A Study on Clothing Functionality of the Girdle

- Clothing comfort, mobility, and shape-controlling effect -

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Abstract: This study investigated how the difference of yarn types on girdles impacted clothing comfort, mobility and shape-controlling effect. Three girdles, which differed in size and type of spandex were used. The subjects were ten undergraduate females, and their clothing comfort was evaluated by use of clothing pressure, psychometric evaluation and ECG. The mobility was evaluated by using EMG and acceleration measurement while moving (ie. walking). In addition, the shape-controlling effect was quantitatively estimated by using a 3D measurement. As a result, the small sized girdle made from high extension and high reconstruction spandex showed medium clothing pressure, high clothing comfort, small muscle burden and high mobility, and was found to be the best of the three samples. In the shape-controlling effect, the compensation effects were recognized in several ways: the lines were smoother and the boundary lengths were smaller than those without girdles.

Key words: Girdle, Clothing comfort, Mobility, Shape-controlling

1. Introduction

In 2011, the ladies' clothing market in Japan recorded positive growth for two consecutive years[1]. This brisk performance may be attributed to the arrival in recent years of a variety of functional underwear. "Functionality" here refers to two particular aspects: "the functional properties of the fibers themselves" and "functions that are exhibited when such underwear is worn." Of all the types of functional underwear, those that conform to changes in body habitus attract particular attention, and the girdle is the most popular type of body shape-controlling underwear. Worn by women to control body shape from the abdomen down to the waist, the girdle has generally been regarded as something from which one cannot expect comfort. However, if one can overturn this kind of public perception and achieve a good balance between the shape-controlling function and comfort, it is expected that a new type girdle can be developed. The purpose of this research is to analyze the wearing comfort, ease of movement, and the shape-controlling function of a girdle made from high-performance fibers in innovative sizes. Although there are several studies about effects of girdles' design[2,3], our research is the only one to focus on the effects of fiber types.

2. Methodology

2.1 Experiment samples and subjects

As shown in Table 1, three experiment samples were prepared by using knitted fabrics made of polyurethane fibers (Asahi Kasei Fibers Corporation polyurethane elastic fiber ROICA reg. type [Sample A], and ROICA HS type [Samples B and C]) and inelastic yarns. Sample A and Sample B were prepared in the same set of sizes, but had different fiber properties, whereas Sample B and Sample C had the same fiber properties but were prepared in a different sets of sizes. Tensile testing by the A&D Company constant-rate-of-extension type tension tester RTG-1210 showed that both extensibility and reversibility were higher for Samples B and C than for Sample A (Figure 1). Concerning size variations, Samples A and B were made available in ordinary S, M, and L sizes, while Sample C items were made in half-sizes smaller, i.e., XS-S, S-M, and M-L. Ten female college students in their 20s were selected as subjects and asked to wear samples of sizes that fit their body types.

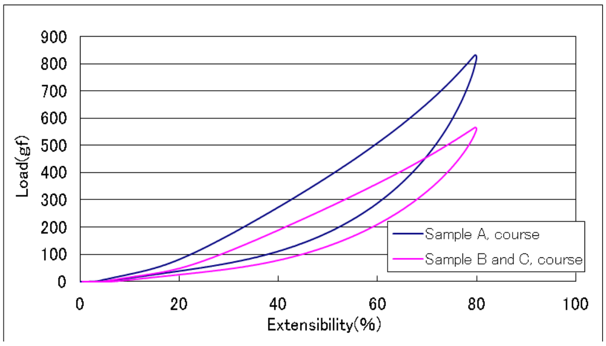

Fig. 1 Tensile testing results

Table. 1 Subjects data

Size in everyday	Subject No.	Height	Waist	Hip
S	1	146	63	86
	2	154	67	87
M	3	151	64	88
	4	160	69	92
	5	161	64	92
	6	159	67	83
	7	161	64	95
	8	159	57	86
L	9	161	69	95
	10	166	67	98

(cm)

