

Study on the Clothing Pressure Developed by Yukata

—In Special Reference to Deformation of Dressing and Sensory Evaluation—

Tamaki MITSUNO and Kazuo UEDA*

*Graduate School of Home Economics, Kyoritsu Women's University, Hachioji 193-8501, Japan*** Faculty of Home Economics, Kyoritsu Women's University, Hachioji 193-8501, Japan*

In this paper, yukata-pressure at rest-standing, degree of slippage (the amount of kikuzure (deformation of dressing)) caused by bowing, its sensory evaluation, and body proportions were investigated using the SPEARMAN ranking correlation. Subjects were 5 women aged 20 to 30 years old. Yukata-pressures measured by a hydrostatic pressure-balanced method were changed by many factors, such as respiratory movements, body movements, and so on. The yukata-pressures were generated mainly at the abdomen. The highest pressures were recorded on the horizontal plane between the yukata and the koshi-himo (cord around the hip) under the obi at rest-standing (10.7 ± 9.7 mmHg (14.6 ± 13.2 gf/cm²)) and seiza-sitting (18.9 ± 10.8 mmHg (25.7 ± 14.7 gf/cm²)). It was found that the greater the difference between bust girth and below bust girth, the greater the slippage on the chest. The degree of slippage on the right side line correlated with the extent of tightening of the koshi-himo, and it was determined that pressure should not exceed 20 mmHg (27 gf/cm²). Moreover, as the slippage on the chest increased, the intensity of the pressure sensation decreased.

(Received April 24, 1997; Accepted in revised form December 4, 1997)

Keywords: clothing pressure, yukata, sensory test, comfortability, figure, deformation of dressing.

INTRODUCTION

It is said that the kimono worn by Japanese women at the present is "kosode" which first appeared as an upper garment in the Muromachi period (Nakajima 1966). We give the name of Japanese clothes "wafuku" to the kimono, in contrast to Western clothes "yofuku" which began to be worn in the Meiji and Taisho eras.

Scientific research on wearing comfort of Japanese clothes was first presented by Otake and Sanari (1961) on obi-pressures. Afterwards, Akaboshi and Nakahashi (1972) reported on wafuku-pressures generated by accessories. However, there has been no research of clothing pressures based on human factors such as physical constitutions of subjects, body positions, body movements, respiratory movements, and sensory evaluation, among others.

The present study forms a first series on the clothing pressure developed by yukata (the simplest Japanese clothing) and its purpose is to clearly show the relationship between clothing pressures (yukata-pressure) and "kikuzure" (deformation of dressing)

caused by body movements. First of all, this paper describes a topography of yukata-pressures developed in two different postures (rest-standing and seiza-sitting (seiza: sitting posture in the formal Japanese style, namely, to sit with the legs folded under themselves on tatami or floor)), and then indicates the relationship among yukata-pressure thus obtained, sensory evaluations, respiratory movements, and physical constitutions of subjects.

We suppose that the pressures are affected greatly by the quality of "kitsuke" (to dress oneself or to have the kimono put on neatly by an expert) and the extent of "kinare" (to be accustomed to wearing the kimono), in addition to the factors mentioned above. In this paper, the "kitsuke" effect may be left out of consideration, because each subject put on the yukata by herself. We shall report the changes in the yukata-pressures with body movements and the effects of kinare on both the yukata-pressures and the wearing-comforts in coming papers.

Table 1. Physical constitution of subjects

Item (unit)	Subject 1	Subject 2	Subject 3	Subject 4	Subject 5
Age (year)	30	36	23	22	22
Height (cm)	153.9	158.9	159.5	157.7	154.0
Weight (kg)	43.0	55.0	57.0	57.0	62.0
Bust girth (cm)	75.1	89.0	89.0	84.2	93.0
Under bust girth (cm)	69.7	75.5	69.0	74.3	75.0
Waist girth (cm)	61.8	72.8	68.8	65.0	66.0
Hip girth (cm)	83.7	91.2	88.8	98.4	97.0
Rohrer index	118.0	137.1	140.5	145.3	169.8

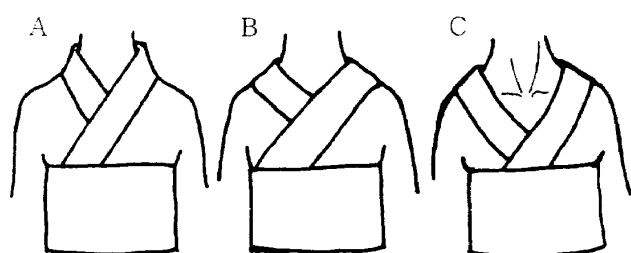


Fig. 1. Wearing appearance of the yukata

In this study, subjects wore the yukata as A and B. See text for details.

METHODS

1. Subjects, magnitude of slippage and sensory evaluation

1) Subjects

The subjects were 5 women from 20 to 30 years old, whose physical constitutions are shown in Table 1. The Rohrer index $\{\text{weight (kg)}/[\text{height (cm)}]^3 \times 10^7\}$ of each subject was calculated and is shown at the bottom line of the table. The Rohrer index stands for the degree of obesity and is defined as normal range of woman between 109 and 140. More than 156 characterizes excessive body fat (Nihon Kasei Gakkai 1991). Therefore, the figures exhibited a wide range of variation from 118.0 to 169.8.

The subjects put on the yukata samples (see 2-1)) by themselves using a han haba obi (obi in half the regular width) and two cords (Bunko musubi). The yukata samples were made to measure (see 2-2)). Measurements of the magnitude of slippage (see 1-2)), its sensory evaluation (see 1-3)), and yukata-pressure (see 3-1) and 2)) started after the subjects had worn the yukata 19 times (at least 1 h/time, a total of over 90 h). The yukata-pressure generated in the abdomen was measured at 120-210 min after meals.

2) Magnitude of slippage

First of all, we set base lines on the yukata using surgical white tape (12 mm width) immediately after being put on. Three kinds of wearing appearance of the yukata with regards to the neckline are shown in Fig 1. In Fig. 1-A and B, the opening width at the neckline was set at about three fingers' width. The difference between A and B was the degree of opening at the nape (almost no opening in A, about one fist width in B). In C, the length of the neckline was set longer than A and B, as far as a depression at the base of the neck was visible. In this study, the subjects wore the yukata as A and B. These wearing appearances were the same as those of the modern kimono in "The metamorphosis of modern kimono II" described by Daimaru (1985).

From the results of preliminary experiments, magnitudes of slippage were to be measured in 17 body regions (3 points on the chest, 3 points on each dorsal and ventral upper edge of the obi, 3 points on the dorsal¹ ohashori, 5 points on the right side line). The above measuring regions were located at intervals of about 10-15 cm on the base line. From these data, we calculated slippage per region at the chest, upper edge of obi, dorsal ohashori, and right side line, respectively.

3) Sensory evaluation

Kikuzure is concerned primarily with movements of the whole body. Kikuzure at miyatsuguchi is caused by elevations of the arms, and that at the hem is caused by movements of the legs (walking). The mechanisms for the development of kikuzure by the movements mentioned above will be reported in coming papers. In the present study, we shall report

¹ The slippage on the ventral ohashori was not measured because it was scarcely observed during bowing movements.

