Subjective Sensation and Objective Body Physiology Responses of Breast Prosthesis in Dry and Wet States among Korean Women without a History of Breast Cancer

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Keywords: Breast Prosthesis, Breast Cancer in Women, Objective Human Physiological Responses, Subjective Sensory, Dry and Wet Condition

Abstract: In order to contribute to the development of breast prosthesis products for breast cancer patients in Korea, this experiment was conducted with 9 participants from June to July 2018, in Seoul, Korea. The breast prosthesis consisted of three kinds of material: silicone breast prosthesis 1, silicon breast prosthesis 2 and silk fabric breast prosthesis 3. Subjects were evaluated by touch in a dry state without water and a wet state with 30~35degree hot water. Evaluation was performed using Schuhfried's biofeedback 2000x-pert wireless multi-module for measuring skin conduction level, skin temperature, and blood flow. Subjective sensory evaluation including thermal sensation, humid sensation, and feeling of comfortable was implemented with the scale test. Results showed that there was no significant difference in an objective human physiological response according to the state of dry and wet. However, there was a significant difference with subject sensory perception in dry and wet. Furthermore, the breast prosthesis made with silk fabric, the humid sensation was significantly higher in the wet state whereas a thermal sensation and feeling of comfortableness were not significantly difference between dry and wet. Therefore, this study suggests that researchers develop and apply other materials like silk for breast cancer patients.

1 INTRODUCTION

Today, breast cancer is the second most common cancer for woman in Korea. In 2014, the number of Korean women experiencing breast cancer was 16,521 people, which is more than four times higher than the 3,801 people in 1996, 15 years ago. However, breast cancer is relatively well treated and overall has a high survival rate of over 90.0% when detected early (National Cancer Information Center, 2013). In the case of breast cancer in the West, the incidence is high in women after menopause.

In Korea, it highly occurs in women in their 40s who are most active in family and society (Breast cancer white paper, 2013). Thus, the increase of the breast cancer's incidence in a relatively younger age group means that these women live longer as breast cancer survivors. When breast cancer progresses, more than half of breast cancer patients still need complete mastectomy (Glaus & Carlson, 2009). While this is a life-saving procedure for the breast cancer patient, the loss of one or both breasts may cause mental shock due to physical changes and cosmetic damage (Kim et al., 2006). In other words, it is not merely a re-sectioning of a part of the biological body, but impacts the breast, with its symbolic meaning of femininity, hence the experience of stress as the appearance of the body and the identity of femininity are both impacted (Kwon & Yi, 2012). Therefore, in order to improve physical image and quality of life, emotional stress should be reduced for the patients (Roberts et al., 2003). The use of breast reconstruction or using of breast prostheses after mastectomy is helpful in the recovery process of breast cancer survivors (Gallagher et al., 2010). Due to the problem of multiple operations for breast reconstruction and the burden of cost, some breast cancer survivors have chosen breast prosthesis over cosmetic surgery (Baron, 2007).

Breast prostheses are produced in a variety of sizes, shapes, and nipple types, so that women of all ages can choose a breast that is almost identical to

Oh, H. and Oh, H.
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DOI: 10.5220/0008394100002442
In *Proceedings of the Aceh International Nursing Conference (AINC 2018)*, pages 21-29
ISBN: 978-989-758-413-8

their own (Glaus & Carlson, 2009). However, in the case of Korea, most Korean woman who have had a mastectomy use silicone breast prosthesis imported from western countries. The wearing of silicone breast prostheses in summer, with its high humidity, is uncomfortable due to the creation of sweat inside the device, making some breast cancer patients avoid breast prosthesis (Oh, 2016a; Oh, 2016b). Therefore, it is necessary to develop a functional breast prosthesis that is comfortable even in the high humidity of a Korean summer.

In order to improve the quality of breast prosthesis for breast cancer patients, this study showed the reality of physical and physiological discomfort to discern the differences in materials for breast prosthesis.

