KEER2010, PARIS | MARCH 2-4 2010
INTERNATIONAL CONFERENCE ON KANSEI ENGINEERING AND EMOTION RESEARCH 2010

INFLUENCE OF CLOTHING PRESSURE BY WAIST BELTS ON BRAIN ACTIVITY

BRAIN ACTIVITY ON DIFFERENCE OF PERCEPTION MODALITY OF CLOTHING PRESSURE BY WAIST BELT: INFLUENCE OF INFORMATION FROM VISUAL PERCEPTION

Masayoshi Kamijo[*a], Tomohiro Uemae[a], Euichul Kwon[a] , Yosuke Horiba[b], Hiroaki Yoshidab, Mika Morishimac

[a] *Dept. of Bioscience and Textile Technology, Interdisciplinary Graduate School of Science and Technology, Shinshu University, Japan*

[b] *Kansei Engineering Course, Faculty of Textile Science and Technology, Shinshu University, Japan*

[c] *Dept. of Design for Contemporary Life, Gifu City Women's College, Japan*

ABSTRACT

The purpose of our study was to construct a method for evaluating the influence of clothing pressure on the human body by measuring brain activity in the state of perceiving fastening the waist belt. Tightening of the waist belt can be perceived by somatic perception and visual perception. The condition of brain activity resulting from pressure exerted on the abdomen by waist belts was evaluated by electroencephalogram (EEG) measurement. We investigated the possibility of estimating psychological and physiological stress arising from waist belts in clothing, based on EEG measurements. There are many studies to the effect that pressure on the abdomen exerted by clothing is not desirable; however there is hardly any research on the relation between pressure exerted by clothing and brain activity. Moreover, there is hardly any research describing the mutual relationships among the following: pressure exerted by clothing, feelings of clothing comfort, and physiological response. In this study, electrodes were fixed to the scalp and EEG was measured for states of abdomen pressure and non-pressure exerted by waist belts, with eyes opened and with eyes closed. Additionally, sensory tests for sensations of tightness, arousal, and feelings of comfort were carried out. Frequency analysis of measured EEG data was carried out, and brain activity as reflected in the intensity of alpha waves under the conditions of pressure exerted by waist belts was evaluated.

Keywords: *Clothing comfort, Clothing pressure, Brain activity, Stress, Autonomic nerve*

[*] **Corresponding author**: 3-15-1,Tokida,Ueda,Nagano, 386-8567, Japan, kamijo@shinshu-u.ac.jp

1. INTRODUCTION

Clothing comfort can refer to feelings in a number of aspects, such as thermophysiological comfort, tactile comfort, body-fit comfort, and esthetic comfort. This suggests that clothing comfort is multimodal and involves complex processes, in which a large number of stimuli from clothing and external environments are communicated to the brain through multiple channels of sensory responses to form subject perceptions. However, the clothing comfort was evaluated by the sensorial method, which is a subjective evaluation method from the subjects. There are some variations among individuals in linguistic sense, environmental condition, time, seasons, age, occupation, body condition, gender, feeling, experiences of subjects, etc. So, an objective method using physiological response, such as heart rate variability, brain wave, pulse and the like, has lately attracted considerable attention in various fields. Some researchers have been carried out on the objective physiological index between clothing and the human body [1].

Excessive clothing pressure is one of the most important factors not only in clothing comfort but also in the hygienic aspect. Some researchers have investigated the effect of clothing pressure on the peripheral nervous system [2] and the central nervous system using analysis of brain waves [3, 4]. Most of the works on clothing comfort were done by evaluating sensorial measurement of psycho-physiological response to the stimuli. Actually, clothing comfort is not affected by only one sensory organ, but can be evaluated using complex information from the various sensory organs. So, it becomes possible to practically evaluate clothing comfort through information from the various receptors.

In our previous study to fasten waist-belt, we have found that the clothing pressure is made to lower the brain activity. However, the arousal sensation of subjects hardly changed. The human has not perceived the change degree of the arousal of the brain [4]. The evaluation of the relation between clothing comfort and clothing pressure was performed by sensory measurement from somatic sensation with closed eyes. We studied clothing comfort with consideration of *kansei* evaluation [5], which is information from various sensory organs. We evaluated the perception from somatic sensation and the brain activity from visual information with clothing pressure. Human gets much information through visual sensation, so clothing comfort with visual information is very important. In this study, we inspected the brain activities with pressure stimulus and visual information. We measured brain waves, which are a macroscopic index of brain activity and mental state, and then analyzed the relations between them.

