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Clothing Pressure of selected Support Panty Stockings

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Abstract : The purpose of the study was to obtain the basic data on the self-adjusting ability of the support panty stockings. Ten healthy women in the twenties were selected as subjects and clothing pressure of 9 support panty stockings made of single covered yarn (SCY) and double covered yarn (DCY) were measured under the standard environmental condition for the study. Data was analysed statistically according to body postures, sides, and parts. The results were as follows: Clothing pressure according to body posture was order of 'sitting-on-a-chair', 'stepping-up-a-stair', and 'standing'. High clothing pressure was obtained in the parts of calf (9.4 gf/cm^2) in 'standing' and knee (9.7 and 16.5 gf/cm^2) in both 'stepping-up-a-stair' and 'sitting-on-a-chair', respectively. The order of clothing pressure with body sides was 'front', 'side', and 'back'. The highest clothing pressure was knee (18.8 gf/cm^2) on the front, thigh (8.8 gf/cm^2) on the side, and calf (6.4 gf/cm^2) on the back. Clothing pressure of DCY at abdomen and knee was a little higher than those of SCY. 3. In terms of material structure variation, clothing pressure of thigh, calf and ankle with SCY was a little higher than those with DCY, while clothing pressure of abdomen and knee with DCY was a little higher than those with SCY.

Key words : support panty stocking, clothing pressure, single covered yarn (SCY), double covered yarn (DCY)

INTRODUCTION

Stockings, one of the most essential clothing for women in the all range of age throughout the year, are defined as a full-length close-fitting covering for the foot and leg (Linton, 1979). Stockings were first made around the 16th century with their advantage of protecting skin when they were used inside the hard and rough boots. Since the knitting machine for stockings had been invented by William Lee in 1859, several kinds of stockings started to be produced.

Currently, the use of support stockings made of PU (polyurethane) covered with nylon yarn is getting increased rather than the use of mono-stockings made of nylon yarn only or wool stockings. SCY has three kinds of size of S, M and L but the free size is getting increased due to the increase of use of support stockings. DCY has better tactile sensation, quality, elasticity and improvement in its loose fitting than SCY.

However, it has no classified sizes due to its good elasticity (Kim, 1992).

Support panty stockings originally had been developed for the treatment of varicose patients having problem in the flood of blood when they had to stand or sit for a long time causing pooling of blood in the lower limbs. It is therefore appropriate to say that support stockings have the effects on stimulating venous flood and preventing leg edema in the lower limbs (Yoneda, 1982). In addition to these medical effects, properties such as durability, elasticity and wearing sensation has been highly improved and consumers thought on the support panty stockings that it is a kind of throwing away thing have changed into that it is an important accessory for one's style, so they have come in several different kinds of color, design, and pattern these days (Kim, 1992).

Foreign studies related to physiological responses of the support panty stockings have been reported about subjects such as status, clothing pressure (Ito *et al.* 1994; Momota *et al.*, 1995) warming effect (Otomasu *et al.*, 1990), skin troubles (Morooka *et al.*, 1993), physiological effects (Morise *et al.*, 1978; Ishibashi *et al.*, 1973) and etc. Domestic studies have been reported about clothing pressure (Kim, 1987), physiological responses (Park, 1997), body temperature (Ryu, 1994) and etc.

In this study, nine different types of support panty stockings available on the market were selected for measuring, analyzing, and comparing clothing pressure by material structure, body postures, body phase and parts to provide basic data on the compliance of the comfort support panty stockings.

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Table 1. Physical characteristics of subjects and the comparison to '97 standard physical characteristics and the results for this study

