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The Effects of Wet Heat and Dry Heat on the Gait and Feet of Healthy Adults

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Abstract. [Purpose] The purpose of this study was to examine the degree of changes in gait and feet after wet heat and dry heat exposure for 20 minutes. [Subjects] The participants of this study were 17 young adult males. The subjects were divided into a wet heat group of 9 subjects and dry heat group of 8 subjects. [Methods] Dry heat was applied for 20 min. To facilitate temperature adjustment of an electrical hot pack, to which a temperature controller was attached to the hot compress, the outer cover of the electrical pad was wrapped in a cotton towel and then rolled around the femur and the leg. As a hot compress, a constant-temperature water tank with double-boiling functionality was used for the hot pack unit. Its surface was covered with a towel twice or three times, as needed. We measured gait and feet. [Results] Left and right step time and the step width significantly increased in the wet heat group. Left foot flat to heel off significantly increased in the dry heat group. Right heel contact to foot flat significantly increased in the wet heat group. Left rearfoot pressure significantly increased in the dry heat group. [Conclusion] Wet heat affects physical functions like gait more than dry heat. However, there is no great difference between wet heat and dry heat with respect to the distribution of foot pressure.
Key words: Dry heat, Wet heat, Gait and feet

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INTRODUCTION

At present, heat therapy is widely used in the field of physical therapy, and it is mainly used to reduce pain or muscular cramping. Heat therapy increases the tissue temperature and the amount of local blood circulation[1)], the encouraging the rapid removal of inflammatory metabolic products such as prostaglandin, bradykinin, and histamine, thereby alleviating pain and promoting healing. In addition, physical changes to collagen tissue, increases in metabolic activity, decreases in muscle cramping, changes to neurological responses, the activities of the musculoskeletal system, and muscle strength and endurance, and feelings of heat and warmth may increase comfort and reduce anxiety in psychological terms[2–5)]. Such changes suggest that heat therapy generally affects the body. By extension, then, this therapy should also affect gait and feet.

Heat therapy can be categorized as superficial heat therapy or deep heat therapy, according to the profundity of the application. Superficial heat therapy can be subdivided into wet heat therapy and dry heat therapy, according to the environment in which it is applied[6)]. A hot compress—a representative wet heat therapy—uses a hydrocollator pack that involves the use of silicate gel in a cotton bag. This inhibits perspiration and moisture loss while concurrently applying heat. Among the dry therapies, a dry hot pack produces heat through the use of electricity that is applied directly to the body. Many hospitals make use of this therapy today.

According to Saunders et al.[7)], in thermodynamic terms, a wet environment is more effective for heat conduction than a dry environment. At present, however, hospitals seem to arbitrarily use dry heat and wet hot packs, regardless of their possibly different treatment effects. Research on how dry heat and wet heat affect the body is very scarce, and this study sought to fill that research gap by examining the differential effects of applications of dry heat and wet heat. Accordingly, this study compared the physical influence of wet and dry heat therapies as manifested in changes in gait and foot condition.

SUBJECTS AND METHODS

The participants of this were 17 young adult males who voluntarily consented to participate in this study and had no disease history or problems with walking. Approval was received from the Research Ethics Committee of Kangwon National University prior to the initiation of the study.

The subjects were divided into a dry heat group (N = 8) and a wet heat group (N = 9). In each group, measurements were taken prior to the intervention, and again at the end of the 20-min intervention. The dry heat group's average age was 21.72 ± 2.07 years, average height was 164.52 ± 8.14 cm, average weight was 60.25 ± 8.60 kg, and average foot length was 245.54 ± 16.60 mm. The wet heat group's

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average age was 22.13 ± 2.13 years, average height was 168.63 ± 6.59 cm, average weight was 62.25 ± 7.44 kg, and average foot length was 252.54 ± 16.48 mm.

Gait Analyzer™ (TechStorm Inc., Seoul, South Korea)[8] was used to measure the subjects' gait and feet. The measurement values were analyzed with Gait Analyzer application software (v3.1). To analyze gait, the values of foot length (cm), foot width (cm), foot angle (°), step time (s), step length (mm), and step width (mm) were examined. To analyze the feet themselves, the rate of movement of each segment from heel contact to foot flat, from foot flat to heel off, and from heel off to toe off during the stance phase were analyzed. As for pressure on the feet, the percentages of fore foot pressure and rear foot pressure were calculated.