2. EXPERIMENTALS

2.1. Human subjects and materials

Subjects were 9 female university students. All subjects were required to wear underwear, a short-sleeved shirt, and short pants. They were stabilized in a room maintained at a temperature of 25°C and a relative humidity of 65%. We considered excluding the movement of head and muscle potential for holding up the head that could act as an artifact in the measurement of brain waves. The waist belt used in this study was non-elastic material and 4 centimeters in width.

2.2. Experimental Procedures

Pressure amounting to ten percent of the subjects' waist size was applied to their abdominal region. We investigated the effects of somatic and visual sensation to brain activity with input conditions, which are abdominal pressing and visual information. Four kinds of experimental conditions are as follows:

(1) Condition with eyes closed

(2) Condition with eyes opened in darkness

(3) Condition that the subjects can see the pressing waist belt with eyes opened

(4) Condition that the subjects cannot see the pressing waist belt with eyes opened

In case of condition (2), the subjects were required to be in a dark condition for 5 minutes before the measurement. In the cases of conditions (3) and (4), we put a mirror in front of the subjects, and showed the image between the chest and legs so that they could see the visual information of tightening and releasing the waist belt. In case of condition (4), we covered the waist with a cloth so that they could not get the visual information of tightening and releasing the waist belt.

2.3. Measurement of electroencephalogram (EEG)

We investigated α waves as the index of brain activity, and these was measured by the system of MP100WS (BIOPAC Systems, Inc.). According to the International 10-20 System, reference allocates were placed on both ear lobes and 3 electrodes were placed on *Fz* of the frontal region, *Cz* of the vertex region, and *Pz* of the occipital region. We set the positions of electrodes around the vertex because the region mainly responds to somatic sensation. EEG was recorded for 2 minutes with 200Hz sample frequency with the pressing stages.

It is known that the power spectrum of α waves increases when a person feels comfort. In this study, we investigated the relation between the comfort and intensity of alpha waves, which were obtained with a fast Fourier transform (FFT). The human subjects were required to rest for 5 minutes before the measurements. The measuring procedure was as follows:

(1) Before pressing with a waist belt: sensory test (comfort, tightness, arousal sensations)

(2) Before pressing with a waist belt: EEG measurement (for 2 minutes)

(3) During pressing with a waist belt: sensory test (comfort, tightness, arousal sensations)

(4) During pressing with a waist belt: EEG measurement (for 2 minutes)

(5) After pressing with a waist belt: sensory test (comfort, tightness, arousal sensations)

(6) After pressing with a waist belt: EEG measurement (for 2 minutes)

2.4. Analysis of brain waves

We calculated the power spectrum of brain waves, and then did the sum of the alpha waves zone. This was used for the index of brain activity. We removed the trend of the brain waves, and then a band pass filter with a bandwidth of 1-35 Hz was applied to the sectioned EEG to obtain the alpha waves. The power spectrum of brain waves was calculated through FFT with Hamming function. The data for 12 seconds before and after the measuring moment was eliminated to prevent inserting noise. Power spectrum of the alpha waves was given by

$$P = \sum_{\omega=8}^{13} p(\omega) \tag{1}$$

where, p(ω) was the added mean of the power spectrum. Generally, there are many individual variations in the alpha waves, so we indicated the relative values of each subject through controlling the power spectrum of the alpha waves before pressing by the waist belt.

2.5. Subjective sensory assessment

The generally applicable method of psychophysical scaling was used in rating subjective perception. We used it to assess pressure perception and other wearing sensations in wearer trials. Subjects were asked to rate the sensations of comfort, tightness and arousal on a scale of 0-10. Because the human has not perceived the change degree of the arousal of the brain [4], we assess the 3 kinds of sensation.

3. RESULTS AND DISSCUSSION

3.1. Subjective sensory assessment

Figure 1 shows the results of the subjective sensory test for women subjects. The ** mark in the figure means that there are significant differences at the 0.01 level of significance by using the Sheffe multiple comparison. If the score of comfort, arousal, and tightness sensation is high, it means that they feel more comfortable, more aroused, and that the belt is tighter. The subjects receiving pressure answered that they were more uncomfortable and that the belt was tighter than the cases of before and after pressure. The results commonly appeared in all measuring conditions. On the other hand, the arousal sensation showed a common tendency with the pressing condition, and decreased with time.