Subject	Height (cm)	Body weight (kg)	Waist girth (cm)	Abdomen girth (cm)	Hip girth (cm)	Thigh girth (cm)	Knee girth (cm)	Calf girth (cm)	Ankle girth (cm)	Waist length (cm)	Gluteal length (cm)	Hip length (cm)	Rohrer index[a)]	B.S.A (m^2)[b)]
A	160.5	48.6	65.2	74.9	87.4	50.9	32.8	33.0	19.2	98.9	31.3	20.8	117.5	1.444
B	160.2	48.6	65.4	75.0	88.8	52.3	33.0	32.2	19.2	98.5	28.6	20.9	118.2	1.442
C	161.4	56.1	70.5	79.5	92.3	55.0	35.4	33.9	21.2	101.6	30.3	20.9	133.5	1.545
D	160.6	51.0	64.6	75.3	89.0	55.7	35.5	36.0	21.3	100.2	29.8	21.5	122.9	1.475
E	158.0	51.0	69.6	76.4	89.7	56.6	34.2	33.7	20.1	95.1	26.6	21.1	129.3	1.460
F	158.2	47.9	64.8	76.4	89.0	53.4	34.3	34.6	20.0	99.0	29.9	20.9	120.3	1.421
G	162.6	53.3	64.4	77.0	91.1	57.7	35.5	35.9	21.5	105.1	30.4	22.4	123.9	1.517
H	161.4	53.6	69.8	83.9	92.0	54.1	34.8	34.4	20.4	103.3	30.0	22.3	127.4	1.514
I	159.0	50.6	66.0	76.5	91.0	54.4	34.8	32.7	21.0	100.4	29.8	21.8	125.9	1.461
J	160.2	50.5	68.2	77.2	89.4	53.8	34.3	35.0	20.8	98.4	28.0	20.98	122.8	1.467
Means	160.2	51.1	66.9	77.2	89.9	54.4	34.5	34.1	20.5	100.1	29.4	21.4	124.2	1.439
S.D	1.46	2.58	2.45	2.70	1.53	2.00	0.96	1.29	0.83	2.80	1.35	0.62	4.96	10.64
'97 Means	160.0	52.2	65.5	79.3	89.2	52.3	33.9	33.8	23.4	97.9	29.1	20.1	125.9	1.452
S.D	5	6	4.9	5.8	4.4	3.9	1.9	2.2	1.2	3.8	2.2	2.4	14	10.98
t-value	-0.22	1.35	-1.65	2.1	-1.30	-1.55	-3.31***	-1.85	-0.83	-0.80	11.11***	-2.65	-0.03	0.19

***p<0.001

a) Rohrer Index= $W/H^3 \times 10^7$

b) Body Surface Area = $W^{0.444} \times H^{0.663} \times 88.83$

EXPERIMENTAL

Subjects

Based upon the National Anthropometric Physique Survey in 1997 (KRISS, 1997), ten adult females in the twenties who are close to the average in their size were used as the subjects and their physical features were shown in Table 1.

The t-test analysis for the comparison of physical conditions of the subjects and those of the average in the above report in 1997 was carried out. The results showed that average knee girth of subjects was shorter than that of the standard in 1997 ($p<0.001$) However, there was no significant difference of weight between two groups, so it was safely to say that the subjects were similar to the standard in 1997 in their physical conditions in general.

Environmental conditions

Measurements were conducted in the environmental laboratory of Daegu Catholic University from April 18th, 1998 to May 25th, 1998 with preparatory process from April 10th, 1998 to April 17th, 1998 in advance.

The experimental temperature was set to $20 \pm 0.1^{\circ}C$, the humidity was set to $65^{\circ}C \pm 5\%RH$ and the air current was set to less than 0.1 m/sec.

Specimens

Nine kinds of support panty stockings of free size, including seven kinds in the domestic market and two kinds made in Japan were used as the specimens. Physical features were shown in Table 2.

Measuring method

Measuring points : The Martin's anthropometric instrument (Yamakoshi Seisakusho Co. LTD.) was used for measuring physical measurements.

Basic points and lines for measuring were firstly marked with elastic cords, and the subjects were posed on the anthropometric instrument standing straight. Then, required points were marked on the front and back central lines on the right leg, and waist, abdomen, femur, knee, crus and ankle points on the right side line were marked with water marking pen.

The eighteen marking points on the front, back and side phases of the lower limb were referred to the National Anthropometric Survey in 1997 (KRISS, 1997) and shown in Fig. 1.

Measuring postures : Measurement were also conducted in three postures of standing posture, sitting-on-a-chair posture and stepping-up-a-stair posture. Each posture was shown in Fig. 2.