2 METHODS

This experiment was exempted from IRB and it was conducted in the clothing laboratory (26 ± 1 %, 50 ± 10% RH) of the university from June to July 2018, Seoul, Korea. A total of 9 female Korean participants in their 40s without a history of breast cancer and no experience with breast prosthesis participated. The subjects could participate in the experiment 2 hours after eating and the 3 kinds of breast prostheses were touched with the left hand. Breast prosthesis 1 is a silicone prosthetic by T company, Breast prosthesis 2 is a silicone prosthetic by S company, and Breast prosthesis 3 is handmade product of silk fabric (Table 1). Subjects were evaluated by touching the prostheses under 2 kinds of conditions: First, they were touched in a dry state without water and secondly, in a wet state with 30 ~ 35 degree hot water to replicate sweat.

The contents of the experiment are an objective human physiological responses evaluation and subjective sensory evaluation. The former was performed using Schuhfried's biofeedback 2000x-pert wireless multi-module for measure skin conductance level (SCL), skin temperature (TEMP), blood volume pulse (BVP), and pulse (Puls). The measurement was performed automatically at intervals of 0.038 sec., or 1578 times per minute. The sensor was attached to the right hand of the end of the third finger using a Velcro band. The measured data output used Biofeedback 2000xpert Tele-BFB ver. 2.0 software. Meanwhile the latter as thermal sensation (7 scale), humid sensation (4 scale), and feeling of comfortableness (4 scale) was implemented via survey method (Table 2). As the number increases, thermal sensation and humid sensation refers to heat or humidity, and the feeling of comfortableness means greater or less comfort. Prior to questioning, the definitions of thermal sensation, humid sensation, and feeling of comfortableness were defined

Table 1: Three kinds of breast prosthesis for experiment.

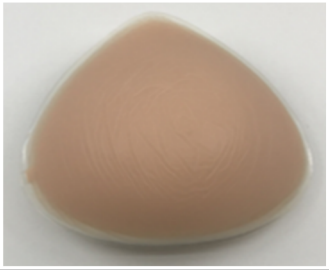
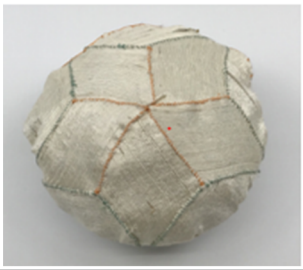
Type	Breast Prothesis 1	Breast Prothesis 2	Breast Prothesis 3
	S product	T product	Handmade product
Material	Silicone	Silicone	Silk fabric
Weight (g)	150	120	150
photo			

Table 2: Subjective sensory evaluation.

Thermal sensation	very hot	(3)	hot	(2)	warm	(1)	normal	(0)	little cold	(-1)	cold	(-2)	very cold	(-3)
Humid sensation	very humid	(3)	little humid	(2)	little humid	(1)	normal	(0)						
Feeling of comfortable	comfortable	(3)	little uncomfortable	(2)	little uncomfortable	(1)	uncomfortable	(0)						

All quantitative data for objective human physiological responses evaluation and subjective sensory evaluation were expressed as mean and standard deviations (Mean, ±S.D.). In order to analyze the touch evaluation for dry and wet breast prostheses, a Kruskal-Wallis Test was performed for the 3 conditions--dry, wet, and no touching status with three kinds of breast prosthetics. Once a significant main effect was found, a post hoc analysis using the Mann-Whitney U-test was undertaken. All statistical analysis of experimental data was carried out using SPSS (Version 24.0, SPSS Inc., USA).

