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Comparing Skin Temperatures between Nordic Walking and General Walking for 60 Minutes

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Abstract

The purpose of this study was to identify the effects of 60-minute walking workouts using nordic walking poles on skin temperatures, and examine differences in body heat changes between nordic walking and general walking. Infrared thermal imaging was measured in healthy male and female adults (nordic 17, general 16). The participants were attached radial markers on upper extremity, trunk, and lower extremity to be recognized accurately. After attaching the markers then measured standard skin temperature by Digital Infrared Thermal Imaging (IRIS-XP, MEDI-CORE, Co., Ltd., Seoul, Korea). Both group walked for 60 minutes, the retest were taken 4 times per 20 minutes. Region of interest was set at below the radial marker and compared average value between nordic walking and general walking. For nordic walking, all muscles except the triceps in the upper extremity showed statistically significant differences in body heat changes according to time variations (0,20,40,60) (<0.05). Nordic walking showed statistically significant differences in body heat changes in the external oblique, rectus abdominis, and erector spinae of the trunk ($p<0.05$), and the body heat decreased during the workouts. Nordic walking showed statistically significant differences in the rectus femoris and hamstring of the lower extremity ($p<0.05$) and the body heat decreased with time. Human skin temperature declines during both nordic walking and general walking.

Keywords: Infrared Thermal Imaging, Nordic Walking, Skin Temperature

1. Introduction

As walking is less restricted by time and places than the other general exercises and is appropriate for regular exercises, it is widely used[1]. In Korea, populations performing various types of walking workouts are also rapidly increasing. These include general walking, power walking that applies strong upper-body movements without instruments, dumbbell walking which refers to walking holding dumbbells, and nordic walking using nordic walking poles[2].

Nordic walking was designed for the summer training of Finland's skiers and has become popular spreading from the Scandinavian Peninsula to other European regions due to its advantage of enabling workouts with low skills[3]. Nordic walking uses poles for walking, which are light and usable for long hours, to protect joints against external impacts. These poles are divided into those that can control their lengths and those with fixed lengths. They also have ergonomic handgrips and wrist straps installed[4]. When walking using nordic walking poles, an individual should relax his/her shoulder, look straight ahead, and stand while holding the poles with both hands. The poles should be placed close to the trunk, and when an arm moves forward, the leg on the other side should move forward. In this manner, nordic walking lets

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an individual continue to walk while swinging the arms and legs in opposition[5,6]. Nordic walking is more effective in inducing muscle activities in the upper body than general walking[7].

Volkanen[8] compared the levels of muscle activation during nordic walking and general walking using electromyography and reported that nordic walking showed higher levels of muscle activation in the erector spinae, deltoid, triceps brachii, vastus medialis, and gastrocnemius than general walking.

In addition, Sprod et al.[9] conducted a study on a control group that performed aerobic, muscle strengthening, and flexibility exercises for the rehabilitation of the upper extremity after breast cancer surgery and the test group that performed nordic walking in addition to the exercises performed by the control group. As a result, the test group exhibited improved levels of muscle endurance in the pectoralis major and minor, deltoid, triceps brachii, and latissimus dorsi.

Skin temperatures are externally affected by temperature, humidity, and air current, and internally affected by skin blood flow (5-6mm deep). When the external temperature is fixed at 21 degree Celsius, average skin temperatures range from 24 to 34 degree Celsius, and are mostly controlled by vasoconstriction and vasodilation.

Therefore, while skin temperatures under normal conditions show bilaterally symmetrical temperature distributions in terms of physiological functions, asymmetrical temperature distributions appear when dysfunctions in vasomotor mechanism occur[10].

The body heat pattern analyzer is a digital infrared thermal imaging system. It can sense infrared rays that are naturally emitted from the body surface, process them using the computer, and record them by visualizing them into images. It offers a non-invasive diagnosis method without biological risks. It can be useful for researching signs of abnormality in the physiological control of body temperatures, which directly or indirectly influences skin temperatures, by measuring and recording temperature distributions in the skin surface of each part of the human body. In other words, it is infrared thermography that images and visualizes infrared rays that occur in the human body[11,12].