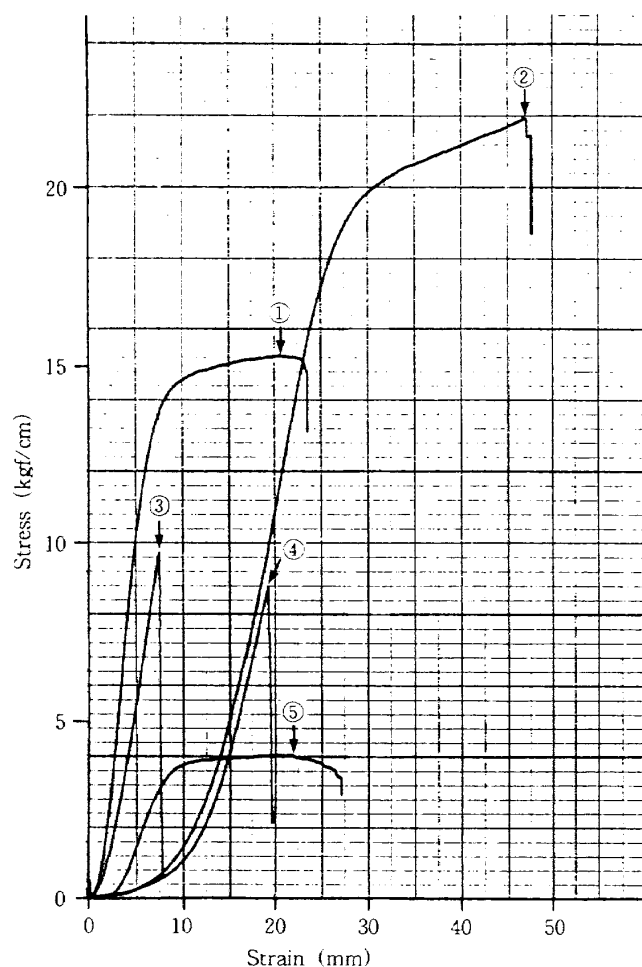


Fig. 2. Stress-strain curves of yukata, obi, and cord (himo)

The curves show the obi materials (100% wool) stretched in warp ① and weft direction ②; the yukata materials (100% cotton) in warp ③ and weft direction ④; and the cord materials (100% wool) in warp direction ⑤. Arrows indicate breaking points.

the mechanism of kikuzure caused by bowing (forward bending of the upper part of the body). The subjects wearing the yukata repeated bows at three arbitrary angles about 360 times from the straight position of the upper body at rest-standing and seiza-sitting. The subjects were requested to report on the wearing-feeling of the yukata during these body movements. In this study, intensities of pressure sensations (tightness or looseness) developed by yukata were measured in terms of the subjects' estimate on a "ratio scale." See Mitsuno and Ueda (1997) for details.

The subjects estimated intensities of pressure sensation for tightness as compared with two standard sensations ("perfect fit" as +1 and "very

tight" as +10) under 8 postural conditions: rest-standing, standing with bowing at 3 arbitrary angles, seiza-sitting, sitting with bowing at 3 arbitrary angles. In the same manner, they estimated intensities of pressure sensation for looseness taken as two standard sensations ("perfect fit" as +1 and "very loose" as +10) under the same 8 conditions. We multiplied the intensity of pressure sensation by the complaint number to score the evaluation.

2. Yukata for experimental samples

1) Physical properties of experimental samples

Yukata ($n=5$), obi, ($n=5 \times 6$, width: 15.3 ± 0.2 cm, length: 327.6 ± 3.7 cm), and cord (himo, $n=10 \times 6$, width: 4.6 ± 0.1 cm, length: 205.3 ± 0.6 cm) used in this study were obtained at a market. They were plain weaves, and their materials were either 100% cotton (yukata fabrics) or 100% wool (obi and cord fabrics). Thickness of the materials was measured by the PEACOCK DIAL THICKNESS GAUGE as 0.29 ± 0.01 mm (yukata, $n=5 \times 12$), 1.39 ± 0.06 (obi, $n=5 \times 6$) mm, and 0.31 ± 0.01 mm (cord, $n=10 \times 5$). The densities of materials were measured as 69.7 ± 2.0 warps per inch and 58.2 ± 1.8 wefts per inch (yukata, $n=5 \times 6$), 31.2 ± 1.4 warps per inch and 29.1 ± 0.5 wefts per inch (obi, $n=5 \times 6$), and 52.8 ± 2.4 warps per inch and 45.3 ± 0.9 wefts per inch (cord, $n=10 \times 6$). The tensile strength of each sample (material) in warp and weft directions, which was adjusted with the labeled stripping method, was examined by the Tensilon (UTM-250, Orientec Co.) at 10 cm catching intervals and at a velocity of 5 cm/min, in an artificial climate room (temperature: 21.0°C , relative humidity: 65.0%).

A typical example is shown in Fig. 2. Samples ① and ② were the obi materials (wool 100%) stretched in warp and weft directions; samples ③ and ④ were the yukata materials (cotton 100%) stretched in warp and weft directions. Sample ⑤ was the cord material (wool 100%) stretched in warp direction. The stress strain curves of samples ①, ②, and ⑤ resembled one another, because the materials were all 100% wool. The curves provided from samples ③ and ④ made up of the cotton material were similar to each other. However, the obi materials were stretched more about 2.3 times in weft direction (sample ②) as compared with that in warp direction (sample ①), as well as the yukata materials were stretched more about 2.5 times in weft direction (sample ④) than that in warp direction (sample ③). That is, in the obi and the yukata materials, there was a difference of stretchability not only according to the kind of material, but also according to the direction of fabric.

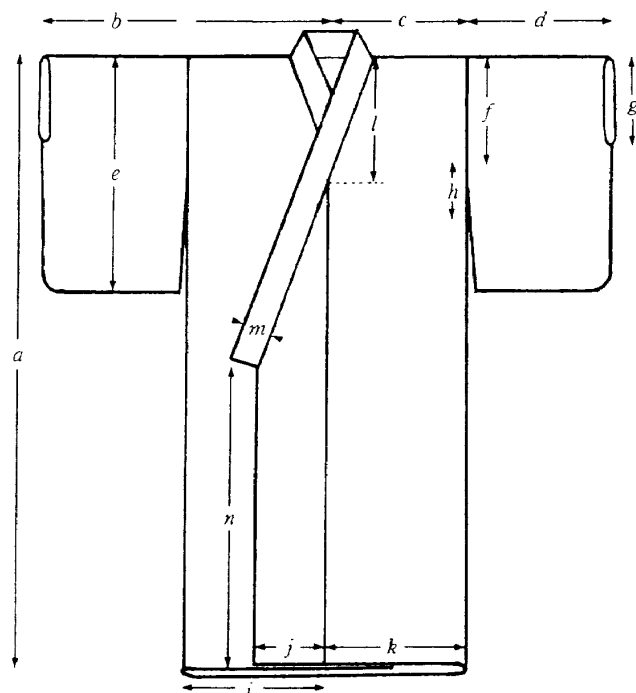


Fig. 3. Designation of the yukata (Japanese summer kimono)

a: mitake (length from shoulder to hem); *b*: yuki (width from center back seam to sleeve opening); *c*: kata-haba (shoulder width); *d*: sode-haba (sleeve width); *e*: sode-take (sleeve length); *f*: sode-tsuke (length of seam from shoulder to side opening); *g*: sode-guchi (sleeve opening); *h*: miyatsuguchi (length of side opening); *i*: ushiro-haba (a half width of body back); *j*: okumi-haba (a half width of overlap at hem); *k*: mae-haba (a half width of body front); *l*: okumi-sagari (length from shoulder to the top end of seam between okumi and front panels); *m*: eri-haba (collar width); *n*: eri-shita (length from lower edge of collar to hem).