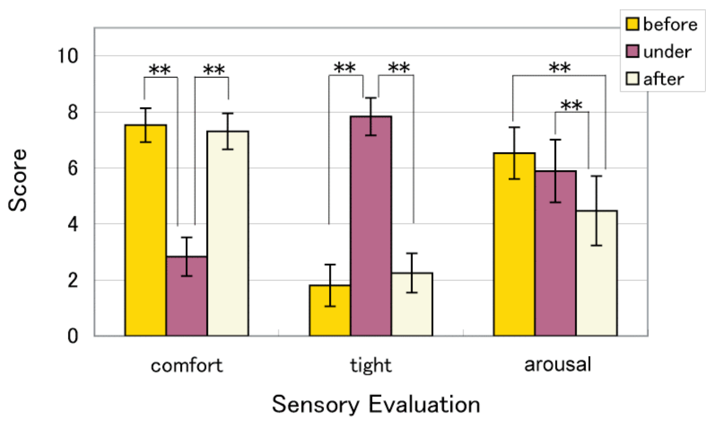

Figure 1: The results of sensory evaluation

3.2. Brain waves

3.2.1. A condition with eyes opened

Figure 2 shows the typical brain waves and the power spectrum after Fourier transform of subject A with eyes opened. Figure 3 shows the mean power spectrum of alpha wave in all measuring conditions. The power spectrum of alpha wave decreased with pressing, and increased with releasing. We carried out variance analysis with three pressing conditions (stable, pressing, re-stabilized) on three measuring positions (*Fz, Cz, Pz*). As the result under the Sheffe multiple comparison, there was significant difference among the pressing conditions but we could not detect the changes among measuring positions and the interaction between pressing conditions and measuring positions. The power spectrum of alpha waves on the brain was not changed with pressing conditions.

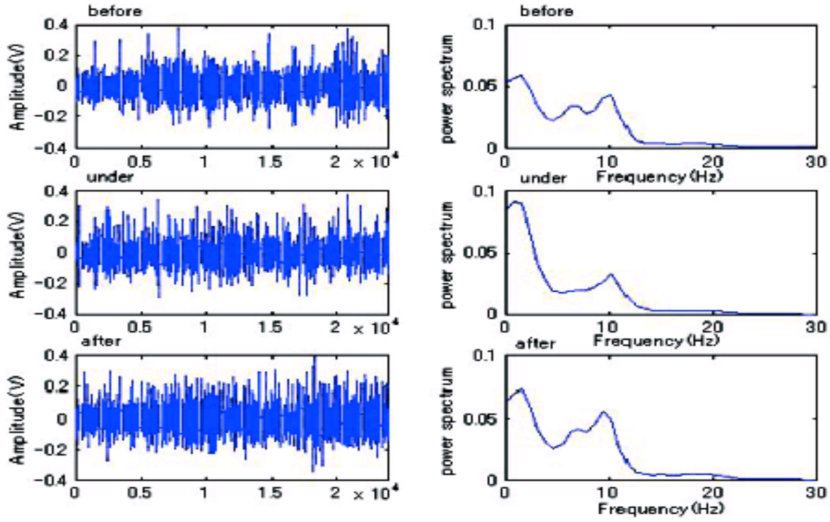

Figure 2: Brain waves and power spectrum of subject A with eyes closed.

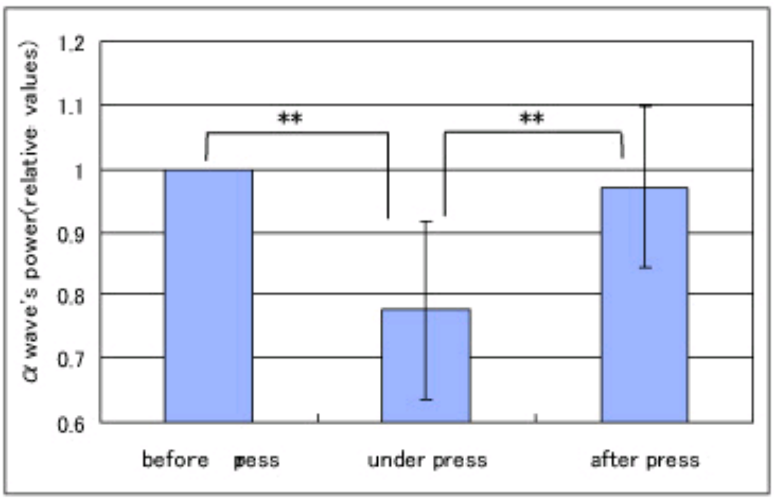

Figure 3: The alpha wave's power spectrum with eyes closed.