Table 2 Experiment samples

	Sample A	Sample B	Sample C
Polyurethane fiber properties	Regular yarn	Highly extensible and reversible	Highly extensible and reversible
Sizes	S, M, L	S, M, L	XS-S, S-M, M-L

2.2 Measuring clothing pressure

Clothing pressure was measured while subjects were stationary (standing and sitting positions) and in motion (walking, up-and-down motion on the chair). For measurement, an air-pack type pressure sensor (AIM Techno Co., Ltd. AMI3037-2) and an AD converter (BIOPAC Systems Inc. MP150) were used. Measurements were taken at three regions: the abdomen (front), thighs (front), and buttocks. Sampling frequencies were 20Hz when the subjects were stationary and 200Hz when in motion. After measurements of the subjects were made while stationary and in motion, a questionnaire survey was conducted on wearing comfort-related sensations such as "tightness," "slipping," "ease of movement," and "comfort."

2.3 Measuring clothing comfort

To assess clothing comfort, physiological and psychological assessments were made by electrocardiography and semantic differential, respectively. Assuming the ordinary length of time when such clothing is worn, physiological stress caused by wearing the samples was calculated immediately upon wearing (morning), after three hours of wearing (noon), and after six hours of wearing (evening) they were put on. For psychological assessment, "tightness," "slipping" and other parameters on wearing comfort were measured. Subjects evaluated the girdle on a +5 /-5 point scale for each questions. For electrocardiography, CCI Corporation's wireless bio-analysis system was used to compute physiological stress from wearing the samples by conducting heart rate variability analysis. The experiments lasted for a total of three days, with each subject wearing one sample for one day. Other than the girdles, subjects were asked to wear exactly the same clothing. The temperature and humidity in the laboratory were 23.1±1.4℃ and 45.9±5.0%, respectively.

2.4 Measuring ease of movement

To assess ease of movement, Nihon Kohden Corporation's wireless measuring system WEB-1000 was used to take an electromyogram (EMG) and measure acting acceleration. For the electromyography, EMGs were taken of the rectus femoris muscle and biceps femoris muscle. The acting acceleration sensor was attached at the waist (around the fourth and fifth lumbar vertebrae). The subjects were asked to walk for five minutes on a treadmill (at 3.5 km/h) and rise from and sit on a chair for five cycles. After these movements, the subjects were asked to fill in a questionnaire on "tightness," "slipping," ease of movement," and other parameters according to the semantic differential method. Subjects evaluated the girdle on a +5 /-5 point scale for each questions. For purposes of analysis, muscle potential signals were used to calculate integrated electromyograms (IEMGs) and assess the burden on motion. Also, in order to assess the reproducibility of movements, an interclass correlation coefficient was calculated for a vertical accelerogram at the time of ground contact for five walking cycles.

2.5 Measuring the shape-controlling function

To assess the shape-controlling function, measurements were taken for two subjects (because of a similar waist and hip size in subject no.4 and no.9), who were asked to wear the same shorts under their girdles. While in a standing position they were asked to raise both hands horizontally, and morphometric analysis was conducted using Hamano Engineering's laser three-dimensional measuring instrument VOXELAN.

3. Results & Discussion

3.1 Clothing pressure

Measurements found that clothing pressure was highest in the order of Sample A, Sample C, and Sample B in many cases, regardless of whether the subjects were stationary or in motion. Figures 2 - 4 show clothing pressure on the thighs. Clothing pressure for Samples B and C ranged between 11 and 14 hPa when the subjects were standing still, sitting still, or walking. The results show that Sample B demonstrated a more fitted body than Sample A. This is because Sample B was more extensible and reversible than Sample A, resulting in Sample B having a lower clothing pressure than Sample A. Sample C was little high value than Sample B. It might show effects of small sized.