The values of stress and extension ratios at the breaking point of each sample were respectively ① 17.5 ± 1.64 kgf/cm, $17.7 \pm 4.37\%$; ② 22.6 ± 0.45 kgf/cm, $50.6 \pm 5.10\%$; ③ 9.43 ± 0.21 kgf/cm, $6.67 \pm 1.03\%$; ④ 9.25 ± 0.46 kgf/cm, $20.3 \pm 0.94\%$; ⑤ 4.01 ± 0.23 kgf/cm, $22.1 \pm 1.01\%$, (①-④: $n=5 \times 3$, ⑤: $n=10 \times 3$). In short, the obi material was stretched easily in weft direction, while the yukata material was scarcely stretched in warp directions.

2) Dimensions of yukata

A yukata suitable for each subject was made according to her physical constitutions. Designation of the yukata is shown in Fig. 3, and dimensions of completion are indicated in Table 2. We computed dimensions suitable for each subject: mitake, yuki, sode-haba, kata-haba, mae-haba, ushiro-haba, and eri-shita, which were related to designation of height

and girth (see * marks in Table 2). Furthermore, the yukata was sewn by hand, based on the method of "oodachi onnamono hitoe nagagi" (normal cuttings of full-length kimono without a lining for women) in "Wafuku Saihou Zensho" (Complete Works of Japanese Clothes Sewing, Yamamoto *et al.* 1979).

3. Method for the measurement of yukata-pressure

1) Measuring system

The yukata-pressure were measured by a hydrostatic pressure-balanced method (Mitsuno and Ueda 1994). A diagram of the measuring system used in this research is shown in Fig. 4. Two electric signals of yukata-pressure from pressure-detector (Pouch, Nihon Kohden Co., TM-200T) and -transducer (Pressure Transducer, Nihon Kohden Co. TP-300T), and of respiratory movement from thermistor (Thermistor, Nihon Kohden Co., YSI-402J) were obtained by this system. These signals, which appeared on the oscilloscope monitor, were recorded simultaneously by a pen drawing apparatus (Pen Oscillograph, NEC Sanei Co., Omnicase RT2108A). At the same time, these signals were recorded on a magnetic tape recorder (Magnetic Recorder, TEAC, RD-111T). We recorded changes of body position and movement of subjects with the help of two video cameras (Video Camera, SONY Co., TR205) which were set at angles of 90° . Two signals from the cameras were displayed bilaterally in one image with a digital AV mixer (Digital AV Mixer, Matsushita Electrical Co., WJ-MX12). Electric signals of the yukata-pressure and the respiratory movement were superimposed on this image by using a video gram (Video Gram, Hoei Co., VG-40). In this way, time relations of 3 physiological responses (yukata-pressure, respiratory movement, body movement) were ascertained.

2) Measuring regions of yukata-pressure

Preliminary experiments showed that all the subjects complained about the wearing comfort of the brassieres for kimono use (two of five subjects (①, ④) complained of their being too loose, but, the other three subjects (②, ③, ⑤) complained of their being too tight, although the size of brassiere was regarded as suitable for each subject). On the other hand, when we tried hadajuban (underwear for kimono) on the subject without a brassiere before wearing the yukata, subject ③, who had the biggest difference between bust girth and under bust girth, complained that it gave her no satisfaction around the chest. Next, we tried to compensate the proportion in three subjects

Study on the Clothing Pressure Developed by Yukata

Table 2. Dimensions of the yukata (Japanese summer kimono) made to subject's measurements

Dimension	Subject ①	Subject ②	Subject ③	Subject ④	Subject ⑤
Mitake*	153.0	159.0	160.0	157.0	154.0
Yuki*	64.0	63.0	67.0	64.0	63.0
Sode-haba*	32.5	32.0	34.5	33.0	32.0
Kata-haba*	31.5	31.0	32.5	31.0	31.0
Sode-take	50.0	50.0	50.0	50.0	50.0
Sode-guchi	23.0	23.0	23.0	23.0	23.0
Sode-tsuke	23.0	23.0	23.0	23.0	23.0
Eri-kataaki	8.5	8.5	8.5	8.5	8.5
Miyatsukuchi	13.0	13.0	13.0	13.0	13.0
Ushiro-haba*	29.0	31.0	29.0	31.0	31.0
Mae-haba*	23.0	25.0	23.0	24.0	25.0
Okumi-haba	15.0	15.0	15.0	15.0	15.0
Okumi-sagari	23.0	23.0	23.0	23.0	23.0
Eri-shita*	76.0	79.0	79.0	78.0	77.0
Eri-haba	5.5, 6.5	5.5, 6.5	5.5, 6.5	5.5, 6.5	5.5, 6.5

* Experimental yukatas were made by these measures.

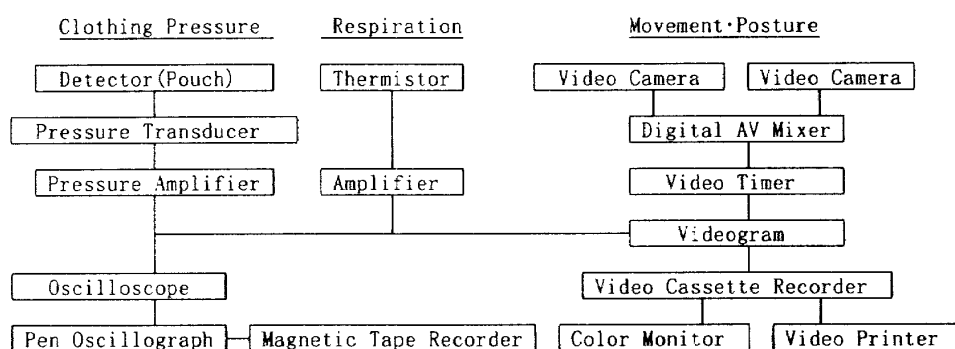


Fig. 4. Diagram of the measuring system for clothing pressure by a hydrostatic pressure-balanced method

See text for details.

by sarashi (Japanese towel), but they all complained of it being too tight before putting on the yukata. In this study, therefore, we had the subjects wear their brassieres and panties of every day use before putting on the yukata. We shall report in coming papers on the compensation of the proportion of the body.

The measuring regions of yukata-pressures are shown in Fig. 5 (see RESULTS-3 for details). The subjects wore susoyoke roughly at their waistlines. And the pressures generated in a space between the skin and the cord (himo) for susoyoke, which is described as horizontal I plane, were measured at 12 regions: 2 regions were on the anterior median line (AM) and on the posterior median line (PM), and 10 regions on the right (R) and left (L) sides were 3 cm

apart from the anterior median line (A), on the mamillary line (B), on the middle axillary line (C), on the scapular line (D), and 3 cm apart from the posterior median line (E). As for abdominally horizontal II-VIII planes as described later, we measured the yukata-pressures with 12 regions per plane as described above. The subjects put on the yukata themselves by the use of two cords (mune-himo (cord beneath the breast) and koshi-himo (cord around the hip)). The pressures generated between the yukata and each cord (II and III planes) were measured. After an obi had been tied on the cords, the pressures between the obi and the yukata on the upper edge of the obi (IV plane), on the middle of the obi (VI plane), on the lower edge of the obi (VIII plane), and between