Dry heat was applied for 20 min. To facilitate temperature adjustment of the electrical hot pack, which had a temperature controller attached to the hot compress, the outer cover of the electrical pad was wrapped in a cotton towel and then rolled around the femur and the leg, so that it was evenly attached. The surface temperature was measured using an infrared temperature gauge, and the temperature controller was adjusted to maintain a constant temperature of 40–45°C.

As a hot compress, a constant-temperature water tank with double-boiling functionality was used for the wet heat hot pack unit. The temperature of the water in the tank was set to 70°C, and the double-boiled hot compress was then maintained for more than 1 h in the tank, then removed. Its surface was covered with a towel twice or three times, as needed. The surface temperature of the hot compress was measured using a portable infrared temperature gauge, Based on the temperature presented by the heat therapy manipulation guideline[9], the hot compress was applied for 20 min to the subject's lower limbs and the surface temperature was maintained at 40–45°C.

To increase both the reliability of the measuring method and inter-rater reliability, one person was tasked with taking all measurements. All subjects participated in the experiment in the same measuring room and were given at least 10 min of adaptation time. Temperatures could have been affected by the ambient environment, so the temperature and humidity of the laboratory where dry heat and wet heat were applied were adjusted to about 18°C and 40%, respectively. To make the experiment and the measurements therein more convenient to execute, the subjects wore short-sleeved t-shirts and short pants. Prior to the experiment, the gait and feet of members of both groups were measured. After application of heat for 20 min, measurements were again taken of gait and feet, and comparisons were made.

The measured data were analyzed with SPSS 19.0 (SPSS Inc., Chicago, IL, USA) statistical software, and the collected data are presented as mean and standard deviations. We examined pre and post-test measurements using the paired t-test for both groups. The statistical significance level, α, was chosen as 0.05 for all data.

RESULTS

First, we looked at gait. In the dry heat group, the left and right foot lengths, left and right foot widths, left and right angles, left and right step times, step length, and step width were not significantly different between the pre and post-test measurements ($p > 0.05$). In the wet heat group, the left and right foot lengths, left and right foot widths, left and right angles, and step length were not significantly different between the pre- and post-test measurements ($p > 0.05$); however, the left and right step time and the step width significantly increased in the wet heat group ($p < 0.05$) (Table 1).

Table 1. Comparison of gait between dry heat and wet heat treatments

			Pre	Post	
Length (cm)	Lt	D	25.41±2.17	26.12±1.84	
		W	25.56±1.77	24.92±2.32	
	Rt	D	25.90±1.65	26.85±1.56	
		W	25.67±1.97	25.18±2.65	
Width (cm)	Lt	D	8.87±3.63	10.14±0.75	
		W	10.33±0.75	9.72±1.59	
	Rt	D	8.80±3.59	10.37±0.67	
		W	9.81±0.73	9.69±1.24	
Toe angle (°)	Lt	D	3.18±3.26	6.18±5.23	
		W	4.87±3.52	5.44±4.47	
	Rt	D	4.44±2.82	5.02±5.45	
		W	5.94±3.84	6.62±6.36	
Step time (sec)	Lt	D	0.60±0.30	0.62±0.07	
		W	0.66±0.15	0.58±0.48	*
	Rt	D	0.61±0.27	0.66±0.08	
		W	0.68±0.15	0.61±0.12	*
Step length (mm)		D	556.04±28.45	623.50±38.09	
		W	609.33±32.98	595.11±47.19	
Step width (mm)		D	37.00±12.53	27.00±16.53	
		W	16.89±22.78	33.78±17.79	*

* Statistically significant, $p<0.05$
Lt: Left, Rt: Right, D: Dry heat group, W: Wet heat group

Next, we looked at the feet. In the dry heat group, the rate of each segment from left and right heel contact to foot flat, right foot flat to heel off, and left and right heel off to toe off were not significantly different between the pre- and post-test measurements ($p > 0.05$); however, the left foot flat to heel off significantly increased in the dry heat group ($p < 0.05$). In the wet heat group, the rate of each segment from left heel contact to foot flat, left and right foot flat to heel off, and left and right heel off to toe off were not significantly different between the pre- and post-test measurements ($p > 0.05$), but right heel contact to foot flat significantly increased in the wet heat group ($p < 0.05$).

