

# The Effects of Diverse Warm-up Exercises on Balance

KANGHOON KIM, MS, PT<sup>1)</sup>, TAESIK LEE, PhD, PT<sup>2)\*</sup>, GIYEOB KANG<sup>2)</sup>, SANGHUN KWON<sup>2)</sup>,  
SUNGPIL CHOI<sup>2)</sup>, SUNYOUNG PARK<sup>2)</sup>

<sup>1)</sup> Department of Physical Therapy, College of Health Sciences, Catholic University of Pusan, Republic of Korea

<sup>2)</sup> Department of Physical Therapy, Dong-Eui Institute of Technology: 54 Yangji-ro, Busanjin-gu, Busan 614-715, Republic of Korea

**Abstract.** [Purpose] To examine how stretching, plyometric, and treadmill exercises influence the dynamic balance necessary for sports activities. [Subjects and Methods] Twenty-two healthy subjects participated in this study. The subjects conducted stretching, plyometric exercises, and treadmill walking for set times over a period of three days. The subjects' dynamic balance was then measured. The measurements were taken prior to the intervention, immediately after the intervention, and 20 minutes after the intervention. All the intervention times were set at 16 minutes, excluding resting times. The data were analyzed with using the two-way ANOVA. [Results] There was no interaction between exercises and time. There were no statistical differences among the exercises and no statistical differences in changes over time. [Conclusion] This study found that warm-up exercises such as plyometric exercises, stretching, and treadmill walking have no effect on the dynamic of balance in healthy subjects.

**Key words:** Plyometric, Stretching, Treadmill walking

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## INTRODUCTION

Most people conduct warm-up exercises before undertaking sports activities or exercise. Warm-up exercises for postural control are an important factor for normally healthy, ordinary people as well as athletes. Such postural control refers to automatic responses in the vestibular system, vision, and proprioception<sup>1)</sup>. Poor postural control is associated with decreased dynamic balance<sup>2)</sup>. Dynamic balance is the ability to maintain equilibrium while in motion or to move the body from a static to a dynamic state<sup>3)</sup>. Balance impairment is a significant risk factor for falls in healthy people. Fallings are the leading cause of death from injury in elderly people<sup>4)</sup>. In the athletic population, the loss of dynamic balance is an important factor that may cause injury in sport activity<sup>5)</sup>. Warm-up exercises are light exercises that are conducted prior to strenuous physical activity, which aim to reduce damage, such as strains and sprains, during performance. They raise intramuscular temperatures, thereby improving muscle flexibility and adaptability, and enhance postural control<sup>6)</sup>.

Warm-up exercises conducted before exercises or sports activities include stretching, treadmill walking, and plyometric exercise<sup>6, 7)</sup>. Stretching is commonly used as a warm-up exercise to increase people's range of motion and

blood flow rates, and prevent injuries<sup>8)</sup>. Muscle strength and flexibility is boosted by stretching. The body is further able to move more comfortably following stretching, which is also helpful for preventing injuries in all kinds of sports<sup>9)</sup>. Treadmill walking is a warm-up exercise that uses the whole body. It enhances aerobic ability, increases muscle performance during exercise, and has a positive effect on balance ability, as well<sup>7, 10)</sup>. Plyometric training is a type of resistance training. It can improve body equilibrium, coordination, agility, and power, and it has recently received considerable attention as a warm-up exercise that enhances physical ability<sup>6, 11)</sup>. Plyometric exercises use high-speed eccentric exercises to advance concentric muscle action, reflexive responses, and functional exercise patterns. It develops lower body muscle strength, muscle control, and dynamic balance<sup>12-14)</sup>.

As warm-up exercises, the above three exercises greatly affect postural stability. However, research into the effects of each exercise on balance is lacking. Accordingly, this study aimed to examine how stretching, plyometric, and treadmill exercises influence the dynamic balance necessary for sports activities.

## SUBJECTS AND METHODS

The subjects of this study, were 22 healthy undergraduates at D university. Their characteristics are presented in Table 1. The purpose of the study was explained to the subjects who signed consent forms to participation in the study. Then, the approval of the Ethics Committee of the Catholic University of Pusan was obtained (CUPIRB-2014-008). None of the subjects had orthopedic or neurological diseases.