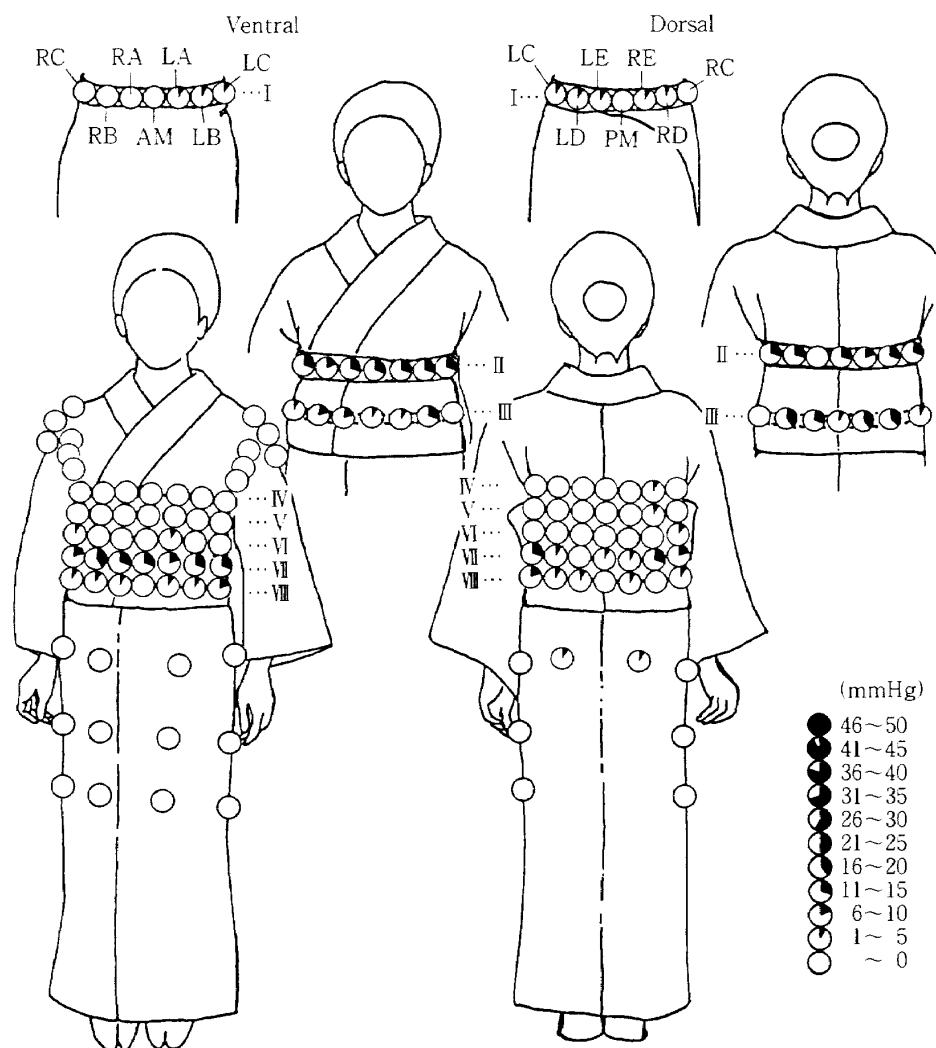


Fig. 5. Regions for measurement of yukata-pressure

The figure shows the measuring regions and a typical example of topography of yukata-pressures (subject ②). The areas of black fan in the circle correspond to magnitudes of the yukata-pressure. See text (METHODS-3-2) and RESULTS-3) for details.

the cord and the yukata on the mune-himo (V plane) and the koshi-himo (VII plane) under the obi were measured. For example, in measuring the region at the intersection of the mammillary line (B) and the upper edge of the obi (IV plane), in the left (L) half of the body, we have substituted the mnemonic name "IV-LB" in order to facilitate comparisons. The other measuring regions were 6 regions at the shoulders: bilateral acromion points on the arm side lines and 3 or 6 cm came down from them; 2 regions on both insertional tendons of the M. pectoralis major and 4 regions on 3 cm above or below them (see Fig. 5); 12 regions on the origin, center and insertion of the M. rectus femoris and M. vastus lateralis on both legs; and 2 regions on the far outside of the dorsal M.

gluteus maximus. The yukata-pressures were measured at a total of 122 regions mentioned above. The subjects tied the koshi-himo at their waistline (between the third and the fourth lumbar vertebrae), and they tied the obi to make its lower edge level at the upper rim of the navel.

RESULTS

1. Magnitude of slippage

Magnitude of slippage per region, caused by repetitions of bows about 360 times, is shown in Fig. 6. The ordinate is the magnitude of slippage per region, and the abscissa is the subjects, which is further divided into five individual sets with 4 bar graphs of slippage measured at the chest (A), the upper edge of

obi (B), the ohashori (C), and the right side line (D). In subjects ① and ④, the slippage was not particularly great, except in the region of the ohashori; in subjects ② and ③, the slippage on the chest and the ohashori was remarkable; and in subject ⑤, the slippage on all regions was great, in particular, it was distinctive on

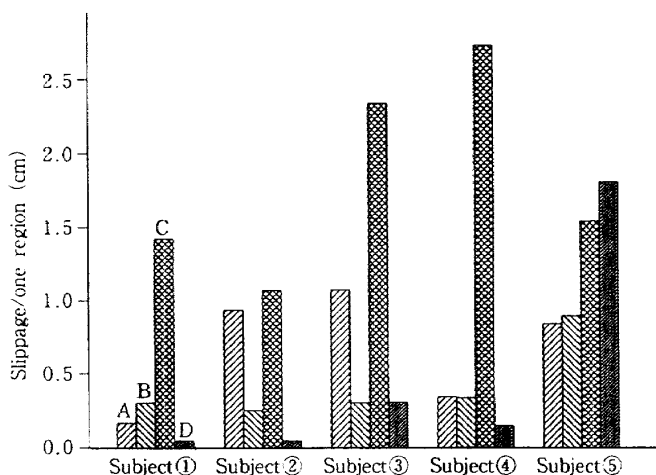


Fig. 6. Magnitude of slippage

The ordinate is the magnitude of slippage per region, and the abscissa is the subjects, which is further divided into five individual sets with 4 bar graphs of slippage measured at the chest (A), the upper edge of the obi (B), the ohashori (C), and the right side line (D). See text (RESULTS-1) for details.

the ohashori and the right side line. In this manner, the region and the magnitude of generated slippage varied among the subjects and will be classified into 3 large groups.

2. Sensory evaluation

Total scores of sensory evaluations in all subjects are shown in Fig. 7, when they changed angles of forward bending in the upper part of the body under both standing and sitting positions (8 conditions). Results were obtained by subjects ①–⑤. The left figure shows the evaluation of tightness (scored by each amount of sensation $\times$ the number of complaints), and the right figure shows that of looseness. From left to right in either figure, abscissas are rest-standing (angle 0°), standing position with 3 bow angles (averages of 3 times: 15 ± 2.0 , 45 ± 2.2 , $70 \pm 3.5^\circ$), and seiza-sitting (0°), sitting position with 3 bow angles (averages of 3 times: 15 ± 2.4 , 45 ± 3.8 , $68 \pm 5.4^\circ$).