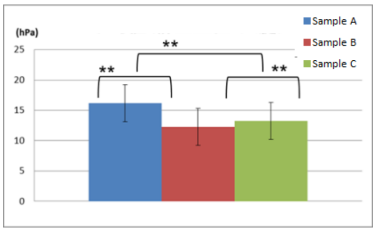

Fig. 2 Clothing pressure measurering results (standing still, thighs)

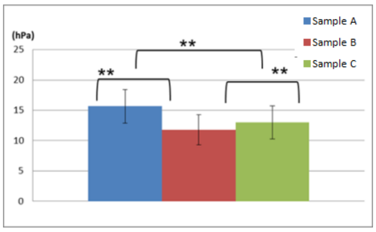

Fig. 3 Clothing pressure measurering results (sitting still, thighs)

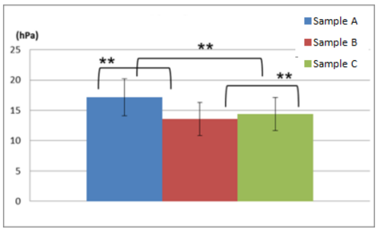

Fig. 4 Clothing pressure measurering results (walking, thighs)

3.2 Wearing comfort

Shown in Figure 5 are the degrees of physiological stress three and six hours after putting on the clothing, with one representing the time immediately after putting it on. Stress from wearing Sample C three and six hours after putting the girdle on was significantly lower than that of Sample A, while no significant difference in physiological stress was observed between Samples B and C. It may therefore be concluded that a half-size difference did not affect physiological stress for girdles made of highly extensible and reversible yarns used as samples in this research. Tightness at the abdomen and hem corresponded to stress while wearing the girdles.

Physiological stress from wearing clothing has much to do with the level of clothing pressure. For example, girdles made of highly extensible and reversible yarns (Samples B and C) presumably helped to lower physiological stress since clothing pressure was significantly lower at all regions when the subjects stood or sat still, and for all the measuring conditions while the subjects were in motion. Sample C's clothing pressure was slightly higher than that of Sample B, as the former was a half size smaller, but this difference was not enough to create any variation in physiological stress among the research subjects. Earlier studies[8] revealed that the range of clothing pressure on the thighs that achieves physiological and psychological wearing comfort is between 11 and 14 hPa (while standing still). This range is almost equivalent to clothing pressure (standing) when wearing Sample B or C. Sample A's clothing pressure, on the other hand, is slightly higher, and thus is deemed to produce higher physiological stress when wearing.

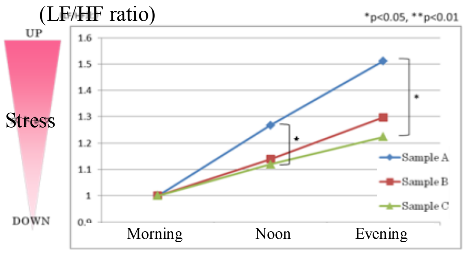

Fig. 5 Physiological measurements

3.3 Ease of movement

Results of EMG analysis of the rectus femoris muscle (Fig. 6) indicated that muscle load was significantly lower for Sample C than for Sample B both when walking and when engaged in up-and-down motion on the chair. The results of acting acceleration analysis showed, on the other hand, the interclass correlation coefficient was significantly higher for Sample C than for Sample B, suggesting high motion reproducibility. It was therefore made clear that the motion load for Sample C was relatively low, and the motion reproducibility was high (Fig. 7). Presumably, since clothing pressure changes within a moderate range while in motion, muscle pump action stimulates circulation of the blood and achieves efficient muscular activity, which in turn contributes to high motion reproducibility. No significant differences were found between samples A and C, or samples A and B.