3.2.2. A condition with eyes opened in darkness

Figure 4 shows the typical brain waves and the power spectrum of subject A with eyes opened in darkness and Figure 5 shows the results from the power spectrum of alpha wave. There were not significant differences with pressing stages. We obtained through a questionnaire that they felt a sense of incongruity or did not realize that they opened their eyes when they opened their eyes in darkness. Since it was an uncommon environment, we could not get the significant change of the subjects.

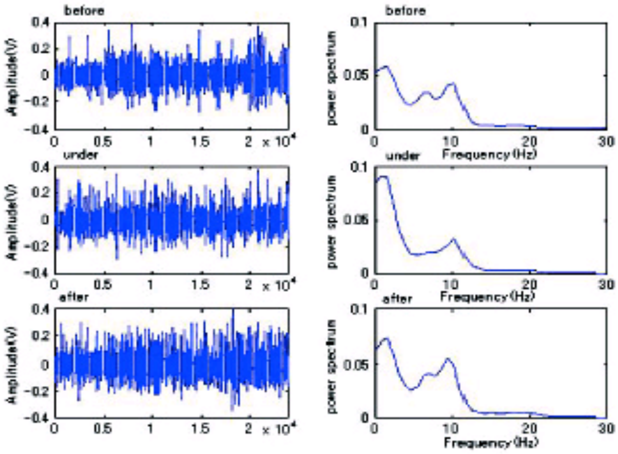

Figure 4: Brain waves and the power spectrum of subject A with eyes opened in darkness.

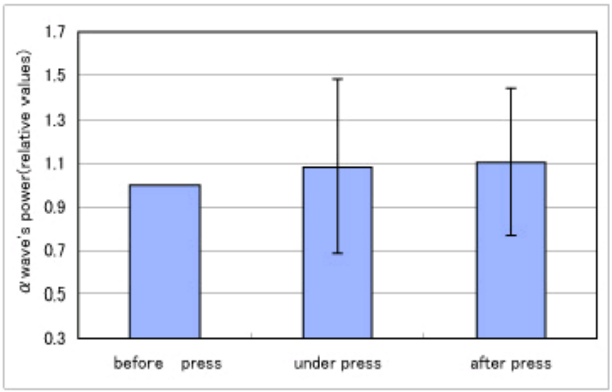

Figure 5: The alpha wave's power spectrum with eyes opened in darkness.

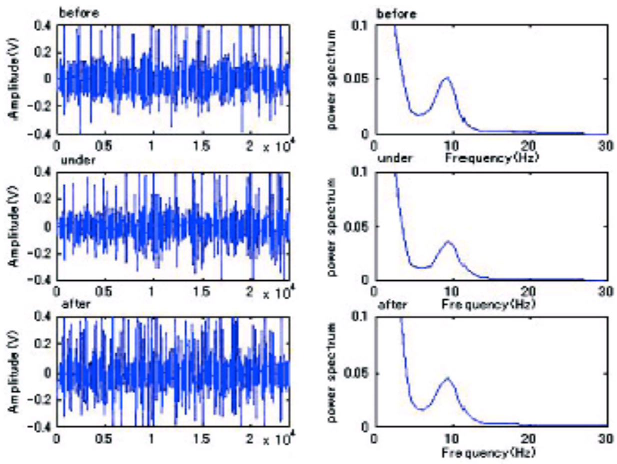

Figure 6: Brain waves and power spectrum of subject A, who can see the pressing waist belt with eyes opened.

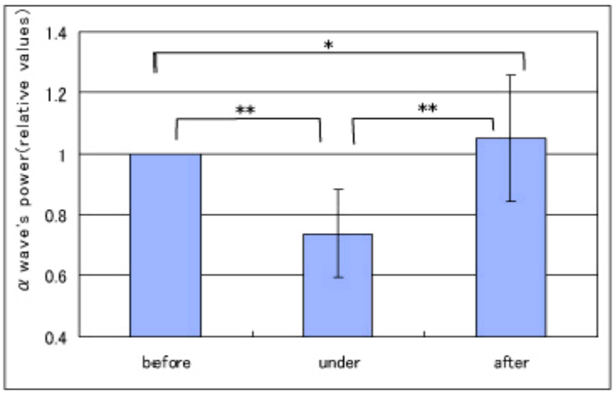

Figure 7: The alpha wave's power spectrum of subject A, who can see the pressing waist belt with eyes opened.