The purpose of this study was to identify the effects of 60-minute walking workouts using nordic walking poles on skin temperatures, and examine differences in body heat changes between general walking and nordic walking which shows higher levels of muscle activation in the upper extremity and the trunk than general walking and reduces weight loads in the low extremity.

2. Materials and Methods

2.1 Subjects

This study was performed after obtaining the approval of the Bioethics Committee of Gangwon University (KWNUIRB-2014-09-011-001). The recruitment of subjects for its experiment was notified targeting healthy male and female adults in their 20s and those who agreed to participate were selected as subjects. The subjects consisted of 17 individuals (male 10, female 7) for nordic walking and 16 individuals for general walking (male 8, female 8). General characteristics of the subjects are shown in Table 1.

Table 1. General characteristics of the subjects

	Nordic walking	General walking	Total
Gender	10/7	8/8	33
Age(years)	20.71 ± 1.93	21.19 ± 1.72	20.94 ± 1.82
Height(cm)	169.65 ± 9.12	166.38 ± 7.54	168.06 ± 8.43
Weight(kg)	66.87 ± 9.11	65.34 ± 12.01	66.13 ± 10.48

2.2 Methods

Body heat measurement, nordic walking, and general walking were all conducted while indoor temperatures were maintained at 22-24 degree Celsius. The subjects changed their clothes in a changing room within our laboratory and took time to adapt to the indoor temperatures while sitting on a chair for 15 to 20 minutes.

To apply identical body heat measurement points to all subjects, infrared reflective markers were attached to the Anterior Deltoid (AD), Biceps Brachii (BC), Flexor Carpi Ulnaris (FC), Posterior Deltoid (PD), Triceps Brachii (TC), and Extensor Carpi Radialis (EC) in the upper extremity. For the trunk, the reflective markers were attached to the Rectus Abdominis (RA), External Oblique abdominis (EO), and Erector Spinae (ES). In the lower extremity, the reflective markers were attached to the Rectus Femoris (RF), Tibialis Anterior (TA), Hamstring (HAM), and Gastrocnemius (GCM).

After all markers were attached, each subject was instructed to stand on a point that was 150cm apart from the body heat pattern analyzer IRIS-XP (Medi-Core Co

Ltd, Seoul, Korea), and then the front and back of the subject's whole body were measured one time. After measuring the resting temperatures of the subjects before starting nordic walking, the subjects in the test group were led to bend their humeral joint and elbow joint to be perpendicular to each other and control the nordic walking poles to be placed close to the iliac crest[13]. After they practiced walking holding the poles in both hands ten times, they started nordic walking in the laboratory.

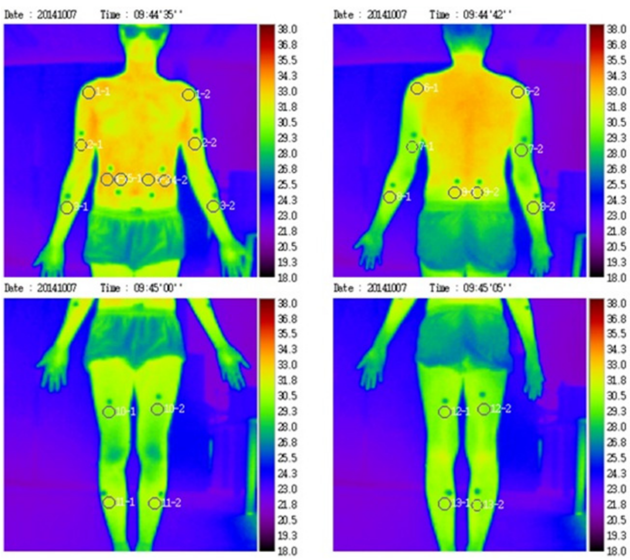

Figure 1. The body heat pattern.

Here, the subjects were instructed to walk at their self-selected paces on the ground. After they performed nordic walking for 20 minutes, the front and back of their bodies were measured using the body heat pattern analyzer, and then they started walking again in the same manner. The subjects were measured four times: before starting the test (resting temperatures), and 20 minutes, 40 minutes, and 60 minutes after starting the test, respectively. For general walking, the same method was applied. After the subjects practiced it ten times, they were measured four times for 60 minutes in the same manner as that for nordic walking (Figure 1).