① Standing posture : posture fixing both heel each

Table 2. Specification of fabrics for support panty stocking

Sample	Textile structure	Yarn count (denier)	Fabric count (yarn/5 cm)	Thickness (mm)			Weight (g)	Foot shape	Price (₩)
			Wale× Course	Belt	Welt	Leg			
A	SCY	PU 16.0 NY 15.0	951× 10	1.32	0.60	0.29	25.21	cylinder	2800
B	SCY	PU 18.0 NY 15.0	90× 120	1.36	0.59	0.30	25.03	leg	3500
C	SCY	PU 20.0 NY 20.0	100× 80	1.17	0.62	0.23	23.28	leg	2450
D	SCY	PU 20.0 NY 15.0	95× 110	1.26	0.54	0.27	24.04	cylinder	1500
E	SCY	PU 20.0 NY 20.0	105× 120	1.36	0.54	0.29	28.45	cylinder	4500
F	SCY	PU 23.0 NY 17.1	105× 100	1.27	0.50	0.27	25.26	cylinder	2000
G	DCY	PU 20.0 NY 10.0	50× 40	1.63	-	0.36	35.08	cylinder	4000
H	DCY	PU 30.0 NY 20.0	70× 70	1.40	0.39	0.26	23.81	leg	2450
I	DCY	PU 35.1 NY 15.6	100× 100	1.18	0.51	0.26	26.50	cylinder	2500

Note) PU: polyurethan, NY: nylon, SCY: single covered yarns, DCY: double covered yarns

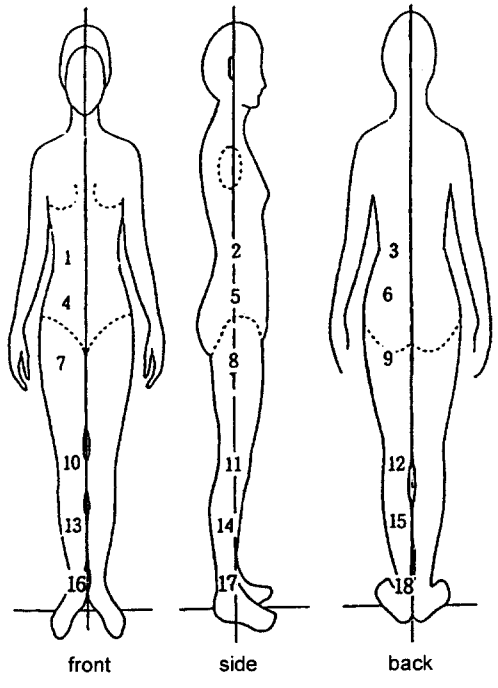

Fig. 1. Measuring points.

other, opening front of feet by 45° angle, straightening waist naturally and looking at the front.

② Sitting-on-a-chair posture : posture sitting on a chair with waist straighten.

③ Stepping-up-a-stair posture : posture stepping up a stair of 17 cm high.

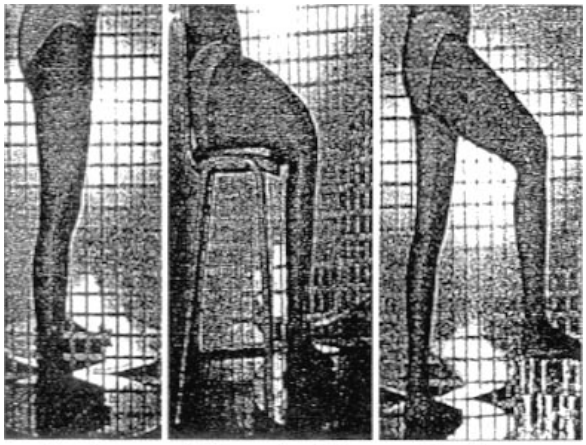

Fig. 2. The postures measurement.

Measure of clothing pressure : The subjects wearing short shirt and pants were equipped with air packs on each measuring point of ankle, calf, knee, thigh and waist on the front, side and back phase, then wore the support panty stockings. When all preparations were completed, clothing pressure was measured in three postures.

The equipment used for measuring clothing pressure was AMI 3037 from AMI Co. Ltd., a contact pressure measuring instrument which had air packs as the sensor for clothing pressure (Fig. 3).