As shown in the left figure, in the standing position, nobody complained of a tightness feeling, disregarding the bows. In seiza-sitting, however, when the upper part of the body was straight, nobody except subject ② complained about that, but as the bow angles increased, the evaluation scores increased in subjects ② and ③, who complained about tightness felt near the pit of the stomach, on the chest, and on

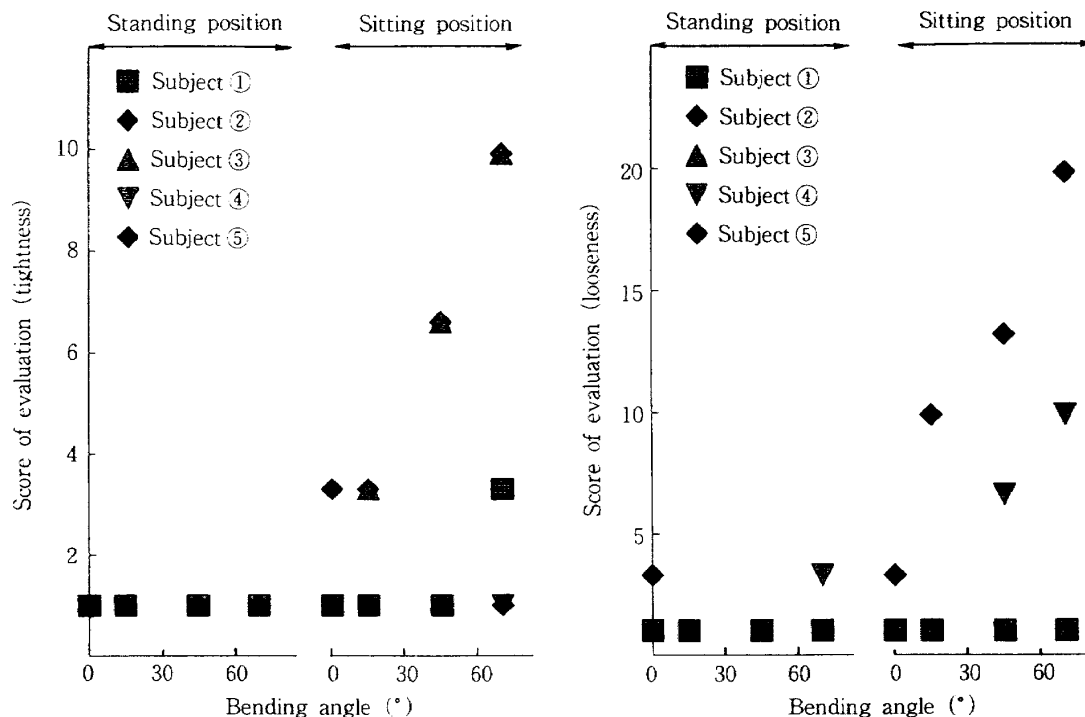


Fig. 7. Sensory evaluations of tightness (left) and looseness (right)

See text (RESULTS-2) for details.

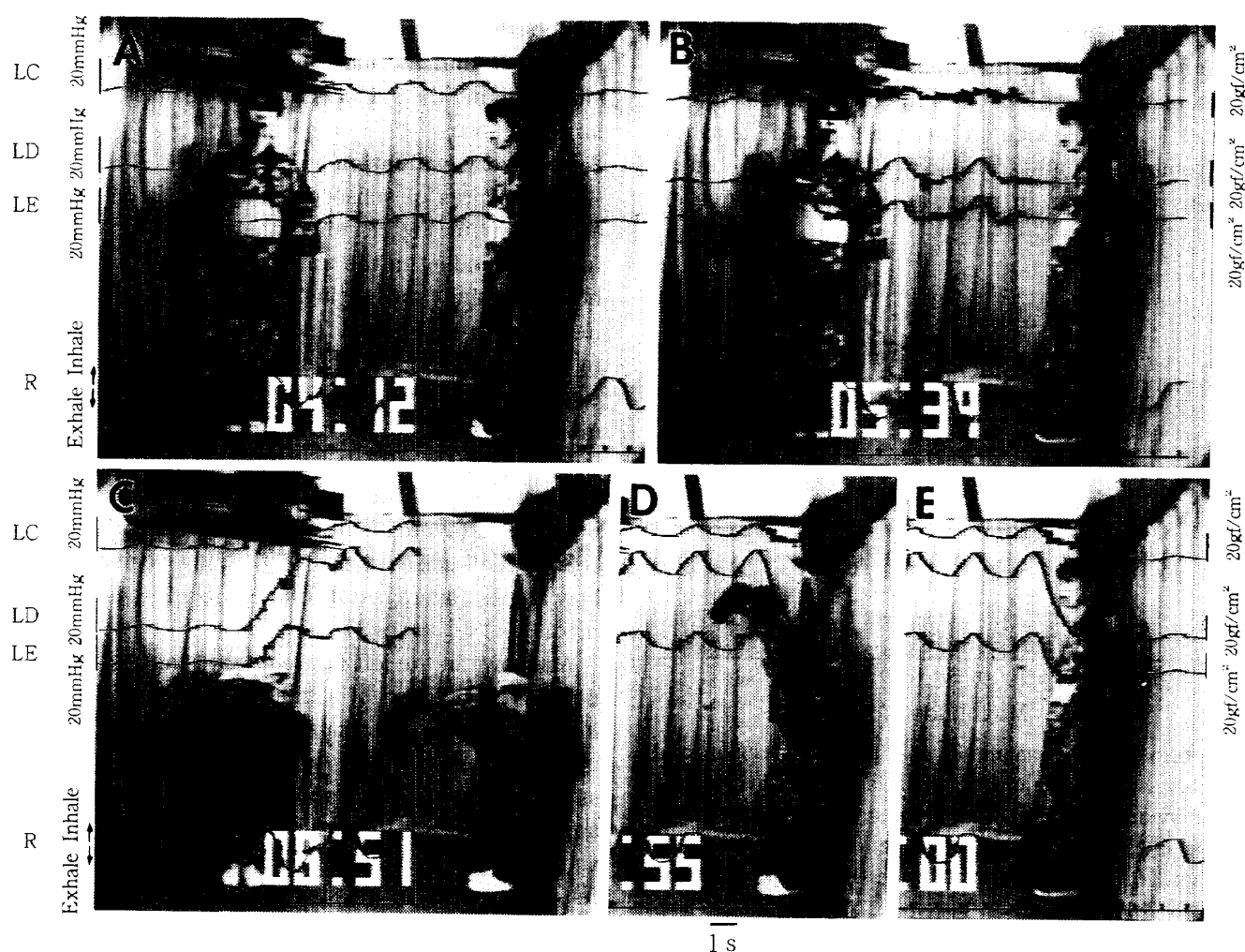


Fig. 8. Relations among yukata-pressure, respiration and body movement

A-C indicate composite images of the frontal (left side of each picture)- and the left side (right side of each picture)-views of subject 2. Superimposed traces from the topmost to the third lines are the yukata-pressures recorded at VII-LC, LD, LE (see Fig. 5). The bottom traces (R) are respiratory movements. A: The subject at rest-standing changed her respiratory conditions from natural to deep. B: The subject bowed 3 times. C-E: The subject was bent her upper half of the body at angles of (C) 70°, (D) 45°, (E) 0°. See text (RESULTS-3) for details.

the koshi-himo planes.

As for the looseness feeling as shown in the right figure, almost no subjects complained in standing position, disregarding the bows. In seiza-sitting, nobody except subject 5 complained (about looseness) when the upper part of the body was straight, but the more the bow angles increased, the more the evaluation scores increased in subjects 4 and 5, who complained about looseness which was felt on the posterior median line and on the overlap regions of the right side line.