The software program SPSS Statistics 21.0 was used for the statistical processing of the study's results. The general characteristics of the subjects were translated into averages. A One-Way Anova was employed to compare the test and control groups for each muscle.

3. Results

3.1 Upper Extremity

For nordic walking all muscles except the triceps in the upper extremity showed statistically significant differences in body heat changes according to time variations (0, 20, 40, 60) (<0.05), and the body heat gradually decreased with time.

For general walking, all muscles exhibited statistically significant differences in body heat changes according to time variations (0, 20, 40, 60) ($p<0.05$), and the body heat gradually decreased with time (Table 2).

Table 2. Changes of upper extremity skin temperature according to time

		0min	20min	40min	60 min	F	p
AD	N	31.06 ± 0.78	29.19 ± 0.91	28.48 ±0.87	28.46 ± 0.94	32.977	0.000*
	G	30.53 ± 0.95	29.39 ± 0.69	29.11 ± 0.65	29.05 ± 0.56	14.436	0.000*
BC	N	30.86 ± 0.72	29.00 ± 0.82	28.79 ± 0.84	28.59 ± 1.00	25.744	0.000*
	G	30.31 ± 0.84	28.73 ±0.67	28.20 ± 0.47	28.14 ± 0.51	40.101	0.000*
FC	N	30.67 ± 0.51	29.17 ± 0.62	29.05 ± 0.70	28.91 ± 0.80	25.821	0.000*
	G	30.23 ± 0.91	28.92 ±0.77	28.49 ± 0.81	28.32 ± 0.90	16.522	0.000*
TC	N	29.27 ± 0.73	28.97 ± 1.16	28.84 ± 1.11	28.64 ± 1.16	01.030	0.386
	G	29.04 ±0.99	27.87 ± 1.04	27.32 ± 0.52	27.10 ± 0.52	18.643	0.000*
EC	N	30.45 ± 0.49	30.12 ± 0.71	29.84 ± 0.73	29.70 ± 0.89	03.706	0.016*
	G	30.05 ± 0.47	28.85 ± 0.54	28.44 ± 0.80	28.23 ± 0.90	21.733	0.000*

Unit:degree Celsius(° C)
Mean±SD
Min: minute; AD: anterior deltoid; BC: biceps brachii; FC; flexor carpi ulnaris;
TC: triceps brachii; EC: extensor carpi radialis; N: nordic walking group; G: general walking group
*Statistically significant at the level of $p<0.05$

Table 3. Changes of trunk skin temperature according to time.

		0min	20min	40min	60 min	F	p
EO	N	31.86 ± 0.60	30.66 ± 0.83	30.32 ± 0.80	30.34 ± 0.81	15.205	0.000*
	G	31.48 ± 0.95	30.59 ± 1.08	31.05 ± 0.89	30.92 ± 0.88	2.374	0.079
RA	N	31.59 ± 0.96	30.01 ±0.89	29.56 ± 0.82	29.51 ± 0.99	19.100	0.000*
	G	30.90 ± 1.31	30.21 ± 1.34	30.23 ± 1.34	30.08 ± 1.46	01.162	0.332
ES	N	30.95 ± 1.05	29.48 ± 0.98	28.80 ± 0.97	28.73 ± 1.09	17.318	0.000*
	G	30.72 ± 1.10	29.82 ± 1.17	29.44 ± 1.27	29.50 ± 1.34	03.733	0.016*

Unit:degree Celsius(° C)
Mean±SD
Min: minute; EO: external oblique; RA: rectus femoris; ES: erector spinae; N: nordic walking group; G: general walking group
*Statistically significant at the level of p<0.05

Table 4. Chnages of lower extremity skin temperature according to time.