Measuring method consisted of equipping with air

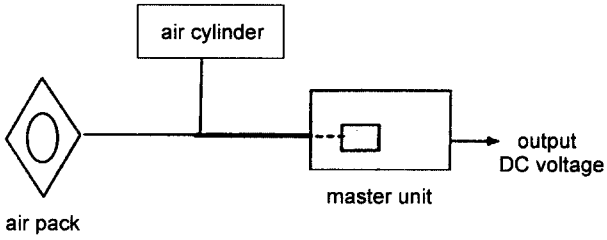

Fig. 3. Specifications of the measuring instruments.

packs in the form of soft bag. When the air packs were pressed, and the internal pressure would be transferring into the sensors of the master unit through the fine tube, and outputting in the form of DC voltage. The contact pressure measuring instrument had advantages of high precision and easy maintenance (Yoshimura *et al.*, 1983).

RESULTS AND DISCUSSION

Table 3 showed distributional analysis of clothing pressure of panty stockings and Table 4 showed average values of clothing pressure and standard deviation measured according to specimen, body posture, body phase and part.

This confirmed significant differences ($p<0.001$) in variables including stockings, body posture, sides and part. In addition, there were significant secondary cross effects in specimen and sides, specimen and part, body posture and part, sides and part. There was significant third cross effects in specimen, state and part and body posture, state and part.

Body posture and clothing pressure

Fig. 4 showed that the distributional analysis of variance of clothing pressure according to body postures had significant differences ($p<0.001$) graphically. It could be said that clothing pressure at the parts of waist, abdomen, thigh, knee and calf was higher in sitting-on-a-chair posture than in other postures, and clothing pressure at the part of ankle was higher in standing posture than in other postures.

In standing posture, clothing pressure of calf (9.4) and thigh (7.7) was the highest, while that of abdomen (4.9) and ankle (5.8) was the lowest. In sitting-on-a-chair posture, clothing pressure of knee (16.5) and calf (10.1) was the highest, while that of ankle (4.0) and abdomen (5.0)

Table 3. Analysis of variance

Factor	DF	SS	MS	F
A	1	0.01	0.01	4.75*
B	2	0.36	0.18	107.56***
C	2	1.14	0.57	339.22***
D	5	2.24	0.45	266.41***
A× B	2	0.00	0.01	0.31
A× C	2	0.00	0.00	0.63
A× D	5	0.02	0.00	2.40*
B× C	4	0.42	0.10	61.10***
B× D	10	1.14	0.11	67.53***
C× D	10	2.94	0.29	174.24***
A× B× C	3	0.00	0.00	0.35
A× B× D	10	0.01	0.00	0.68
A× C× D	10	0.04	0.00	2.64*
B× C× D	20	2.08	0.10	61.80***
A× B× C× D	15	0.00	0.00	0.16
Error	4169	6.91	0.00	

*p<0.05, ***p<0.001
A : stockings, B : postures, C : sides, D : parts

Table 4. Clothing pressure from subjects wearing support panty stocking (unit : gf/cm^2)