3. Yukata-pressure

1) Yukata-pressure and respiratory movement

Pictures A-E of Fig. 8 are composite images of the frontal (left side of each picture)- and the left side

(right side of each picture)-views of the subject 2 (in pictures D and E, images of the left side are omitted) which were recorded by two video cameras which formed an angle of 90° (see METHODS-3-1)). From the upper most superimposed traces to the third one are the yukata-pressures recorded at LC, LD, LE (see Fig. 5) on the VII plane (between the koshi-himo and the yukata under the obi). The bottom traces (R) are respiratory movements showing inhalation (upward arrow) and exhalation phases (downward arrow). The time scale is shown at the bottom of picture D.

Amplitudes of the yukata-pressure signals changed synchronously with the respiratory movements. Picture B shows traces of the yukata-pressure and the respiratory movement, when the subject at standing

position made bows repeatedly 3 times, and returned the upper part of her body nearly to the original position (picture A) after the third bow. In this way, almost similar pressure changes were recorded, when the subject repeated the same body movement. This indicated a good reproduction of the experiment. Picture C shows the yukata-pressures and the respiratory movements when the upper part of the body was bent and kept as it was. The yukata-pressures changed synchronously with the respiration as mentioned above. The pressure values were kept at high level, as the subject breathed during forward-bending. In picture D (4 s after picture C), the yukata-pressures decreased when the subject returned her body position slightly. In picture E (5 s after picture D), when she returned the upper part of her body to the upright position, the yukata-pressures returned to the previous level. The yukata-pressures became high upon inhalation and low upon exhalation.

We have already reported in the previous paper (Mitsuno and Ueda 1997) that the clothing pressures obtained in both inhalation and exhalation phases coincided well with the sensory evaluations. In this paper, therefore, we recorded and analyzed the yukata-pressures obtained at the inhalation phase. The yukata-pressures were easily changed according to the movements like bows at standing position. We shall describe this in more detail in a coming paper.

2) Topography of yukata-pressure

Figure 5 shows the yukata-pressures of the subject ② at rest-standing, who had been accustomed to wearing the yukata (at least 1 h per time, wearing 19 times, a total of over 90 h). Open circles indicate the pressures from minus to 0 mmHg. The areas of black fan correspond to magnitudes of the pressure. As the pressures become high, the areas of black parts in the circle increased, and a full black circle (●) shows pressures from 46 to 50 mmHg.

Pressure was hardly generated when the subject wore only susoyoke. The pressures between yukata and koshi-himo/mune-himo were 20 mmHg at most. When the subject tied an obi on the yukata, the pressures of the mune-himo (V plane) were scarcely generated and those on the koshi-himo (VII plane) were 15 mmHg at most. When the pressures under the obi of V or VII planes were compared with those of II or III planes obtained prior to tying the obi, the former was smaller than the latter. The same results were obtained in all subjects. Pressures less than 5 mmHg were generated at the far edge of the gluteus,

while pressures were scarcely generated at the legs and at the regions from the shoulder down to the axilla.

In this way, it is concluded that the yukata-pressures at rest-standing are generated exclusively on abdominal regions. Therefore, the distribution patterns of yukata-pressures at rest-standing and seiza-sitting were focused on the abdominal regions of all subjects.

3) Distribution of yukata-pressure

Distributions of the yukata-pressures in abdominal regions of all subjects are shown in Fig. 9. The left of the figure is the distributions at rest-standing and the right one is those at seiza-sitting. The results of subjects ①-⑤ were exhibited successively from top to bottom of the figures. Furthermore, the pressure of a given subject is shown with 5 steps of vertical stripes: the upper edge of the obi, the mune-himo, the middle of the obi, the koshi-himo, and the lower edge of the obi (IV-VII planes) from top to bottom. The center of the abscissa shows the posterior median line, while the right and left sides show the anterior median lines.

At rest-standing, pressures of subjects ① and ② were hardly generated, while subject ⑤ generated higher pressures. Distributions of the yukata-pressure showed that the pressures on the koshi-himo plane (VII plane) were the highest as compared with those on the other planes, except subject ①. The averaged pressures of all subjects were, in decreasing order of magnitude, the koshi-himo plane (10.7 ± 9.7 mmHg), the mune-himo plane (4.4 ± 5.4 mmHg), the upper edge of the obi plane (4.0 ± 5.8 mmHg), the lower edge of the obi plane (2.7 ± 4.1 mmHg), and the middle of the obi plane (2.4 ± 4.0 mmHg). The significant differences (paired *t*-test, $\alpha \leq 0.01$ in all combinations) were recognized (1) between the koshi-himo (VII plane) and the mune-himo (V plane), (2) between the upper edge of the obi (IV plane) and the mune-himo/koshi-himo/middle of obi (VI plane).

When the subjects changed their body positions into seiza-sitting (right figure) from rest-standing (left figure), the density of stripes in all the subjects became high, indicating that the yukata-pressures were increased. For example, in subject ⑤ at rest-standing, yukata-pressures were generated on the koshi-himo and the dorsal upper edge of the obi planes; but at seiza-sitting, high pressures were generated not only on the koshi-himo plane but also on the lower edge of the obi plane; and the yukata-pressures became higher on the ventral