		0min	20min	40min	60 min	F	p
RF	E	29.09±0.69	28.10±0.68	28.09±0.66	28.15±0.60	9.442	0.000*
	G	29.03±1.46	28.20±1.27	28.07±1.16	28.23±1.12	1.895	0.140
TA	E	30.01±0.55	30.36±0.53	30.34±0.62	30.36±0.70	1.386	0.255
	G	30.03±0.76	30.25±0.83	30.47±0.89	30.54±0.91	1.209	0.314
HAM	E	29.60±0.80	28.71±0.94	28.72±1.06	28.67±1.15	3.513	0.020*
	G	29.45±1.23	28.99±1.27	29.14±1.30	29.22±1.31	0.368	0.777
GCM	E	29.56±0.78	29.34±1.00	29.39±1.10	29.39±1.07	0.153	0.927
	G	29.51±1.02	29.70±1.10	29.75±1.12	29.63±1.24	0.142	0.935

Unit:degree Celsius(° C)
Mean±SD
Min: minute; RF: rectus femoris; TA: tibialis anterior; HAM: hamstring;
GCM: gastrocnemius; N: nordic walking group; G: general walking group
*Statistically significant at the level of p<0.05

3.2 Trunk

The results of nordic walking showed statistically significant differences in body heat changes in the external oblique, rectus abdominis, and erector spinae of the trunk (p<0.05), and the body heat decreased during the workouts.

The results of general walking showed statistically significant differences in the erector spinae (p<0.05) and overall declines of the body heat in the external oblique and rectus abdominis. However, these declines were not statistically significant (p>0.05) (Table 3).

3.3 Lower Extremity

The results of nordic walking showed statistically significant differences in the rectus femoris and hamstring of the lower extremity (p<0.05) and the body heat decreased with time.

The results of general walking did not reveal statistically significant differences in body heat changes in all muscles (Table 4).

4. Discussion

Compared to general walking, nordic walking, which can be performed by anyone, disperses weight loads into various body regions. Therefore, it can reduce vertical ground reaction and vertical knee joint forces[13,14]. In addition, a study analyzed the gait patterns of young male adults during nordic walking and reported that Nordic walking increased their step lengths[15]. The study also reported that this type of walking largely increased the values of calorie and oxygen consumption. This indicates that nordic walking consumes larger amounts of energy than general walking[7,13,16].

In this regard, the present study measured body heat changes in the subjects for 60 minutes during nordic walking and general walking at their self-selected paces. The test's results showed that the body heat decreased during nordic and general walking. While statistically significant differences were not shown in the triceps brachii during nordic walking, the average body heat decreased. Therefore, there were body heat changes with time during the workouts and these changes were body heat declines.

The skin continues to maintain our body temperatures, and heat is delivered from the deep part to the skin via blood circulation. Skin blood flow can change due to various mechanisms such as a rich network of sympathetic nerve fibers and the loss or evaporation of heat[17].

A study by Torii et al.[18] reported that when healthy male adults rode a bike, their body heat decreased during the exercise. In the initial phase after starting the exercise, body temperature declines were exhibited. Moreover, an increase in exercise intensity led to a corresponding decline in body temperature. As a result, temperature differences of about 1.5 to 2.0 degree Celsius were observed between the temperature in the early phase of the exercise and the final temperature after the exercise. The researchers suggested that these body heat declines are not due to increased sweating, but due to the contraction of blood vessels caused by non-thermal factors.

A study by Ferreira et al.[19] had young male and female adults start localized exercises, and both groups that exercised and did not exercise showed skin temperature declines 10 minutes after starting the exercises. Zontak et al.[17] also reported in their study that during graded load exercises, the contraction of blood vessels continued to occur, thereby lowering the temperatures of hands.

The present study discovered statistically significant differences in the body temperature of the trunk after nordic walking ($p<0.05$). This coincided with the results of Park's study[20] in which the body surface temperature was measured after selective exercises were performed in the rectus abdominis, a main abdominal muscle, and the body surface temperature decreased with time.

During nordic walking, the rectus femoris and hamstring in the lower extremity showed body heat declines. Shim et al.[21] reported that the nordic walking group and the general walking group did not show group differences in muscle activation during their walking on the treadmill. However, the present study examined skin temperature changes during nordic and general walking, and derived the results that differed from the findings for muscle activation. Willson et al.[14] noted that nordic walking poles reduced vertical ground reaction forces, vertical knee joint reaction forces, and knee extensor angular impulse. Therefore, nordic walking poles may have lowered the body heat in the rectus femoris and hamstring by reducing the lower-extremity stress.

5. Conclusion

Both the nordic walking and general walking groups showed body heat declines after starting their workouts. As nordic walking reduces loading conditions (stress) in the lower extremity, it may have further reduced the body heat than general walking.

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