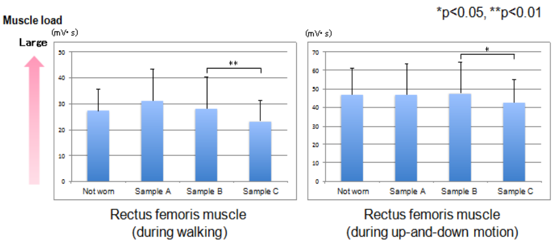

Fig. 6 Electromyogram measurements

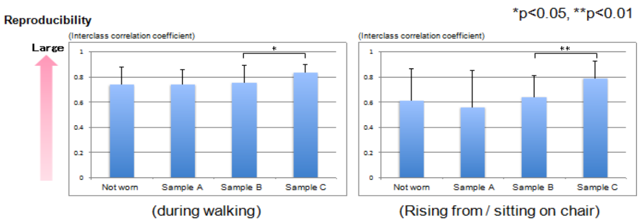

Fig. 7 Acting acceleration measurements

3.4 Shape-controlling function

The silhouettes in Figure 8 did not reveal any dramatic shape-controlling effects in part because they were created using data taken from two subjects, but localized tightening effects were nonetheless observed. The way of standing in subject 4 shows differences by samples, but it is not “shape-controlling” effect. Figure 9 shows that the circumference was noticeably smaller from the abdomen to the thighs when Sample C was worn, with a difference of up to 2.5 cm. Also, Samples A and C, which had high clothing pressure, exhibited tightening effects around the waist, suggesting a correspondence between localized clothing pressure and circumference. The sectional view of the hip (Fig. 10) shows that body shape appeared to be compensated for in some regions and not in other regions. This is presumably because the buttocks were lifted even though the circumference became larger. In other words, since the volume of the buttocks remained the same, some regions became thinner due to controlling effects, but surplus fat gathered to add extra measurements to other regions.

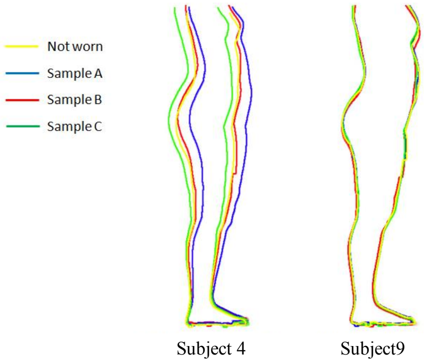

Fig.8 Comparing silhouettes

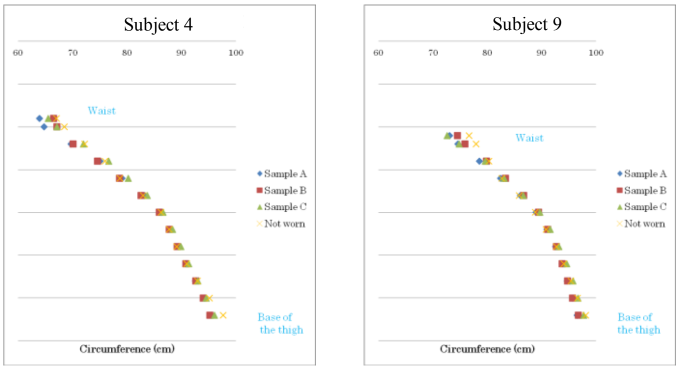

Fig. 9 Comparing circumferences

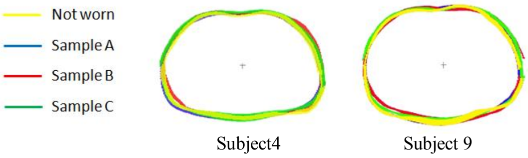

Fig. 10 Comparing sections of hips

4. Conclusion

Compared with a girdle made from regular yarns (Sample A), those made from highly extensible and reversible materials (Samples B and C) helped to lower physiological stress from wearing clothing because their clothing pressure and the range of its fluctuations were relatively small, thus delivering positive psychological clothing comfort. Concerning the effects of varying sizes of girdles, a half-size reduction did not considerably increase clothing pressure or deteriorate wearing comfort. In other words, by using fabrics such as those used for Samples B and C, it is considered possible to develop functional clothing with very extensive and flexible. With regard to the shape-controlling function, Sample C showed a certain level of shape-controlling effect. The results of this research suggest that it is possible to develop girdles that offer clothing comfort and ease of movement while maintaining a shape-controlling effect.

5. References

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