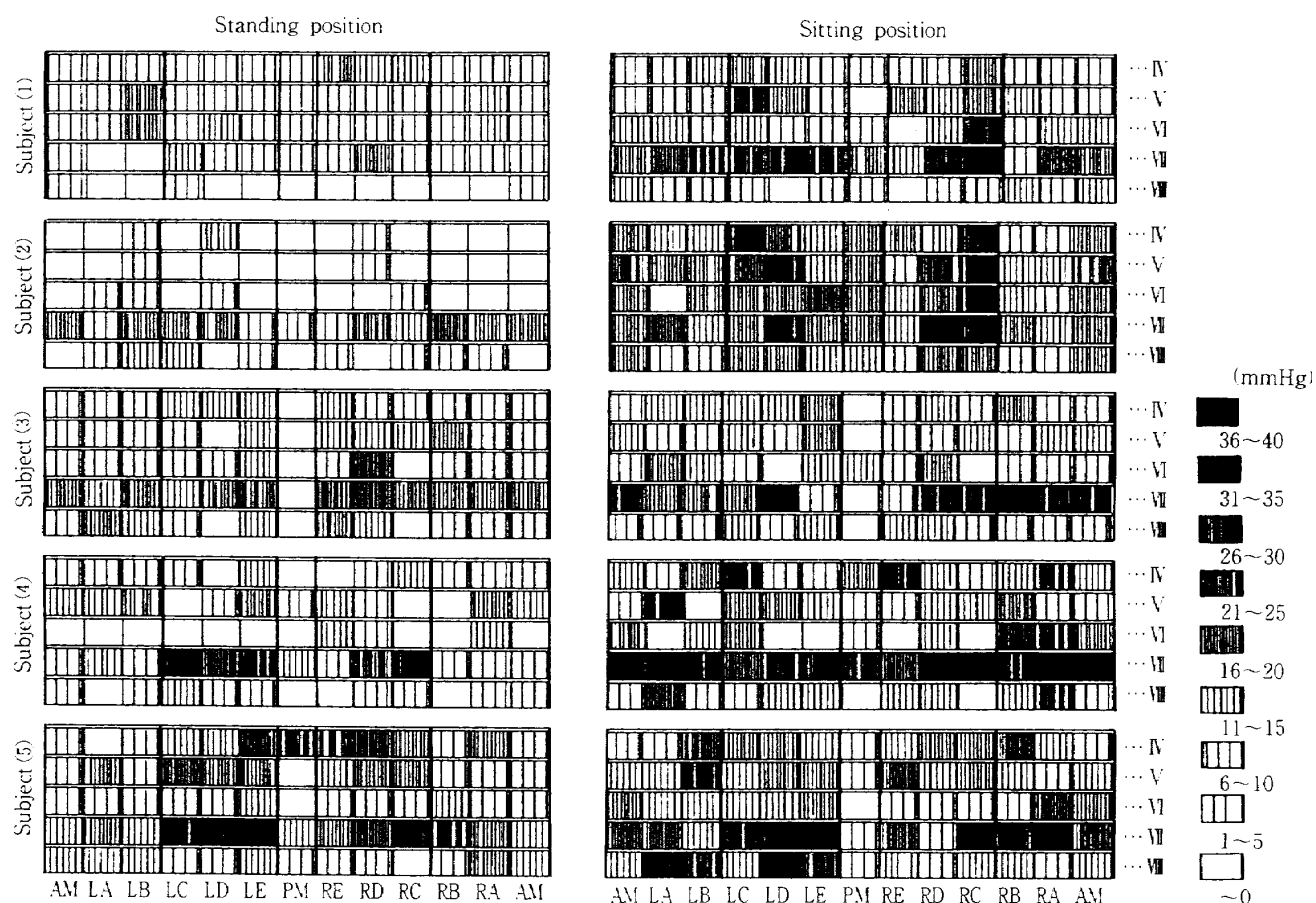


Fig. 9. Distribution of the yukata-pressure

Distribution of the yukata-pressure in abdominal regions of all subjects are shown. The center of the abscissa shows the posterior median line (PM), while the right and the left sides show anterior median lines (AM). LA-LE, RA-RE: measuring regions of the yukata-pressures. IV-VIII: IV-VIII planes. See text (METHODS-3-2) and RESULTS-3) for details.

abdomen rather than the dorsal abdomen. The averaged pressures of all subjects increased significantly ($\alpha \leq 0.01$) in all planes (IV plane: 2.3 times, V plane: 2.4 times, VI plane: 3.1 times, VII plane: 1.8 times, VIII plane: 2.7 times). The highest pressures (18.9 ± 10.8 mmHg) were generated on the koshi-himo (VII plane).

The distributions of yukata-pressures (density stripes in Fig. 9) in abdominal regions seemed to be general throughout the subjects. Significant positive correlations in vertical lines of each subject were recognized between both sides of the body (between RA and LA, RD and LD, RE and LE: $\alpha \leq 0.05$, RB and LB, RC and LC: $\alpha \leq 0.01$). In short, the relative values of yukata-pressure obtained from bilaterally symmetrical regions were very similar in all of the subjects, although the absolute ones were not.

4. Relation between yukata-pressure, sensory evaluation, proportion of the body, and magnitude of slippage

We used the ranking correlation coefficients of SPEARMAN and investigated the relation between yukata-pressure at rest-standing / proportion of the body / sensory evaluation / and magnitude of slippage. The results are shown in Table 3. The item of "yukata-pressure" was divided into 6 sub-items: respective total pressures of 5 planes (IV-VIII planes) obtained at 12 measuring regions per plane, and their grand totals. The item of "magnitude of slippage" was divided into 5 sub-items: slippage per region taken from the chest, on the upper edge of the obi, on the dorsal ohashori, on the right side line, and their grand totals. The item of "proportion of the body" was divided into 3 sub-items: the difference between bust girth and under bust girth (B-UB), between under bust girth and waist girth (UB-W), and between hip girth and waist girth (H-W). The item of "sensory

Study on the Clothing Pressure Developed by Yukata

Table 3. Relation between yukata-pressure, magnitude of slippage, proportion of the body, and sensory evaluation

Item		Yukata(Japanese summer kimono)-pressure						Magnitude of slippage				Proportion of the body			Evaluation (Pressure sense)				
Item	Sub-item	IV plane	V plane	VI plane	VII plane	VIII plane	Total	Chest	U. E. O.	Ohasyori	R. S. L.	Total	B-UB	UB-W	H-W	Upper H.	Lower H.	Right S.	Total
Yukata-Pressure	IV plane																		
	V plane	△																	
	VI plane	△																	
	VII plane																		
	VIII plane																		
	Total					○													
Slippage	Chest	▲		●															
	U. E. O.			▲		▲	▲	△											
	Ohasyori																		
	R. S. L.					○	○	○	▲										
	Total			▲		▲	▲	△	○		▲								
Proportion	B-UB	●	▲	▲				△											
	UB-W																		
	H-W		△			▲								△					
Evaluation	Upper H.																		
	Lower H.															○			
	Right S.		▲											△					
	Total						△	△				△							

Ranking correlation coefficients of Spearman were calculated from the data among the items: "yukata-pressure," "magnitude of slippage," "proportion of the body," and "evaluation." The marks for significant correlation are as follows: ○, positive ($\alpha \leq 0.01$); △, positive ($\alpha \leq 0.05$); ●, negative ($\alpha \leq 0.01$); and ▲, negative ($\alpha \leq 0.05$). The item of "yukata-pressure" consists of six sub-items; six kinds of pressures taken from IV-VIII planes (see Fig. 5) and their total amount, and so on. U. E. O., upper edge of obi; R. S. L., right side line of the body; B-UB, bust girth minus under bust girth; UB-W, under bust girth minus waist girth; H-W, hip girth minus waist girth; Upper H., upper half of the body; Lower H., lower half of the body; Right S., right side line.

evaluation" was divided into 4 sub-items: the scores reported with evaluation scores of tightness and looseness in the upper part of the body (chest and upper edge of obi), in the lower part of the body (ohashori), in the right side line, and their grand totals (see RESULTS-2). The ranking of subjects was arranged in ascending order of values in all items. For example, the premier rank of the subject was given in order of higher yukata-pressure, more amount of slippage, larger difference of girth and tighter evaluation. The combinations having positive correlation are shown by ○ (level of significance, 1%) and △ (5%), while those of negative correlation are shown by ● (1%) and ▲ (5%).

Positive correlations were found between the grand

total of yukata-pressure and the following 3 items: pressure on the koshi-himo plane ($\alpha \leq 0.01$), the magnitude of slippage on the right side line ($\alpha \leq 0.01$), and the total sensory evaluation ($\alpha \leq 0.05$). Positive correlations were also obtained in magnitude of slippage between the upper edge of the obi and the total magnitude of slippage taken from all regions. That is, when yukata-pressure was high, the pressure on the koshi-himo plane became high; the magnitudes of slippage on the upper edge of the obi and their totals decreased; and subjects answered "tight." Further, the more the yukata-pressure was increased, the more the magnitude of slippage on the right side line increased.

Positive correlations were found between "magni-

tude of slippage on the chest" and two sub-items: (1) the difference between bust girth and under bust girth, and (2) sensory evaluation. That is, the greater the difference of girth, the more the magnitude of slippage on the chest increased, and the more the subjects evaluated the yukata as being tight.

DISCUSSION

Most Japanese women do not take pleasure in wearing Japanese clothes as compared with Western clothes for many reasons: (1) feeling uneasy about kikuzure, (2) tightness of the obi (cords), (3) difficulty in moving, (4) high price, among others (Fujii 1952). Our present study concerned with (1) how to prevent kikuzure and (2) how to tie the obi (cords); in a word, how to wear the kimono, in light of the reasons described above.

