



## Changes of the Skin Temperature for Biceps Brachii on the Isotonic, Isometric Exercise and Gender, BMI Index

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### Abstract

**Purpose:** The purpose of this study is to find out changes in skin temperature, which is one of the regulatory systems of homeostasis, according to the isotonic-isometric exercise type, and changes in skin temperature according to gender and BMI index through isotonic-isometric exercise. **Design:** Randomized Controlled Trial. **Methods:** This study was conducted for 28 healthy male and female students from Department of Physical Therapy, G University. Subjects carried out isometric-isotonic exercise using dumbbells of 4kg and 8kg, respectively. And skin temperature was measured by using a computer infrared thermography. **Results:** The isometric exercise group was significantly difference changes in temperature by measurement time. **Conclusion:** In order to find out the effect of isometric exercise and isotonic exercise on skin temperature changes of biceps brachii, this study was carried out for 28 healthy male and female adults. The result of this study may helpful as basic data for orthopedic physical therapy.

**Key words :** Skin Temperature, Isotonic exercise, Isometric exercise

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## I. Introduction

Skin is the outermost tissue of our body that receives all the stimuli from the outside and reacts sensitively. It is the skin that responds appropriately to everything coming from outside, such as light, temperature and humidity, wind, invisible elements and energy in the air, physical-chemical stimuli (McArdle, Katch, & Katch, 2010).

To be precise, skin temperature is the temperature of

skin surface and refers to the temperature of the surface surrounding the core. In everyday living environment, the air temperature is often lower than the body temperature, so the temperature difference from air is formed through the skin from the deep part of the human body and heat is generated by the heat flow. Skin temperature is externally influenced by environmental conditions such as temperature, humidity, and airflow, but it is also used as an index of skin blood flow because it reflects skin blood

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flow near the skin in the body (Petersen, Philipsen, & Wulf, 2014).

In addition, the skin temperature is the temperature of the skin surface and is influenced by the type or intensity of exercise, time, gender, or BMI index. On the other hand, it is said that the thicker the subcutaneous fat, the less the temperature changes inside and outside the body, and considering that body fat is mainly accumulated in the subcutaneous fat, the ability of a person with a lot of body fat to control changes in the internal and external environment is reduced.

Exercise is a mechanism to break the homeostasis of skin temperature, and various exercises can be classified according to the shape of the muscles or the movement of the joints. Therefore, isometric exercise is a form of static exercise that produces muscle contraction and force without muscle length changes or visible joint movement. Concentric contraction refers to the form of dynamic muscle load in which tension occurs in the muscles, and physical shortening of the muscles occurs when external forces are overcome, such as lifting weights.

Eccentric contraction refers to the dynamic load of muscles beyond the force-producing ability of the muscles, which causes physically longer muscle length, such as unloading the weight (Dean, 1998). During exercise, the heat of the brain is increased, and the body temperature rises by the excitement of the body temperature control center by exercise. Changes in body temperature vary according to the type of exercise, exercise time, and the conditions of the surrounding environment (Escamilla-Galindo et al., 2017).

The greater the maximum contraction force during exercise, the shorter the contraction duration compared to the less contraction force and if the maximum retraction force is great, the proportion of Type IIb fibers that can momentarily mobilize large forces must be relatively high. The ratio of Type IIb fiber in men is high, exerting great power (Bogdanis et al., 2017). Norepinephrine also

plays a big role as greater power is exerted.

For research on skin temperature change after exercise, Hyuk-Chul Kwon from Daegu University (1995) measured skin temperature changes in both muscle quadratus femoris after isokinetic exercise in one muscle quadratus femoris. There is also a difference in muscle type and muscle mass depending on the gender, and thus the difference in the amount of hormone used may cause a temperature difference, and a different BMI index for each individual causes a temperature difference.

The purpose of this study is to find out changes in skin temperature, which is one of the regulatory systems of homeostasis, according to the isotonic-isometric exercise type, and changes in skin temperature according to gender and BMI index through isotonic-isometric exercise.