3 FINDINGS

3.1 Dry, Wet, and No Touching

The experimental results showed that there was no significant difference in an objective human physiological experiment between the state of dry and wet. However, table 3 shows the mean and standard deviation of objective human physiological response as skin conduction level, skin temperature, blood flow and pulse for breast prosthesis, as well as χ^2 and p-values in dry, wet, and no touch conditions by a Kruskal-Wallis Test. It reveals a statistically significant difference. Skin temperature was higher for the no touch breast prosthesis than dry and wet conditions χ^2 =10.900, p< .01; in other words, when subjects touched a breast prosthesis under dry and wet conditions, it made a lower skin temperature than no touch (Fig. 1). In order to ascertain which of the breast prostheses is statistically significantly different from the other in conditions of dry, wet and no touching, a Post hoc analysis was conducted. The result of the Mann-Whitney U-test revealed statistically significant differences for all three kinds of breast prosthesis with no touch under dry conditions χ^2=15.998, p< .01, <Fig 2>. But in wet conditions, breast prosthesis 1 was only significantly different with no touching χ^2=14.222, p< .01. Breast prosthesis 2 and breast prosthesis 3 were not significantly different with no touch (Fig 3).

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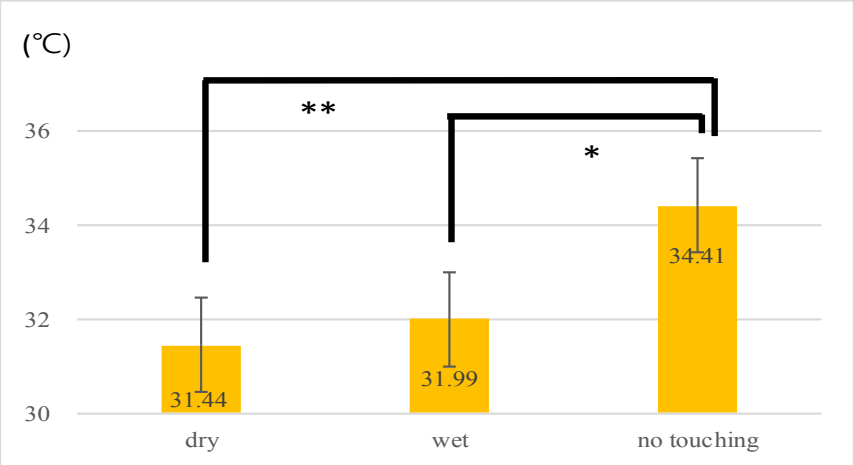
Table 3: Result of measurement for objective human physiological responses from touching abreast prosthesis in dry conditions and wet, and no touch.

breast prosthesis condition / objective human physiological responses	dry Mean (SD)	wet Mean (SD)	No touching Mean (SD)	x^2
SCL(us)	0.424 (0.201)	0.418 (0.184)	0.292 (0.189)	3.877
Temp(℃)	31.442 (2.936)	31.991 (3.054)	34.409 (0.905)	10.900 **
BVP(ml/m/n/100g)	49.286 (0.147)	49.347 (0.196)	49.205 (0.288)	1.384
Puls(bbm)	72.250 (8.352)	73.649 (8.521)	78.035 (9.256)	2.725

