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Original Article

Comparison of the Effects on Dynamic Balance Ability of Warming up in Water Versus on the Ground

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Abstract. [Purpose] This research was designed to find out how the so-called "dynamic balance" is affected by doing different types of warm up exercises. In particular, the research is focused on the difference in the effect on dynamic Balance of warming up in water versus on the ground. [Subjects and Methods] Twenty healthy adults were the subjects of this study, with 10 people assigned each to two groups, one warming up in water and another warming up on the ground. The dynamic balance was measured for all subjects before the warming up. The group warming up on the ground conducted active stretching on the ground, and the group warming up in water conducted stretching in water by using water as resistance. [Results] The results indicate that warming up in water has a more powerful effect on a subject's dynamic balance than warming up on the ground. [Conclusion] The group warming up in water, who made use of the viscosity and flow of the water, showed better balance than the group warming up on the ground. Warming up in water, which entails an element of resistance, should be implemented in warm-up routines in the future.

Key words: In water, Warming up, Balance

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INTRODUCTION

Warming up is a necessary element that should be performed not only to minimize sports-related injuries but also to promote an appropriate response to physical activity, for training, and for competition[1)]. Stretching is well known as a part of these warming up processes[2)]. Stretching is conducted traditionally by athletes for its three benefits such as reduction of injury risk, reduction of muscle pain after exercise, and enhancement of athletic performance ability[3)]. Also, active stretching is suggested enhance exercise conducted after it through temperature-related benefits that help optimize the physical body for participation in exercise tasks. It is well known that there are many benefits of the "active" elements of stretching, which are designed to prepare the physical body for the increase in body core temperature and blood flow and for the exercise[2)]. As examples of these proposed benefits, there are not only the psychological effects but also the increase in neurological conductivity rate, the decrease in resistance of joints and muscles, the reaction speed of metabolism, the increase in blood flow in muscle, and the post-activation potentiation[1)].

Stretching is closely related to balance[4)], and balance is a necessary ability to maintain the physical body in equilibrium in every movement of daily life. Maintenance of balance refers to the ability to maintain the center of gravity (COG) on the base of support (BOS) during static and dynamic movements, and the ability to adjust to the change in center of gravity in any movement is needed to control continuous postures. Maintenance of balance refers to the ability to respond to any small change by correcting the tension of the whole body. Furthermore, balance is a complex exercise control task that includes the integration of sensory information, the response of the nervous system. Postural reaction is the process that work cooperatively by synergism of muscles between legs and body. In controlling balance, a sensory process is progressed through interaction between inputs that enter from the somatosensory system, visual system, and vestibular system including the proprioceptive senses[5–7)].

When exercise is done in water, it can be done safely due to buoyancy, as there exists a reduction in joint impact and weight burden. When the center of buoyancy does not coincide with the center of gravity, the body is inclined, and by using this inclination, the balance training can be performed through movements to maintain an upright posture. Resistance, such as viscosity and flow, which are water characteristics, can be used for all directions of the body as it moves in water, and this resistance can be adjusted to an

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Table 1. Comparison of balance between before and after warming up by type of warming up

	Group	Before stretching (n=10)	After stretching (n=10)
		M ± SD	M ± SD
Time Required to Balance (ms)	Warming up in water	22.1±12.7	24.8±9.0
	Warming up on the ground	22.2± 7.5	23.9±8.6
Body Posture Length of Left/Right-X axis (mm)	Warming up in water	1103.0±365.7	812.4±217.0*
	Warming up on the ground	1337.5±440.1	1667.29±666.7
Body Posture Length of Front/Back-Y axis (mm)	Warming up in water	475.9±126.6	374.2±73.7*
	Warming up on the ground	499.1±103.9	566.8±120.7

*$p<0.05$

individual's physical strength. The resistance in water has an effect that improves the sense of balance[8–10].

However, there is a lack of research concerning the effect on the balance of warming up in water and the difference compared with warming up on the ground. Therefore, the present research was conducted to find out how warming up in water versus on the ground may affect the change in dynamic balance ability.

SUBJECTS AND METHODS

This research was conducted by randomly assigning 10 people each to two groups, a group warming up on the ground and a group warming up in water; in total, 20 healthy adults who were attending K University in Korea volunteered as subjects after receiving an explanation of the experiment.

Subjects were excluded if they were taking medications had any neurological damage, had skin sensory problems, or had abnormal conditions in the joints or musculoskeletal system. For precise measurement, all personal possessions such as jewelry and accessories were removed, as they might affect the experiments.

This research was conducted after receiving the approval of all matters related to the reaearch procedures, safety, and ethics from the Research Ethics Committee at Kyungbuk College. After giving an explanation to all participating subjects about the research and receiving written agreement from those who agreed to participate, the experiment was conducted with these subjects from September 10, 2012, to September 11, 2012.

The experiment was performed by measuring on the dynamic balance of the recruited subjects with a Good-Balance system (Metitur, Finland) before the experiment. For warming up, the group warming up on the ground conducted stretching on the ground, and the group warming up in water conducted stretching in the water. The water reached as high as a point between the navel and xiphoid process of the subjects. The stretching motion was conducted for 15 minutes within the range that people felt no pain but felt extension.

After warming up, the time required to balance and the body posture lengths of the left/right (X axis) and front/back (Y axis) were measured to determine dynamic balance. SPSS for Windows 12.0 was used for data analysis in this research, and to determine differences by group, the independent sample t-test and paired sample t-test were used to compare before and after warming up. The level of significance was set as $p<0.05$.