Regarding foot pressure, in both groups, there was no significant difference between the pre and post-test measurements($p > 0.05$), except for the left rear-foot pressure in the dry heat group, which significantly increased ($p < 0.05$) (Table 2).

DISCUSSION

Heat therapy used in physical therapy is much used as

Table 2. Comparison of feet between dry heat and wet heat treatments

			Pre	Post	
Heel contact – foot flat (%)	Lt	D	11.12±5.96	12.00±1.46	
		W	10.33±5.27	12.22±3.53	
	Rt	D	10.50±4.84	11.07±3.55	
		W	11.11±2.26	13.22±3.11	*
Foot flat – heel off (%)	Lt	D	36.50±10.22	51.37±7.05	*
		W	41.00±17.02	47.67±8.99	
	Rt	D	40.50±14.13	43.25±12.89	
		W	48.67±6.78	47.78±9.67	
Heel off – toe off (%)	Lt	D	34.50±12.17	36.63±8.78	
		W	48.67±21.17	40.11±6.62	
	Rt	D	36.50±8.68	44.75±8.17	
		W	40.22±5.91	39.00±9.58	
Forefoot pressure (%)	Lt	D	29.44±6.12	32.38±3.19	
		W	29.70±11.41	33.74±3.17	
	Rt	D	27.68±6.55	30.81±2.33	
		W	36.67±10.41	33.48±3.11	
Rearfoot pressure (%)	Lt	D	14.99±4.67	18.48±1.49	*
		W	14.69±6.24	16.20±3.62	
	Rt	D	15.39±6.55	18.36±4.09	
		W	18.94±7.03	25.68±8.64	

* Statistically significant, $p<0.05$
Lt: Left, Rt: Right, D: Dry heat group, W: Wet heat group

a treatment method for subacute and chronic pain, and inflammatory diseases, except in the acute stage. Heat therapy can be divided into deep heat therapy and superficial heat therapy, with the latter subdivided into wet heat therapy and dry heat therapy. Hot packs are representative of wet heat therapy, while dry heat therapies include the use of infrared lamps, microwaves, and electrical heat pads[10, 11].

In therapeutic terms, mixed results have been resorted in the literature. Some studies claim that wet heat is more effective than dry heat[7], or that in clinical therapeutics, there are no differences between them. There are yet other studies that have reported outcomes of skin surface temperature and blood circulation change after the application of heat, but research focused on functional changes in gait or foot pressure has been lacking. The current study sought to address this lack by examining the degree of changes, in gait and feet following the application of dry heat and wet heat.

After the application of wet heat, the step time of the participants' right and left feet was reduced. This means that the duration of the gait-stance phase decreased and that of the swing phase increased, thus increasing gait speed. In addition, following the application of wet heat, the participants' step width widened, which suggests that the application of wet heat sufficiently relaxes the muscles, facilitating gait with a wider step width. This result is consistent with the results of various studies that claim that the application of wet heat increases skin temperature, which in turn suggests that an increase in skin temperature accompanies increased blood flow[12–14], increasing muscle metabolism and activity. In those studies—as in the current one—functional changes such as an increase in gait speed have been observed. However, the current study found dry heat to have no great effect on gait. Accordingly, we consider wet heat influences gait and functional changes more markedly than dry heat.

Following the application of dry heat and wet heat, changes in foot pressure were examined. After wet heat was applied, the time from heel contact to foot flat was found to become longer, as did the time from left foot flat to left heel off. It was also found that the application of dry heat increased rear foot pressure more greatly than the application of wet heat. This result shows that wet heat and dry heat may affect foot pressure, but that differences were not apparent.

The results of this study show wet heat more greatly affects physical functions like gait than dry heat. However, there was no great difference between wet heat and dry heat with respect to the distribution of foot pressure. Future research of muscle activity and motion analysis in relation to the application of wet heat and dry heat should be undertaken.

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