** P<.01



P<.05, ** *P*<.01

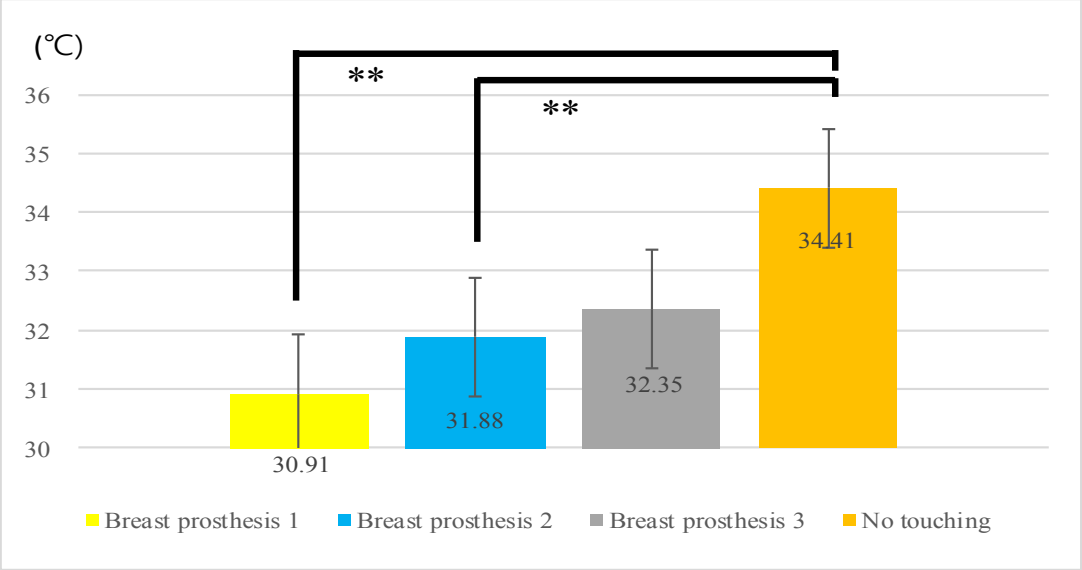
Figure 1: Result of measurement for skin temperature with touching a breast prosthesis in dry and wet conditions, as well as no touching.

Meanwhile, Table 4 shows the mean and standard deviation of objective human physiological response for three kinds of breast prosthesis χ^2 and *p*-values in touching under dry and wet conditions and no touching by the Kruskal-Wallis Test. It reveals a statistically significant difference in skin temperature between touch conditions and no touch for breast prostheses. Skin temperature was higher in no touch breast prostheses than in touching for all of the three breast prostheses. In order to ascertain which of the breast prostheses were statistically significantly different from one another in the condition of touch/ no touch, a Post hoc analysis was conducted. The result of the Mann-Whitney U-test revealed statistically significant differences for silicone breast prostheses than no touch under dry conditions χ^2=12.673, p< .01. The silk breast prosthesis did not show any significant difference.

Table 4: Result of measurement for objective human physiological responses from touching breast prosthesis 1~3, and no touching

breast prosthesis condition / objective human physiological responses	Breast prosthesis 1 Mean (SD)	Breast prosthesis 2 Mean (SD)	Breast prosthesis 3 Mean (SD)	No touching Mean (SD)	x^2
SCL(us)	0.38 (0.199)	0.49 (0.221)	0.39 (0.135)	0.29 (0.189)	5.912
Temp(℃)	30.91 (2.731)	31.88 (3.299)	32.35 (2.864)	34.41 (0.905)	15.998 **
BVP(ml/m/n/100g)	49.33 (0.240)	49.34 (0.174)	49.29 (0.075)	49.21 (0.288)	0.704
Puls(bbm)	73.17 (8.965)	73.20 (8.895)	72.48 (7.952)	78.04 (9.256)	2.717

** *P*<.01*



** P<.01

Figure 2: Result of measurement for skin Temperature with touching breast prosthesis 1 ~ 3, and no touching it.

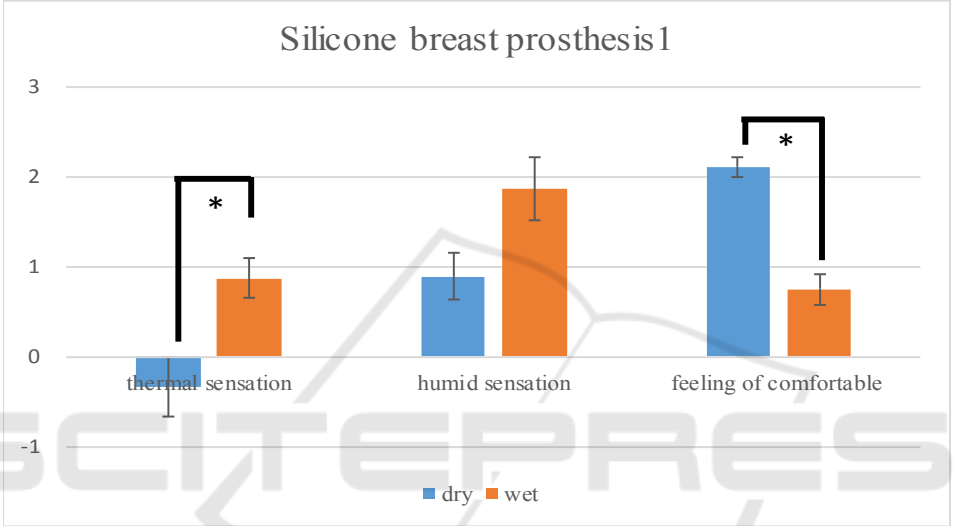
3.2 Subject Sensory Perception under Dry and Wet Conditions