## II. Research Method

### 1. Subjects

This study was conducted for 28 healthy male and female students from Department of Physical Therapy, G University with no disease.

### 2. Research method

#### 1) Exercise method

Women and men were carried out isometric-isotonic exercise using dumbbells of 4kg and 8kg, respectively.

(1) For the isometric exercise, the subject was instructed to keep the elbow joint bent by 90° and hold out as much as possible.

(2) For the isotonic exercise, the subject was instructed to take the same posture as a dumbbell of the same weight as an isometric exercise and did the maximum exercise he/she can do with afferent movement when bending the elbow joint and effervescent movement when

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stretching it.

## 2) Skin temperature measurement

The skin temperature was measured using a computer infrared thermography (IBB - 6000) in the room and the measurement method is as follows:

(1) The chair was placed and fixed so that the subject could sit at 85cm from the camera.

(2) The subject was instructed to remain in the laboratory for 10 to 20 minutes so that the room temperature and body temperature become similar.

(3) In order to measure skin temperature changes, the bundle of biceps brachii was measured with a computer thermography.

(4) The room temperature was maintained between 26°C and 28°C.

(5) The number of shooting is 5 times and the skin temperature was measured after adapting to room temperature and immediately after exercise, after 5 minutes, after 7 minutes and after 12 minutes.

## 3. Analysis method

PASW ver.18.0 was used to check the general characteristics distribution (%) and Repeated ANOVA was used to find out change of measurement time depending on exercise method and One-Way Repeated ANOVA was used to find out changes of variables according to gender and BMI index in each exercise method. When there were significant differences in each variable, a contrast test was performed to confirm the significant difference within the measurement time. The significance level was set to 0.05.

## III. Results

### 1. General characteristics of subjects

The general characteristics of the subjects were as shown in <Table 1>, and seven male and seven female were tested according to each exercise group and the mean age of male and female was 22.71±1.51 years old, height was 170.68±9.44cm and body weight was 62.93±12.61kg.

### 2. Changes in skin temperature according to time change and exercise group

As shown in <Table 2>, skin temperature of both isotonic and isometric group decreased in after the measurement than before. Effectiveness test between individuals, within in the individual depending on the measurement time of body heat change according to exercise group were shown in <Table 3>. Changes in measurement time were statistically significant ( $p<0.05$ ). Change of temperature by measurement time were shown in <Table 4>. There was a statistically significant difference between before measurement and after 12 minutes, and between immediately after measurement and after 12 minutes ( $p<0.05$ ). But there was no significant difference at between 5 and 12 minutes of measurement and between 7 and 12 minutes of measurement.

### 3. Changes in skin temperature by gender and time depending on each exercise

As shown in <Table 5>, the average skin temperature value by time according to each exercise and gender shows the change of skin temperature by time according to each exercise, and it can be seen that the temperature decreases immediately after the measurement, and then the temperature increases again.

As shown in <Table 6>, the multivariate test results by gender and time of the isotonic exercise group conducted One-Way Repeated ANOVA in order to find out gender according to exercise method and results according to measurement time and the p-value of isotonic gender group showed .000 in the Mauchly's sphericity test, so the sphericity hypothesis was not established. The multivariate test was carried out in order to find out the interaction of gender, measurement time and temperature change by measurement time depending on gender of the isotonic exercise group and as a result, all the p-values were less than .05, so both the temperature change by measurement time and the interaction of measurement time and gender were significant. For the results of the effectiveness test between individuals of the isotonic exercise group, the effectiveness test between individuals was carried out in order to find out temperature changes according to gender of the isotonic exercise group as shown in <Table 7> and as a result, the p-value was .155, which is less than 0.05, so it was not significant. The interaction according to measurement time and measurement time gender is significant. As shown in <Table 8>, the contrast test depending on measurement time of change in body temperature for gender group of the isotonic exercise group was conducted in order to find out the temperature change by measurement time depending on gender of the isotonic exercise group and it was found that there was no significant difference before measurement and after 12 minutes, after 7 and 12 minutes and there was a significant difference immediately after measurement and after 12 minutes, after 5 minutes and 12 minutes. As shown in <Table 9>, the effectiveness test between individuals and within individuals depending on measurement time of change in body temperature and gender of the isometric exercise group was conducted in order to find out change of temperature depending on measurement time and it was found that the F-value was 13.222 and the p-value was 0.000, which is