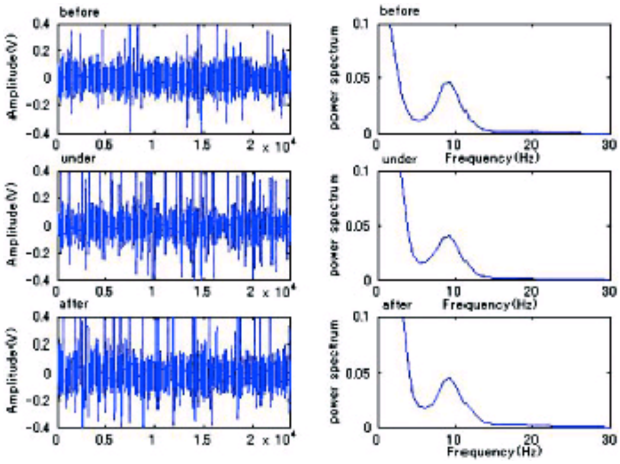

Figure 8: Brain waves and power spectrum of subject A, who cannot see the pressing waist belt with eyes opened.

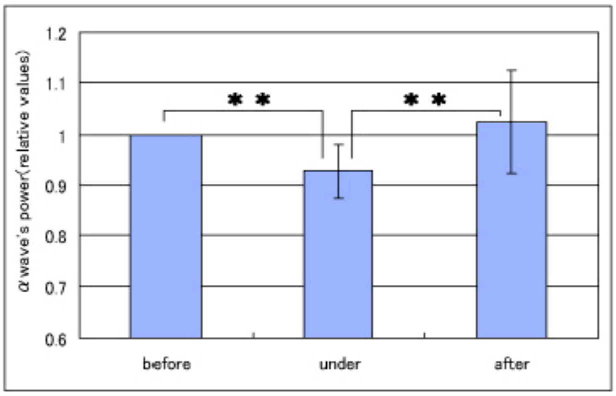

Figure 9: The alpha wave's power spectrum of subject A, who cannot see the pressing waist belt with eyes opened.

3.2.3. The condition in which the subjects can see the pressing waist belt with eyes opened

Figure 6 shows the brain waves and their power spectrum for subject A, who can see the pressing waist belt with eyes opened. Compared with the result before pressing, alpha wave decreased with pressing and then increased with releasing to the initial level. We performed variance analysis on the alpha wave power spectrum of the condition in which the subjects can see the pressing waist belt with eyes opened. In the figure, the marks ** and * mean that there are significant differences at 0.01 and 0.05 levels of significance, respectively. We could find that there were significant differences among pressing stages, and changes with interaction between pressing stages and measuring positions did not appear as the result of the Sheffe multiple comparison.

3.2.4. The condition in which the subjects cannot see the pressing waist belt with eyes opened

Figure 8 shows the brain waves and their power spectrum for subject A, who can see the pressing waist belt with eyes opened. Compared with before the pressing stage, the alpha wave decreased with pressing and then increased with releasing. We performed variance analysis on the alpha wave power spectrum for the condition in which the subjects could not see the pressing waist belt with eyes opened. There were significant differences with pressing stages, and changes with interaction between the pressing stages and measuring positions did not appear as the result of the Sheffe multiple comparison.

3.2.5. The changes of alpha wave power spectrum for the conditions in which the subjects can see and cannot see the pressing waist belt with eyes opened

We compared the changes of alpha wave power spectrum for the conditions in which the subjects can and cannot see the pressing waist belt with eyes opened. Table 1 shows the results of the analysis of variance (ANOVA) of alpha wave power spectrum, and there are 3 pressing stages, 3 measuring parts, and 2 visual conditions. In the table, the * mark means that there are significant differences at 0.01 level of significance. There were main effects of the pressing stages, visual conditions, and the interaction between pressing stages and the visual conditions. However, no significant difference of the main effect and interaction among the measuring parts could be confirmed. Alpha wave, with 2 conditions, decreased with pressing and increased with releasing. Figure 10 shows the amount of increase and decrease with pressing and releasing in the condition in which the increase and decrease in pressing by the waist belt was invisible to the subjects. The colored area in Figure 10 is the variance caused by visual pressing information because the variable factor is visual information only.