Table 5 presents the average values and standard deviations for the subject sensory evaluation as thermal sensation, humid sensation, and feeling of comfortableness along with χ^2 and p-values of dry and wet conditions by Paired-samples t-tests. They revealed a statistically significant difference in all three values. Thermal sensation is significantly higher in wet conditions than dry t =-4.108, p< .001, and humid sensation is significantly higher in wet conditions than dry t =-5.851, p< .001. However, feeling of comfortableness is significantly higher in dry conditions than dry t =6.248, p< .001. This shows that, in the wet condition, the touching of the breast prosthesis regarding thermal sensation and humid sensation is higher than under dry conditions, but the feeling of comfortableness is lower than under dry conditions.

Furthermore, in order to know which of the breast prostheses are statistically significantly different from the others, a Post hoc analysis was conducted. The result of the Mann-Whitney U-test revealed a statistically significant difference with each of the three kinds of breast prostheses in subject sensory evaluation. Breast prosthesis 1 had significantly higher thermal sensation in wet conditions than dry χ^2=5.913, p< .001, but the feeling of comfortableness was significantly higher in dry conditions than wet χ^2=14.069, p< .001. Breast prosthesis 2 had significantly higher thermal sensation in wet conditions than dry χ^2 =10.971, p< .001, and also the humid sensation was significantly higher in wet conditions than dry χ^2 =9.946, p< .01 but a feeling of comfortableness was significantly higher in dry conditions than wet χ^2 =11.306, p< .01. Breast prosthesis 3 had only a significantly higher humid sensation in wet conditions than dry χ^2 =7.344, p< .01, Breast prosthesis 1 and breast prosthesis 2 had significantly higher thermal sensation in wet conditions than dry t =-2.921, p< .05, t =-5.289, p< .001, and humid sensations higher in wet condition than dry t=-2.292, p< .05, t =-5.096, p< .001, but the feeling of comfort was higher in the dry condition than wet t=7.019, p< .001, t =5.541, p< .001. However, in the case of the breast prosthesis made with silk fabric, the sensation of humidity was significantly higher under wet conditions than dry t=-3.377, p< .01. There was no significant difference between the thermal sensation and feeling of comfort between dry and wet states.

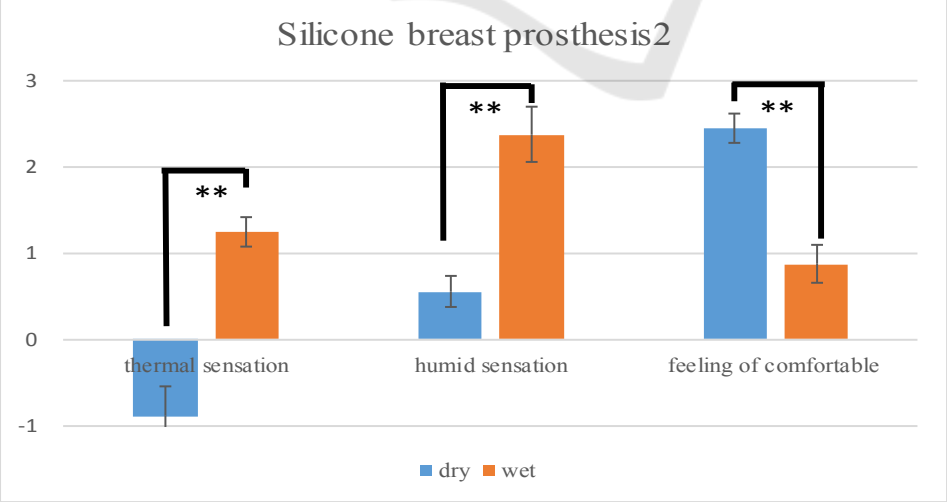
Table 5: Result of survey for subjective sensation evaluation from touching breast prostheses in dry and wet conditions.