\*Corresponding author. Taesik Lee (E-mail: ptoom@dit.ac.kr)

**Table 1.** Subject characteristics (n=22)

	Weight (kg)	Height (cm)	BMI (kg/m <sup>2</sup> )
Male (n=10)	66.9 ± 1.3	171.3 ± 0.9	22.8 ± 0.4
Female (n=12)	52.6 ± 0.6	161.8 ± 0.8	20.1 ± 1.4

**Table 2.** Comparison of limit of stability before and after intervention for each exercise

	Before exercise	After exercise	After 20 min
Stretching	14,936.6 ± 3,816	15,292.1 ± 4,305.2	15,833.2 ± 3,977.9
Plyometric	14,948.1 ± 5,275.8	13,545.9 ± 5,467.8	15,231.9 ± 5,482.4
Treadmill	15,528.6 ± 4,075.3	14,568.9 ± 3,962.2	14,707.3 ± 3,940.8

es, dizziness, or problems maintaining balance. This study utilized BioRescue (RM Ingénierie, Rodez, France) to measure the limit of stability (LOS) into the evaluation of the subjects' dynamic balance.

The subjects conducted stretching, plyometric exercises, and treadmill walking for set times over a period of three days. The subjects' dynamic balance was then measured. The measurements for each exercise were taken three times: prior to the intervention, immediately after the intervention, and 20 minutes after the intervention. All the intervention times were set at 16 minutes, excluding resting times. The subjects rested for 20 minutes after each intervention. The subjects conducted stretching of the bilateral quadriceps femoris, hamstrings, gastrocnemius, and soleus. They extended each muscle for 45 seconds before resting for 15 seconds, repeating the same motion twice. The subjects' treadmill walking was set at 1.2 m/s, the normal gait speed of adults in their 20s<sup>15</sup>. The plyometric exercise program was followed by the methods described in previous research<sup>14, 16</sup>. At a metronome speed of 100 bpm, the subjects conducted four motions—the plyometric squat, plyometric lunge, lateral jump, and forward jump—for 45 seconds before resting for 15 seconds. The subjects repeated the exercises four times.

The data were analyzed using SPSS 21.0. Repeated measures two-way analysis of variance repeated measure was used to examine the effects of the different kinds of exercise over time (Table 2).

## RESULTS

There was no interaction between exercises and time ( $F=0.40$ ,  $p=0.87$ ). There were no statistical differences among the exercises ( $F=0.34$ ,  $p=0.79$ ) and no statistical differences in changes over time ( $F=0.33$ ,  $p=0.71$ ).

## DISCUSSION

Static stretching is generally thought to have a positive effect in since it prevents injuries during a physical activity. Larsen et al.<sup>17</sup> reported that there were no changes in their study subjects' position sense after quadriceps and hamstring stretching. The proprioceptors, which engage in position sense, play a crucial role in conducting actions

to maintain balance<sup>17</sup>. Proprioceptive tissue is thixotropic, and therefore although the proprioceptive sense may be changed by stretching, the stretching need to be conducted for a long time<sup>17</sup>. In this study, stretching was carried out for a short time and therefore was not able to change the proprioceptors.

Research verifying that treadmill walking improves balance ability has mostly investigated patients with neurological system disorders<sup>10, 18</sup>. Therefore, we considered that treadmill walking had no effect on the subjects of the present study because they were healthy people. In contrast with previous study results that showing that a jumping exercise such as plyometric exercise, enhances balance ability, in the present study, the subjects' LOS values, an index of dynamic stability, did not increase. Plyometric exercises use abductor and adductor muscles more than ordinary jumps, and therefore greater loads are imposed by them, triggering the mobilization of additional muscles. Unlike a previous study in which a two-minute resting time was given, this study provided a resting time of only 30 seconds, and therefore the subjects' muscle fatigue were not able to completely recover from fatigue after the exercises<sup>19</sup>. Muscle fatigue affects postural control and considerably decreases balance ability<sup>20</sup>. In particular, the hip extensor muscles influence balance in the standing and bending positions. Balance ability decreases as muscle fatigue accumulates and proprioceptive responses to the joints are inhibited<sup>21</sup>. Interestingly, we found that balance ability greatly decreased immediately after the plyometric exercises but was swiftly recovered thereafter. It is recommended that future research reduce muscle fatigue by extending the resting time and examining the subsequent changes over time.

This study found that warm-up exercises such as plyometric exercises, stretching, and treadmill walking have no effect on the dynamic of balance in healthy subjects.

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