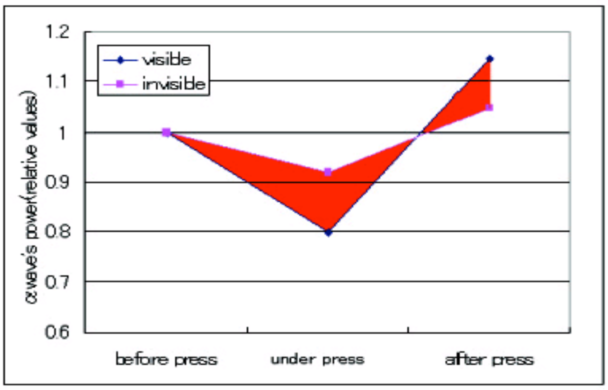

Figure 10: Difference of alpha wave's power spectrum with visible information.

Table 1: The results from the variance analysis of alpha wave's power spectrum.

Factor	Sum of squares : S	Degree of freedom: f	Unbiased variance : V	F values
A (Place)	0.01	2.00	0.00	0.36
B (Vision)	1.94	2.00	0.97	108.27**
C (Press)	0.07	1.00	0.07	7.48**
A × B	0.04	4.00	0.01	0.99
A × C	0.01	2.00	0.01	0.77
B × C	0.59	2.00	0.30	32.93**
A × B × C	0.02	4.00	0.01	0.62
Error : E	1.45	144.00	0.01	
Total	4.13	161		

3.2.6. The relation of alpha wave power spectrum and psychological response with visual stimulation

In two conditions, alpha wave decreased with pressing and increased with releasing, the variance was a little different. The amount of variance in the condition in which the waist belt was invisible to the subjects was less than when it was visible. However, there was not a significant difference in sensory test with visual information. We confirmed that the effects from visual information could not be detected because of indirect stimulation to pressing, but the pressing information unconsciously influenced to brain activity.

4. CONCLUSIONS

In this study, we controlled the visual information of abdomen pressing and inspected the effects of pressing stimulation on brain activity. We measured brain waves, which are a macroscopic index of brain activity and psychological condition, with eyes opened, and then inspected the relation between psychological response and brain waves. The alpha wave power spectrum of the subjects significantly decreased in all cases. From the results of our questionnaire, during pressing, comfort and tightness feeling decreased and increased, respectively. There was not a common tendency in arousal feeling because it was a difficult feeling to recognize. The subjects answered from the questionnaire that they felt a sense of incompatibility in a dark condition with the eyes opened. Since they should be affected by the psychological factor from the environmental condition, the alpha wave power spectrum was not commonly changed with pressing and releasing. We compared the responses with eyes opened and closed; it appeared that the alpha wave power spectrum decreased with pressing and then increased with releasing. The amount of variance in the condition in which they could not see the tightening was less than in the condition in which it was visible. We confirmed that it was caused by visual information of pressing, so it may be possible to evaluate the pressing stimulation with plural sensations. However, there was not a significant difference with arousal information in the sensory test. We confirmed that the brain central nerves were influenced by visual information for pressing though pressing sensation was not remarkably changed. The evaluation for wearing comfort must be performed with consideration of multiple sensations.

The paper described the only females' results. It has been known that there are differences in the brain according to gender. Allen [6, 7] reported a difference by gender in a part of the limbic system, which controls the response to stimuli. Thus, we should know of the existence of structural differences of the brain by gender, and should examine the differences by gender about perception of clothing pressure in the future.

REFERENCES

[1] Nobuko Okada, Effects of clothing pressure on somatosensory evoked potential, Journal of the Japan Research Association for textile end-uses, Vol.36, No.1, pp.138-145, (1995)

[2] Hideko Kawa, et.al., Journal of the Japan Research Association for textile end-uses, Vol.36, No,7, pp.36-39, (in Japanese) (1995)

[3] Yosuke Horiba, et.al., Evaluation of thermesthesia for wearing by using chaotic analysis of EEG, SenI- Gakkai-shi (in Japanese) , Vol.55, No.9, pp. 440 – 446, (1999)

[4] Yosuke Horiba, et.al., Effect on brain activity of clothing pressure by waist belts, *Kansei* Engineering International, Vol.2, No.1, pp.1-8, (2000)

[5] Y.Shimizu et.al; Inter. J. Clothing Sci. & Tech, **16**, 1/2 (2004)

[6] L.S.Allen,R.A.Gorski, Sexual dimorphism of the anterior commissure and massa intermedia of the human brain, J.Comp.Neurol, Vol.312, pp.97-104 , (1991)

[7] L.S.Allen, M.Rickey,Y.Chen, Sex differences in the corpus callosum of the living human being, J.Neurosci., Vol.11 pp.933-942, (1991)