condition / Subjective sensation	dry Mean (SD)	wet Mean (SD)	*t*
thermal sensation	-0.26 (1.163)	0.92 (0.830)	-4.108 ***
humid sensation	0.52 (0.643)	1.96 (1.083)	-5.851 ***
feeling of comfortable	2.30 (0.609)	1.08 (0.776)	6.248 ***



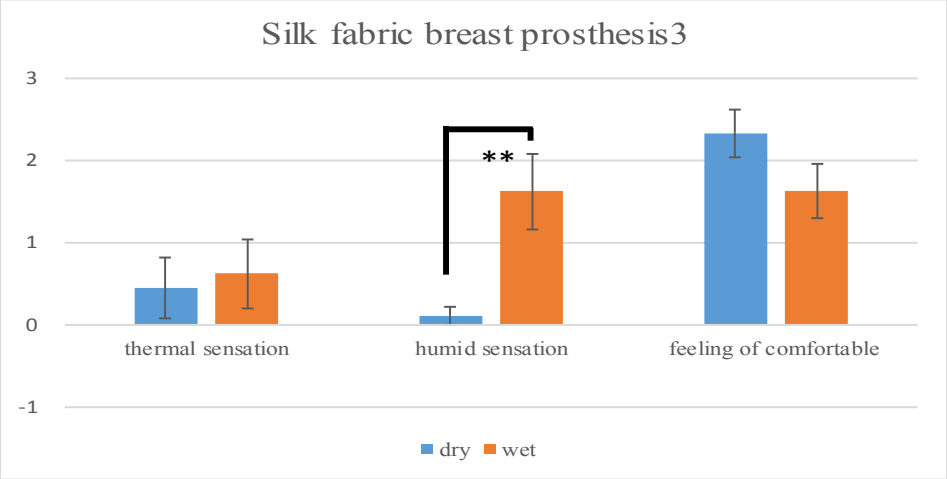
* *P*<.05

Figure 3: Result of survey for subjective sensation evaluation from silicone breast prosthesis 1.



** *P*<.01

Figure 4: Result of survey for subjective sensation evaluation from silicone breast prosthesis 2.



** $P<.01$

Figure 5: Result of survey for subjective sensation evaluation from silicone breast prosthesis 3.

4 DISCUSSION

It is important to maintain lower humidity for breasts prosthetics as this affects the quality of life of breast cancer patients. Tamura (2008) and Yatagai et al. (2012) showed that the temperature and humidity of a brassiere were the same in the right and left breast in healthy women. But in case of breast cancer survivors, the surgery part of breast side was higher in these than the healthy breast side. A mastectomy patient particularly is clearly different with a partial resection. The reason for the high temperature and humidity in brassieres of breast cancer patients is that they wear silicone breast prostheses, which does not have hygroscopicity and moisture permeability. The other reason is that radiation therapy for breast cancer creates a loss sweating functions in the skin, increasing dryness around the breast, and therefore, in the side of the brassiere with a silicone breast prosthesis, temperature is higher.