Posture		Part	Waist			Abdomen			Thigh			Knee			Calf			Ankle		
		State	f	s	b	f	s	b	f	s	b	f	s	b	f	s	b	f	s	b
Standing	SCY	Mean	9.31	12.91	6.60	4.58	6.96	2.78	10.52	7.32	6.91	2.93	5.02	8.20	13.37	8.73	7.49	6.84	4.15	7.02
		S.D.	1.29	2.05	2.43	0.61	1.13	0.89	0.79	1.17	1.70	0.85	1.17	1.88	1.79	1.07	1.40	1.61	0.85	0.99
	DCY	Mean	8.65	11.89	6.75	4.62	6.73	3.54	9.04	6.56	6.01	3.92	4.27	6.99	12.39	8.27	6.39	5.36	4.47	7.01
		S.D.	1.77	2.46	4.87	1.49	1.80	1.54	0.96	1.87	3.04	1.01	0.84	1.85	1.96	0.51	1.36	1.05	1.11	2.88
Sitting on the chair	SCY	Mean	13.44	13.36		3.32	6.39		8.89	10.48		28.33	3.32		12.24	8.24		5.38	2.98	
		S.D.	0.61	2.28		0.42	1.32		0.74	1.38		1.82	0.99		1.38	1.10		1.38	0.69	
	DCY	Mean	11.67	11.54		3.87	6.19		7.97	9.51		31.38	2.90		11.95	7.85		4.33	3.16	
		S.D.	1.37	2.95		1.82	1.71		0.63	1.19		5.03	0.64		0.82	0.58		0.66	1.15	
On stairway	SCY	Mean	10.04	13.59	7.47	3.37	7.23	2.93	11.02	9.07	5.90	22.19	3.82	3.97	12.44	7.90	6.30	5.87	2.72	5.05
		S.D.	1.36	1.70	2.89	0.46	0.97	0.64	1.08	1.13	1.34	2.04	1.02	1.56	1.08	1.07	1.02	1.32	0.79	0.89
	DCY	Mean	9.79	12.15	6.70	3.22	7.03	3.72	10.73	8.93	5.55	25.00	3.57	2.41	11.95	7.61	5.86	4.94	3.31	4.71
		S.D.	1.68	2.81	4.40	1.83	1.57	1.62	1.03	1.26	2.71	4.02	0.46	0.65	0.93	0.54	1.83	0.76	0.65	2.18

Note) f : front s : side b : back

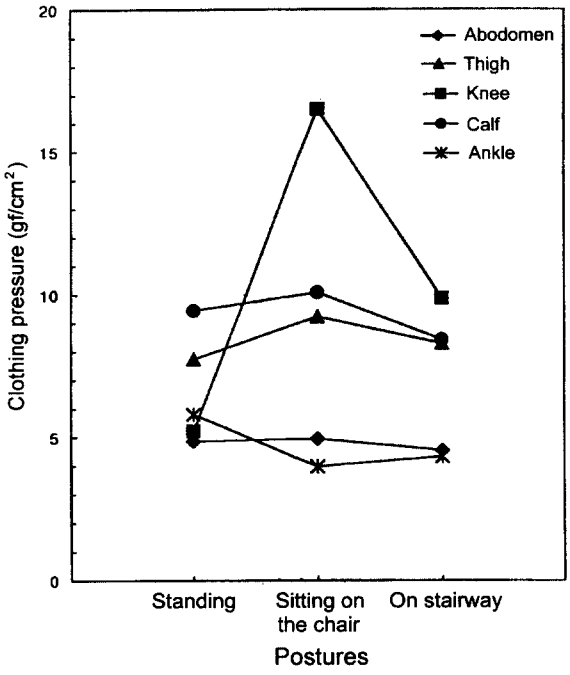

Fig. 4. Clothing pressure with postures.

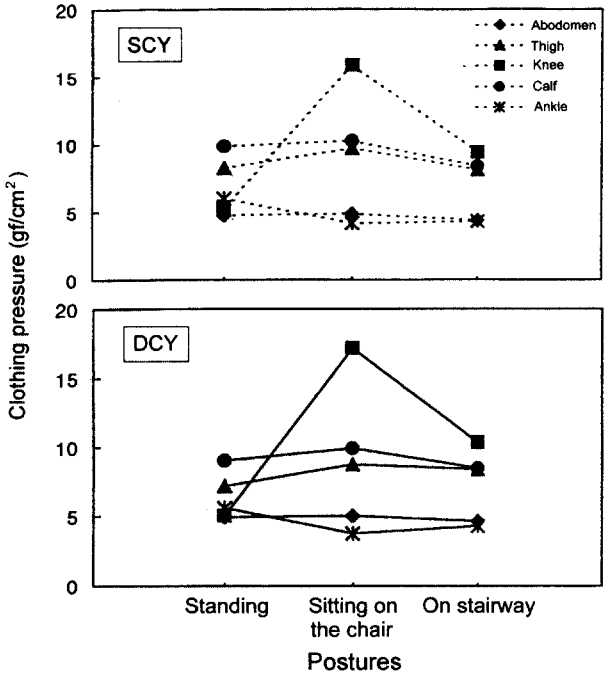

Fig. 5. Clothing pressure with postures and textile structure SCY: single covered yams, DCY: double covered yarns.

was the lowest. In stepping-up-a-stair posture, clothing pressure of knee (9.9) and calf (8.4) was the highest, while that of ankle (4.3) and abdomen (4.5) was the lowest. The tendency of sitting-on-a-chair and stepping-up-a-stair posture was very similar.