smaller than 0.05, so there was a significant difference according to measurement time. The effectiveness test between individuals was carried out in order to find out the temperature change according to gender of the isometric exercise group and as a result, the F-value was 0.135 and the p-value was 0.720, which is greater than 0.05, so there was no difference according to gender. The effectiveness test within individuals was conducted in order to find out the interaction between measurement time and exercise method was carried out and as a result, the F-value was 2.744 and the p-value was less than 0.05, so there was significant differences according to exercise method and measurement time.

As a result, there was the interaction according to measurement time and gender and changes in body temperature by measurement time in the isometric exercise group but there is no difference according to gender. The contrast test and effectiveness test between individuals and within individuals by time of the isometric exercise group are shown in <Table 10> and the p-value of the isometric gender group was .730, so the sphericity hypothesis was established.

In order to the temperature change by measurement time according to gender of the isometric exercise group, a contrast test was conducted and as a result, there was a significant difference before measurement and at 12 minutes and immediately after measurement and at 12 minutes and there was no significant difference at 5 minutes and 12 minutes after measurement, at 7 minutes and 12 minutes after measurement.

#### 4. Skin temperature value according to BMI by exercise group

The average skin temperature value of each exercise by time is shown in <Table 11>, and it was  $35.78 \pm 0.53^{\circ}\text{C}$  before measurement and decreased to  $35.56 \pm 0.57^{\circ}\text{C}$  immediately after measurement in the

low-weight group of the isotonic exercise group. It increased after 5 minutes and decreased after 2 minutes. The remaining normal and overweight groups showed the same temperature changes as the low weight group. All the low-weight, normal, and overweight groups of the isometric exercise group showed the same changes as the isotonic exercise group.

The multivariate test for the isotonic exercise group with respect to the BMI index was as shown in <Table 12> and One Way Repeated ANOVA was carried out in order to find out the results based on BMI and measurement time according to exercise method in BMI by exercise group and the p-value of the isotonic gender group was .024 in the Mauchly's sphericity test indicating that the sphericity hypothesis was not established and the multivariate test was carried out in order to find out the interaction between measurement time and BMI, temperature change by measurement time depending on BMI of the isotonic exercise group and as a result, the p value was smaller than .05 in the temperature change by measurement time according to BMI and the p-value is greater than .05 in the interaction between measurement time and BMI, so the temperature change by measurement time was significant, but not significant at the interaction between measurement time and BMI.

The effectiveness test between individuals depending on the measurement time for the BMI index of the isotonic exercise group is shown in <Table 13> and the effectiveness test between individuals was carried out in order to find out temperature change according to BMI of the isotonic exercise group and as a result, it was not significant because the p-value is 0.288, which is greater than 0.05. The interaction between measurement time and measurement time BMI was significant.

The contrast test within individuals according to isotonic exercise group BMI index is shown in <Table 14>, and the contrast test was conducted in order to find out temperature changes by measurement time according to

BMI of the isotonic exercise group and as a result, there was no significant difference before and after 12 minutes, after 5 minutes, after 12 minutes, after 7 minutes, and after 12 minutes and there was a significant difference immediately after the measurement and after 12 minutes.

The effectiveness test between individuals and within individuals depending on isometric exercise group BMI index and measurement time is shown in <Table 15> and the effectiveness test within individuals was conducted in order to find out temperature changes by measurement time and as a result, the F-value is 8.800 and the p-value is 0.000, which was smaller than 0.05, indicating a significant difference depending on the measurement time.