RESULTS

The general characteristics of the participating subjects were as follows: the subjects in the group warming up on the ground were 20.8±2.4 years of age, 173.5±7.1 cm tall, and weighed 64.1±11.2 kg, and those in the group warming up in water were 20.4±2.1 years of age, 167.7±9.1 cm tall, and weighed 65.2±8.6 kg.

No significant difference was shown statistically in both the comparison of before and after warming up in both groups and the comparison between groups (Tables 1 and 2).

Comparison of the left/right (X axis) body posture length between before and after warming up revealed that the length in the group warming up in water, decreased from 1103.0±365.7 to 812.4±217.0 mm, which showed a significant difference statistically ($p<0.05$). The group warming up on the ground did not show a significant difference statistically (Table 1).

In comparison of the groups (Table 2), there was a significant difference between the group warming up in water and the group warming up on the ground ($p<0.05$).

Comparison of the front/back (Y axis) body posture length between before and after warming up revealed that, the length in the group warming up in water decreased from 475.9±126.6 to 374.2±73.7 mm, which showed a significant difference statistically ($p<0.05$). However, the group warming up on the ground did not show a significant difference statistically (Table 1).

In comparison of the groups (Table 2), there was a significant difference between the group warming up in water and the group warming up in water ($p<0.05$).

DISCUSSION

This research was conducted using normal adults as subjects to determine out the change in dynamic balance resulting from warming up in water versus on the ground. Warming up was conducted before the subjects performed their main exercise for the purposes of injury prevention and

Table 2. Comparison of balance by type of warming up

	Group	M ± SD
Time Required to Balance (Unit: ms)	Warming up in water	2.6±7.8
	Warming up on the ground	1.6±8.4
Body Posture Length of Left/Right (X axis) (mm)	Warming up in water	−290.5±394.4*
	Warming up on the ground	329.7±475.1*
Body Posture Length of Front/Back (Y axis) (mm)	Warming up in water	−101.6±126.7*
	Warming up on the ground	67.6±153.4*

*p<0.05

enhancement of athletic performance during the main exercise. Warming up before performing your main exercise increases the blood flow in the heart and skeletal muscles and raises the body temperature to reduce stress on joints and muscles, and help to reduce the burden on the heart.

In general, it is well known that the warming up is effective for reducing the risk of injuries that may occur during intense physical activity[11]. Dynamic balance ability consists of the interaction of automatic posture reaction and voluntary movement. On an unstable surface, since the central nervous system restricts the proactive posture control, voluntary changes in the posture of the body and movement of all four limbs (arms and legs) play a more important role[12].

In order to enhance this kind of balance ability, in water exercise that makes use of the viscosity, buoyancy, and resistance of water is frequently used. The flow and buoyancy of water in the underwater environment were shown to enhance balance function by stimulation of muscle proprioception, which prevented injury in individuals due to falls resulting from loss of balance[13]. According to the results of in water resistance training in menopausal women reported by Sattar et al. (2013) and others, psychosocial state and physical function were enhanced compared with a comparison group not subjected to the intervention[14]. Behm et al. reported that a significant difference was found in balance ability after stretching in 16 normal adult subjects[4]. The group warming up in water in this research also showed enhancement in dynamic balance ability. These subjects, it showed a significant difference in front/back body posture length, which decreased from 1103.0±365.7 to 812.4±217.0 mm, and left/right body posture length which decreased from 475.9±126.6 to 374.2±73.7 mm. However, in the group warming up on the ground, the front/back body posture length showed no significant difference, increasing from 1337.5±440.1 to 1667.2±666.7 mm, and the left/right body posture length also showed no a significant difference, decreasing from 499.1±103.9 to 566.8±120.7 mm.

In this research, it is believed that the reason why balance ability was enhanced by more after warming up in water than after warming up on the ground was that the stimulation by proprioceptive organs was more vigorous in water than that caused by the gravity on the ground, because more of a strategy of biomechanical movement was used to maintain the postural balance during stretching, which is affected by the flow and buoyancy of water and because of the greater need for rotational movement of the head and body to recover a normal posture when in an unstable posture. In addition, we believe better mechanical skills for balancing are obtained through functional improvement of muscles and joints in such areas as the quadriceps, hamstring, tibialis anterior, and calf.

In comparison of the group warming up in water and the group warming up on the ground, the front/back body posture length showed significant differences of −101.6±126.7 and 67.6±153.4 mm, respectively, and the left/right body posture length showed significant differences of −290.5±394.4 and 329.7±475.1 mm, respectively. Movement of an object through liquid with viscosity like water can produce more somatosensory input than the movement through air, which has relatively low viscosity, and the resistance against the movement causes expansion or extension of skin to induce stimulation, which helps mechanoreceptors adapt quickly, and to contribute to proprioception; also, the effects of the buoyancy and resistance of water can enhance the function of the proprioceptors of whole body parts. In addition, open kinetic chain exercise and closed kinetic chain exercise can be applied more easily in water than on the ground, which can maintain various postures through the rotational control of head[8, 15, 16]. If this kind of body posture is induced by the interaction of buoyancy and gravity resulting from the movement in water, the proprioceptive mechanoreceptor is stimulated actively in order to recover the body posture. Considering the previous research stating that the water pressure acting on the body during exercise in water can help maintain balance by inducing stimulation of proprioceptors[8, 17], it can be interpreted as a result that the characteristics of water and movement in water more actively stimulated proprioceptors than in the case of warming up on the ground.

Therefore, it is believed that the use of water as resistance for warming up before a person performs their main exercise is effective for enhancement of dynamic balance ability in the main exercise. In the future, research to compare the effects of warming up using other forms of resistance should continue.

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