The highest clothing pressure was knee (16.5) and calf (10.1) in sitting-on-a-chair posture and the lowest clothing pressure was ankle (4.0) in both sitting-on-a-chair and stepping-up-a-stair posture among all postures.

The highest clothing pressure was shown in sitting-on-a-chair posture and followed by stepping-up-a-stair and standing postures, which was in agreement with previous reports (Cho *et al.*, 1987) indicating that the greater motile angle of lower limb was, the more clothing pressure increased.

Fig. 5 showed distributional analysis of clothing pressure and material structure, which showed no significance between them, so just clothing pressure at the part of knee showing somewhat different tendency deserved to deal with.

Clothing pressure of SCY panty stockings at the part of knee increased by 69% and 294% in the sitting-on-a-chair posture compared with those in the stepping-up-a-stair and standing postures, respectively, and increased by 74% in stepping-up-a-stair posture compared with that in standing posture. In case of DCY panty stockings, clothing pressure increased by 66% and 339% in the sitting-on-a-chair posture compared with those in the stepping-up-a-stair and standing postures respectively, and increased by 204% in stepping-up-a-stair posture compared with that in standing posture were shown.

Therefore, clothing pressure of SCY at the part of knee has been increased by 6% compared with that of DCY in the standing posture, while decreased by 8% and 10% compared with those of DCY in the sitting-on-a-chair posture and stepping-up-a-stair posture, respectively.

Clothing pressure of both SCY and DCY panty stockings was the highest in the sitting-on-a-chair posture and followed by the stepping-up-a-stair posture and standing posture accordingly.

There was no significant difference in clothing pressure by knitting structures of SCY and DCY, which was supposed to be due to the fact that DCY and SCY had similar yarn thickness.

Physical parts and clothing pressure

Fig. 6 showed the result of distributional analysis of parts and clothing pressure.

There was significant difference ($p<0.001$) and the results were as follows. Clothing pressure at the side of waist was 12.53 gf/ which showed 19% and 85% increases compared with 10.51 gf/ at the front and 6.76 gf/ at the back, respectively, and 56% increase at the front compared with that at the back.

Above results revealed that clothing pressure at the front was the highest in knee and followed by calf, thigh,

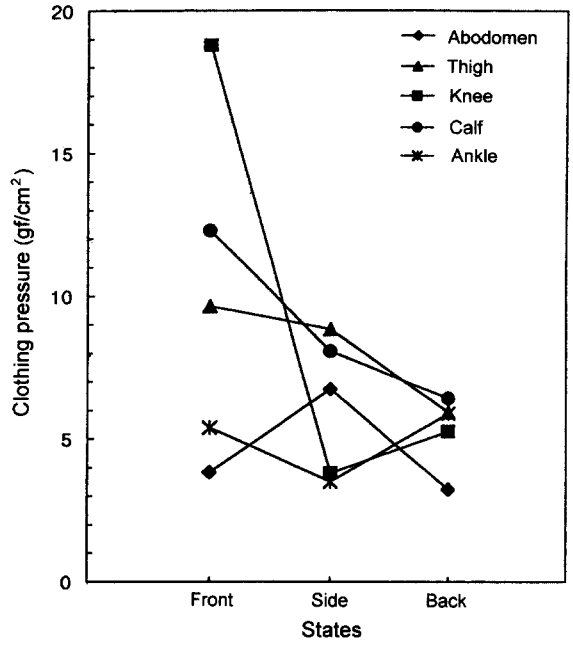

Fig. 6. Clothing pressure with states.