In order to find out the temperature change depending on BMI of the isometric exercise group, the effectiveness test between individuals was conducted and as a result, the F-value is 3.484 and the p-value is 0.067 in the exercise group, which is greater than 0.05, indicating no difference depending on BMI. The effectiveness test within individuals was conducted in order to find out the interaction between measurement time and exercise method and as a result, the F-value is 0.672 and the p-value is greater than 0.05, indicating no significant difference depending on the exercise method and measurement time.

As a result, there was no difference depending on BMI and interaction between measurement time and BMI in the isometric exercise group. The p-value of the isometric gender group was .135, indicating the sphericity hypothesis was established.

The contrast test within individuals according to the isometric exercise group BMI index is shown in <Table 16>, and the contrast test was carried out in order to find out temperature change by measurement time according to BMI of the isometric exercise group and as a result, there was a significant difference before measurement and at 12 minutes, immediately after measurement and at 12 minutes and there was no significant difference at 5 minutes and 12 minutes after measurement and at 7 mi-

minutes and 12 minutes after measurement.

#### IV. Review

Escamilla-Galindo et al. (2017) said that the skin temperature of each body part was found to be significantly different depending on temperature and humidity change during submaximal exercise in changes in skin temperature and the amount of sweat depending on temperature and humidity changes during submaximal exercise and the skin temperature of each body part showed a tendency that the temperature went up and down, and went down and up again without showing a constant change over time. Therefore, this is considered to have a mechanism to maintain the equilibrium of heat incoming and outgoing of the body because as the temperature of the environment increases, the capillary blood vessels of the skin surface expand, so the blood flow increases and the skin temperature rises and on the other hand, when the environmental temperature is lowered, the blood vessels contract and the blood flow decreases, resulting in a drop in the skin temperature.

Schlader et al (2011) said that the skin temperature begins to decrease at the beginning of the exercise and as the intensity of the exercise increases, the skin temperature falls further because of the vasoconstriction caused by the non-body heat factor. In this study, however, the skin temperature by time of each exercise group did not show statistical significance differences according to exercise method but after any exercise, temperature decreased slightly and gradually increased, then decreased again, showing that the skin temperature decreased immediately after exercise.

There was a significant difference both in temperature change and interaction by measurement time in the isotonic exercise gender group and there was an interaction according to measurement time and gender but there was no difference between male and female in the isometric

exercise gender group. The results of the comparison of male and female in the isotonic exercise group at mean skin temperature showed that the male group had a higher temperature change than the female group. Kreisman et al(2003) reported that men can show a great deal of power due to the high percentage of Type IIb fibers and norepinephrine in circulating blood, which reduces skin temperature, increases proportionally with the burden in relation to exercise intensity or body burden, indicating that the temperature decreases immediately after measurement of male group than the female group as shown in this study.

Yeung-Mo Yang (2005) showed significant results at the start of exercise and 5 minutes of exercise and in recovery after exercise in changes in mean skin temperature by each time at the intervals of 5 minutes in changes in skin temperature after exercise of obese students and standard weight students. At this time, the skin temperature of obese students is significantly lower than that of standard weight students. It is said that the effect of thick subcutaneous adipose tissue caused disturbances in the peripheral circulation blood flow enhancement function.

Also in this study, the temperature change by measurement time in the BMI group with isotonic exercise was significant, but the interaction between BMI and measurement time was not significant. The BMI group with isometric exercise showed no difference according to BMI and the interaction between measurement time and BMI in the BMI group with isometric exercise. The results of the comparison of low, normal, and overweight in the average skin temperature of the isotonic exercise group showed that changes in temperature were higher in the normal group than in the low-weight group, and higher in the overweight group than in the normal group.

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## V. Conclusion

In order to find out the effect of isometric exercise and isotonic exercise on skin temperature changes of biceps brachii, this study was carried out for 28 healthy male and female students from Department of Physical Therapy, G University from 28 May to June 8, 2013.