Most Korean breast cancer patients wear imported silicone breast prostheses. The purchase of the breast prosthetics is often directly introduced in hospital in Korea, but there are many cases where it is necessary to find products personally, creating hassle in the purchasing procedure and the inconvenience caused by this, which is not taken under consideration (Choi & lee, 2001; Kim, 2004). In Korea, wearing breast prosthetics in summer, with its high humidity, is highly uncomfortable due to heat, sweat, and moisture. Experimental results showed no significant difference in objective human physiological responses evaluation as skin conductance level (SCL), skin temperature (TEMP), blood volume pulse (BVP), and Pulse (Puls) under a dry or wet status. However, the result of comparing with touch under dry conditions and wet breast prosthesis and no touching, the no touching temperature average was 34.409 (SD = ±0.905), significantly higher than the touching of breast prosthesis. It is considered that the body skin temperature without breast prosthesis is significantly higher than the touching of breast prosthesis. For this study, the breast prostheses materials were at a temperature of 27 □ in the laboratory, and, in order to replicate a breast prosthesis with sweat, the breast prosthesis was soaked in hot water at 30 to 33 □. The breast prosthesis with silicone material was lower in temperature than the silk fabric breast prosthesis. According to the Morooka (2015) experiment, the humidity of the silicone breast prosthesis was almost zero in hygroscopicity and moisture permeability, while cotton material was higher than silicone. Meanwhile, there was a significant difference between silicone breast prosthesis 1, silicone breast prosthesis 2 and no touching in objective human physiological responses evaluation. There was no significant difference in touching the silk fabric breast prosthesis and no touch.

The results of this survey for subjective sensory perception of silicone breast prostheses found that they were less comfortable in wet conditions than in

dry conditions. However, the silk fabric breast prosthesis was found to have no difference in dryness and wetness in terms of comfort. Mooroka (2015) showed that a breast prosthesis should be characterized by high moisture, and that such materials are good for breast prosthetics for women who have undergone a mastectomy.

Silk is very skin-friendly. Silk is composed of fibroin (70 ~ 75%) in the middle and is surrounded with sericin (25 ~ 30%). These are 85% or more protein. Fabric is made from the fibroin remaining after dissolving sericin by hot water extraction. It is composed of more than 90% of amino acids such as glycine, alanine, serine and tyrosine, etc. It is known that when attached to the skin surface with an extra-humidifying ability, it maintains the moisture required by the skin and activates collagenase in the cells to help skin fibrosis. It also has the function of holding or releasing moisture by temperature and humidity. Recently, due to the rapid development of the applied biomedical industry, silk has also been studied for various bio applications as a very friendly component to the human body as a protein resource material. As such, breast prostheses should not be limited to silicon as they are now, but can be produced in various forms such as with human-friendly materials.

5 CONCLUSION

In order to contribute to the development of products for breast cancer patients in Korea, this experiment was performed with nine female Korean participants in their 40s who did not have a history of breast cancer using three kinds breast prostheses. In Korea, the most common age group for breast cancer is women in their forties. Experimental materials were composed of silicone breast prostheses and one made of silk fabric. According to objective human physiological responses, only temperature was significantly different between touching and no touching of the breast prostheses. Skin temperature without breast prosthesis showed a higher skin temperature than touching. However, comparing three kinds of breast prostheses and no touching, only silk was not significantly different to no touching of the breast prosthesis. According to subjective sensation in touching dry and wet breast prosthesis, the thermal and humid sensation was significantly higher in wet conditions, but the feeling of comfort was significantly higher in dry conditions. Furthermore, an analysis of three kinds breast prosthesis respectively found that the breast prostheses of silicone and silk fabric had high humid sensations in wet states but that the silk fabric beast prosthesis still felt as comfortable as in the dry state. Therefore, it is necessary to change the direction of making breast prostheses from only concentrating on verisimilitude in shape and touch to considering biometric reactions such as body temperature and moisture. This study suggests silk as an alternative to silicone. In the future, it will be necessary to study the application of silk as a breast prosthetic to breast cancer patients and to study the suitability of other natural fibers such as cotton and wool.

ACKNOWLEDGEMENT

This work was supported by the Ministry of Education of the Republic of Korea and the National Research Foundation of Korea (NRF-2018S1A5A8027072)

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