Studies on comfort of Japanese clothes have been quite few compared to those on Western clothes. Otake and Sanari (1961) reported from a hygienical standpoint that obi-pressure of Japanese clothes was extremely high as compared with Western clothes. They used an elastic rubber bag as a pressure detector, though its efficient contact area was inevitably varied according to the magnitude of growing pressure. Akaboshi and Nakahashi (1972) measured wafuku-pressure with a resistance wire strain gauge as a pressure detector, as well as muscle activities and lung capabilities. They compared the differences of the pressure between the use of new accessories and traditional ones. Mitsuno and Ueda (1994) have already discussed the disadvantage of using the elastic rubber bag and the rigid sensor for the measurement of clothing pressures generated on the human abdomen. From this point, we did not suppose that both Otake and Sanari, and Akaboshi and Nakahashi have measured the clothing pressure precisely. In such circumstances, this study aimed at accurate measurements of yukata-pressure, as well as many-sided investigations.

As shown in Table 3, the kikuzure on the chest was caused by physical constitutions of the subjects: the greater the difference between bust girth and under bust girth, the more the slippage increased on the chest. As shown in Fig. 6, the kikuzure on the chest scarcely occurred in subjects ① and ④, whose differences between bust girth and under bust girth were as little as 5.4 cm and 9.9 cm respectively (see Table 1). The kikuzure on the upper edge of the obi was related to the extent of tightening the koshi-himo and obi. When the subjects were tied closely on the

middle of the obi (plane VI) and koshi-himo (plane VII), the magnitude of slippage on the upper edge of the obi decreased, but their feeling became poor. Therefore, it is ineffective or rather undesirable for reducing the magnitudes of slippage on the upper edge of the obi for the subjects to be tied too firmly by the obi and the koshi-himo at these regions (planes VI and VII). That is, to prevent the kikuzure on the chest and the upper edge of the obi, it will be useful to adjust the proportion of the body with a towel, so as to minimize the above mentioned difference. The kikuzure on the right side line was also related to the extent of tightening of the koshi-himo. The more pressure developed on the koshi-himo plane (VII plane), the more slippage on the right side line increased. In particular, much slippage was found in subjects who generated 20 mmHg more over per measuring region. Therefore, the pressure value on the koshi-himo plane should not exceed 20 mmHg.

The magnitude of slippage at the ohashori was unexplained in this study. The kikuzure never occurred unless the subject moved. That is, "clothing materials are incapable of following the skin expansion resulting from bodily motion" would be a principal cause of kikuzure. As shown in Fig. 1, yukata material (100% cotton) was scarcely stretched, and the "stretch" has never been observed so far during the body movements. Therefore, measurements of the skin expansion (see Kirk and Ibrahim 1966) are necessary for an explanation of kikuzure at the ohashori. We shall report the point under discussion in a forthcoming paper.

SUMMARY

In this paper, the relations among yukata-pressure at rest-standing, magnitude of slippage (the amount of kikuzure (deformation of dressing)) caused by bowing, its sensory evaluation and the proportion of the body were investigated with the SPEARMAN ranking correlation. Subjects were 5 women aged 20 to 30 years old. Yukata-pressures measured by a hydrostatic pressure-balanced method were changed by many factors, such as respiratory movements, body movements, and so on. The yukata-pressures were generated mainly at the abdomen of the body. The highest pressures were recorded on the horizontal plane between the yukata and the koshi-himo (cord around hip) under the obi at rest-standing (10.7 ± 9.7 mmHg (14.6 ± 13.2 gf/cm²)) and seiza-sitting (18.9 ± 10.8 mmHg (25.7 ± 14.7 gf/cm²)). The greater

Study on the Clothing Pressure Developed by Yukata

difference between bust girth and under bust girth, the more the slippage on the chest enlarged. The magnitude of slippage on the right side line was concerned with the extent of tightening of the koshi-himo, and it was suggested that the pressure should not be greater than 20 mmHg (27 gf/cm²). The more the slippage on the chest, the more the intensity of the pressure sensation decreased.

This research was supported by Grants-in-Aid for Scientific Research from the Ministry of Education, Science, Sports and Culture, Japan (05405007) and from the Center for Interdisciplinary Studies of Science and Culture, Kyoritsu Women's University.

REFERENCES

- Akabosni, T., and Nakahashi, M. (1972) The Effects of the Accessories of a Woman's "Kimono" on the Wearer—Comparative Studies on the Traditional and New Accessories— (in Japanese), *Nihon Kasei Gakkaishi (J. Home Econ. Jpn.)*, **23**, (7), 45-53
- Daimaru, H. (1985) The Metamorphosis of the Modern Kimono II (in Japanese), *Bull. Nat. Mus. Ethnol.*, **10** (1), 131-232
- Fujii, C. (1952) Wayoufuku no Ichigenka ni Taisuru Shian (in Japanese), *Nihon Kasei Gakkaishi (J. Home Econ. Jpn.)*, **3**, 9-13
- Kirk, W., Jr., and Ibrahim, S. M. (1966) Fundamental Relationship of Fabric Extensibility to Anthropometric Requirements and Garment Performance, *Textile Res. J.*, **36**, 37-47
- Mitsuno, T., and Ueda, K. (1994) The Measurement of Clothing Pressure (in Japanese), *Nihon Kasei Gakkaishi (J. Home Econ. Jpn.)*, **45**, 179-188
- Mitsuno, T., and Ueda, K. (1997) The Clothing Pressure Developed at Waistband and the Pressure Sense Estimated in a Ratio Scale (in Japanese), *Nihon Kasei Gakkaishi (J. Home Econ. Jpn.)*, **48**, 989-998
- Nakajima, K. (1966) Studies on the Character of "Genroku-Kosode" as a Design (in Japanese), *Nihon Kasei Gakkaishi (J. Home Econ. Jpn.)*, **17**, 88-95
- Nihon Kasei Gakkai (1991) *Kankyo to shiten no Hifuku*, Asakurashoten, Tokyo, 107
- Otake, K., and Sanari, I. (1961) Studies on the Sash Pressure (in Japanese), *Nihon Kasei Gakkaishi (J. Home Econ. Jpn.)*, **4**, 333-338
- Yamamoto, R., Hatae, H., Horinouchi, K., and Kusama, Y. (1979) *Shinpan Wafuku Saihou Zensho*, Dainihontoshou, Tokyo, 24-64

浴衣圧の研究

—着崩れおよび官能評価に関連して—

三野たまき, 上田一夫*

(共立女子大学家政学研究科, *共立女子大学家政学部)

原稿受付平成9年4月24日; 原稿受理平成9年12月4日

本研究では、静立位の浴衣圧・それに対する官能評価・体型・浴衣の着崩れとの関係を SPEARMAN の順位相関を用いて検討した。被験者は 20～30 歳代の成人女子 5 名であった。浴衣圧（液圧平衡法を使用）は呼吸運動や動作などの様々な因子によって変化した。浴衣圧は主に腹部に発生していた。最も高い圧が計測されたのは帯の下層の、浴衣と腰紐との間の水平面であった（静立位では 10.7 ± 9.7 mmHg (14.6 ± 13.2 gf/cm²), 正座位では 18.9 ± 10.8 mmHg (25.7 ± 14.7 gf/cm²)). トップバストとアンダーバストの差が大きい被験者ほど、胸元の着崩れ量が多かった。右脇線の着崩れ量は腰紐の締め方に依存した（20 mmHg (27 g/cm²) を超えないように、腰紐をしめるべきである）。胸元の着崩れ量が多い被験者ほど、圧感覚（締め感覚）の大きさは小さかった。

キーワード：被服圧, 浴衣, 官能検査, 快適性, 体型, 着崩れ。