The following results were obtained.

1. In changes in skin temperature according to isometric isotonic exercise, temperature decreased immediately after exercise regardless of the exercise group.

2. In differences in skin temperature between genders, each exercise group showed temperature decrease immediately after measurement and the isometric exercise group showed a temperature difference before measurement and after 12 minutes and immediately after measurement and after 12 minutes and isotonic exercise group showed a temperature difference immediately after measurement and after 12 minutes, after 5 minutes and after 12 minutes.

3. In the difference according to the BMI index, each exercise group showed temperature decrease immediately after measurement and the isotonic exercise group showed a significant difference immediately after measurement and after 12 minutes and the isometric exercise group showed a temperature difference before measurement and at 12 minutes, immediately after measurement and after 12 minutes.

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Appendix 1. Table

Table 1. General Characteristics of the Subjects

	Isotonic(n=14)		Isometric(n=14)	
Gender(n,%)	M 7(50)	M 7(50)	M 14(100)	
	F 7(50)	F 7(50)	F 14(100)	
Age(year)	22.64±1.45 <sup>a</sup>	22.78±1.62	22.71±1.51	
Height(cm)	170.42±8.51	170.92±10.60	170.68±9.44	
Weight(kg)	63.36±11.95	62.50±13.68	62.93±12.61	

<sup>a</sup>Mean±SD

Table 2. Changes in Skin Temperature According to Time Change and Exercise Group

	Before-measurement	After-measurement	After 5 min	After 7 min	After 12 min
Isotonic(n=14)	35.69±0.65 <sup>a</sup>	35.36±0.61	36.19±0.84	36.12±0.99	35.94±0.91
Isometric(n=14)	35.47±0.83	35.12±0.97	35.92±0.71	36.00±0.82	35.86±0.62

<sup>a</sup>Mean±SD

Table 3. The Effectiveness Test Between Individuals, within in the Individual Depending on the Measurement Time of Body Heat Change according to Exercise Group

	SS	df	MS	F-value	P-value
Measurement time	14.091	4	3.523	23.252	.000*
Exercise method	.247	1	.247	.465	.502
Measurement time * Exercise method	.182	4	.046	.300	.877

\*p<.05



Table 4. Changes of temperature by measurement time

	measurement time	SS	df	MS	F-value	P-value
Measurement time	before-measurement/after 12 min	2.925	1	2.925	9.123	.006*
	after-measurement/after 12 min	12.356	1	12.356	30.490	.000*
	after 5 min/after 12 min	.691	1	.691	3.215	.085
	after 7 min/after 12 min	.673	1	.673	2.472	.128

\*p&lt;.05

Table 5. Changes in skin temperature by gender and time depending on each exercise

		Before-measurement	After-measurement	After 5 min	After 7 min	After 12 min
Isotonic (n=14)	M(n=7)	35.98±0.44 <sup>a</sup>	35.52±0.57	36.57±0.72	36.43±1.00	36.24±0.84
	W(n=7)	35.39±0.72	35.19±0.64	35.81±0.83	35.80±0.94	35.65±0.95
Isometric(n=14)	M(n=7)	35.60±0.69	34.92±0.60	35.94±0.70	36.24±0.91	36.08±0.45
	W(n=7)	35.33±0.98	35.31±1.26	35.90±0.76	35.75±0.69	35.70±0.76

<sup>a</sup>Mean±SD

Table 6. The multivariate test results by gender and time of the isotonic exercise group

	값	F-value	가설 자유도	오차 자유도	P-value
Measurement time	.975	89.439	4	9	.000*
Measurement time*Gender	.763	7.241	4	9	.007*

\*p&lt;.05

Table 7. Effectiveness test between individuals of the isotonic exercise group

	SS	자유도	F-value	P-value
Gender	1.166	1	2.307	.155

Table 8. The contrast test depending on measurement time of change in body temperature for gender group of the isotonic exercise group