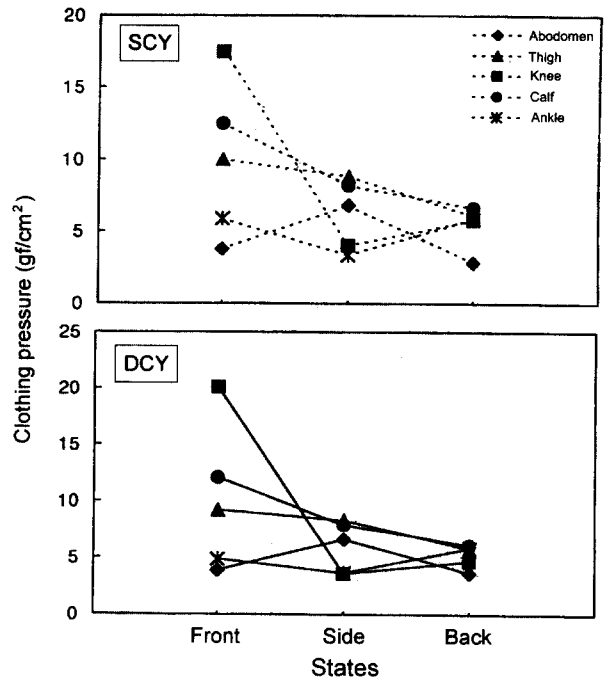

Fig. 7. Clothing pressure with states and textile structure. SCY : single covered yarns, DCY : double covered yarns.

ankle and abdomen, the highest in thigh, calf, abdomen, knee and ankle at the side, and in order of calf, thigh, ankle, knee and abdomen at the back.

Clothing pressure of knee (18.8) and calf (12.3) at the front was the highest, while that of abdomen (3.8) and ankle (5.4) was the lowest. Clothing pressure of thigh (8.8) and calf (8.0) at the side was the highest, while that of ankle (3.5) and knee (3.8) was the lowest. Clothing pressure of calf (6.4) and thigh (5.9) at the back was the highest, while that of abdomen (3.2) and knee (5.2) was the lowest.

The highest clothing pressure was knee (18.8) at the front and thigh (8.8) at the side and the lowest clothing pressure was abdomen (3.2) at the back and ankle (3.5) at the side among all positions.

In general, clothing pressure at the front was the highest and followed by those at the side and at the back, which was concluded that the knee part with high clothing pressure at front had less subcutaneous fat and received more pressure by bending movement based on the previous studies (Song, 1986) implying that the more subcutaneous fat physical part had, the less pressure the part received.

Fig. 7 showed differences of clothing pressure between material structures in terms of physical parts, indicating that there was significant changes ($p<0.005$).

Clothing pressure of waist, thigh, calf and ankle with SCY was a little higher than those with DCY, while clothing pressure of abdomen and knee with SCY a little higher than those with SCY.

In SCY, clothing pressure of knee at the front (17.5) was the highest, while that of abdomen at the back (2.8) was the lowest. In DCY, clothing pressure of knee at the front (20.1) was the highest, while that of knee at the side (3.6) was the lowest.

High pressure at the waist seemed to be due to the thick waist band and somewhat short waist girth.

Clothing pressure of both SCY and DCY products in terms of parts was the highest at the front and followed by the side and the back.

CONCLUSIONS

This study has been performed to provide basic data for compliance of comfort support panty stockings. For the study, clothing pressure by material, posture, phase and physical part were measured and the data was statistically analyzed and compared. The results obtained were as follows:

1. Clothing pressure according to body posture was order of 'sitting-on-a-chair', 'stepping-up-a-stair', and 'standing'. High clothing pressure was obtained in the parts of calf (9.4 gf/cm^2) in 'standing' and knee (9.7 and 16.5 gf/cm^2) in both 'stepping-up-a-stair' and 'sitting-on-a-chair', respectively.

2. The order of clothing pressure with body sides was 'front', 'side', and 'back'. The highest clothing pressure

was knee (18.8 gf/cm^2) on the front, thigh (8.8 gf/cm^2) on the side, and calf (6.4 gf/cm^2) on the back. Clothing pressure of DCY at abdomen and knee was a little higher than those of SCY.

3. In terms of material structure variation, clothing pressure of thigh, calf and ankle with SCY was a little higher than those with DCY, while clothing pressure of abdomen and knee with DCY was a little higher than those with SCY.

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