the small size had some dimensions shown significance, which we think that the lower half of the subjects body is slightly bent as well as they are paralyzed. Except that, we could get the same result as the master pattern.

IV. Conclusions

This report studied the male paraplegics in order to develop the pants with high fitness and to suggest the pants pattern which will make ready-to-wear.

The study results are as follows.

1. We found that the waist circumference and the abdominal circumference of paraplegics are much bigger than those of the normal people. So we thought that new sizing system is needed for them. We finally analyzed that the pattern should be constructed on the basis of the measurement measured in the sedentary posture.

2. To make the pattern ready-made pants, we constructed the pattern by the master size and used the absolute value. We used 98cm of the sitting waist circumference, 102cm of

the sitting hip circumference, 107cm of pants length, 26cm of crotch length. With these measurements, the wearing evaluation received excellent grades.

3. With the measurement value of the subjects, we analyzed the frequency of the measurement and set 7 different sizing system and established the study grading rule. We could examine the fitness by receiving excellent scores in the wearing evaluation on the size of 88-93, and the size of 108-111.

This study conducted the anthropometric measurement on only 30 subjects paraplegics, living in Busan, so it had the limitation of the subject number. And it constructed a pattern and conducted the grading with only one design. So its result should be interpreted carefully. Also, persistent and systematic studies from various fields are needed in order to design the various clothes with beauty and functionality for the physically handicapped people.

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