	Measurement time	SS	df	MS	F-value	P-value
Measurement time	before-measurement/after 12 min	.900	1	.900	2.545	.137
	after-measurement/after 12 min	4.779	1	4.779	10.959	.006*
	after 5 min/after 12 min	.880	1	.880	5.558	.036*
	after 7 min/after 12 min	.432	1	.432	1.619	.227

\*p<.05

Table 9. The effectiveness test between individuals and within individuals depending on measurement time of change in body temperature and gender of the isometric exercise group

	SS	df	MS	F-value	P-value
Measurement time	7.755	4	1.939	13.222	.000*
Gender	.073	1	.073	.135	.720
Measurement time*Gender	1.609	4	.420	2.711	.039*

\*p<.05

Table 10. The contrast test and effectiveness test between individuals and within individuals by time of the isometric exercise group

	measurement	SS	df	MS	F-value	P-value
Measurement time	before-measurement/after 12 min	2.161	1	2.161	6.347	.027*
	after-measurement/after 12 min	7.755	1	7.755	27.603	.000*
	after 5 min/after 12 min	.057	1	.057	.203	.660
	after 7 min/after 12 min	.252	1	.252	.808	.386

\*p<.05

Table 11. The average skin temperature value according to BMI and each exercise by the time

		Before-measurement	After-measurement	After 5 min	After 7 min	After 12 min
Isotonic (n=14)	Low-weight(n=4)	35.78±0.53 <sup>a</sup>	35.56±0.57	36.24±0.71	36.34±0.47	36.09±0.58
	Normal(n=6)	35.90±0.63	35.58±0.57	36.11±0.73	36.44±1.24	36.10±1.12
	Overweight(n=4)	35.28±0.75	34.07±0.42	35.52±0.45	35.41±0.72	35.56±0.95
Isometric (n=14)	Low-weight(n=2)	34.71±0.84	34.83±0.50	35.53±0.35	35.48±0.13	35.38±0.27
	Normal(n=10)	35.80±0.69	35.42±0.92	36.11±0.74	36.24±0.85	36.11±0.51
	Overweight(n=2)	34.56±0.07	33.87±0.34	35.39±0.55	35.29±0.41	35.86±0.62

<sup>a</sup>Mean±SD

Table 12. The multivariate test for the isotonic exercise group with respect to the BMI index

	값	F-value	가설 자유도	오차 자유도	P-value
Measurement time	.975	89.439	4	9	.000*
Measurement time*BMI	.763	7.241	4	9	.679

\*p&lt;.05

Table 13. The effectiveness test between individuals depending on the measurement time for the BMI index of the isotonic exercise group

	SS	F-value	자유도	P-value
BMI	1.463	1.395	11	.288

Table 14. The contrast test within individuals according to isotonic exercise group BMI index

		SS	df	MS	F-value	P-value
Measurement time	Before-measurement/after 12 min	.934	1	.934	2.442	.146
	After-measurement/After 12 min	4.784	1	4.784	9.873	.009*
	After 5 min/After 12 min	.697	1	.697	4.285	.063
	After 7 min/After 12 min	.293	1	.293	1.242	.289

\*p&lt;.05

Table 15. The effectiveness test between individuals and within individuals depending on isometric exercise group BMI index and measurement time

	SS	df	MS	F-value	P-value
Measurement time	6.165	4	1.541	8.800	.000*
BMI	2.549	2	1.275	3.484	.067
Measurement time*BMI	.942	8	.118	.672	.713

\*p<.05

Table 16. The contrast test within individuals according to the isometric exercise group BMI index

	Measurement	SS	df	MS	F-value	P-value
Measurement time	Before-measurement/after 12 min	2.073	1	2.073	5.950	.033*
	After-measurement/After 12 min	5.475	1	5.475	13.272	.004*
	After 5 min/After 12 min	.183	1	.183	.589	.459
	After 7 min/After 12 min	.167	1	.167	.475	.505

\*p<.05