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Original Article

Effect of progressive resistance exercise with neuromuscular joint facilitation on the dynamic balance performance of junior soccer players

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Abstract. [Purpose] The aim of this study was to investigate the change in dynamic balance performance of junior soccer players after progressive resistance treatment with neuromuscular joint facilitation (NJF). [Subjects] The subjects were 14 healthy males who were divided into two groups, namely the NJF and control groups. The NJF group consisted of 8 subjects, and the control group consisted of 6 subjects. [Methods] The participants in the NJF group received NJF progressive resistance treatment. Dynamic balance performance was measured before and after 3 weeks of exercise. [Results] Significant improvement in dynamic balance performance was observed both in the NJF and control groups. In the NJF group, dynamic balance performance was significantly increased compared with that in the control group. [Conclusion] The NJF intervention shortened movement time, which implies that NJF is effective for dynamic balance performance.

Key words: Neuromuscular joint facilitation, Dynamic balance

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INTRODUCTION

Dynamic balance can be defined dynamically as the ability to perform a task while maintaining a stable posture. The influence factors of dynamic balance include sensory information obtained through the somatosensory, visual, and vestibular systems and motor responses that affect coordination joint range of motion (ROM) and muscle strength. All sports likely require the sensorimotor processes to perform skills and protect the neuromuscular joint system from injuries. Proprioceptive training programs have been used to prevent lower limb injuries in many sports. Quantification of dynamic balance is often necessary to properly evaluate athletes' current level of motor ability. Dynamic balance of the lower limb is often best assessed by using the squatting-rising test on an unstable surface. Squatting activities may be used within exercise programs to preserve physical function[1)]. Furthermore, the reciprocal influence of balance and sport performance has been recently investigated, especially concerning unilateral stance[2)]. Researches on theories of sport training showed that increased dynamic balance of the lower limbs may effectively enhance athletic trainer performance. Intense balance training can improve some aspects of soccer performance, especially at early ages[3)].

Neuromuscular joint facilitation (NJF) is a new therapeutic exercise based on the knowledge of kinesiology. It integrates the element of proprioceptive neuromuscular facilitation to joint composition movement, and improves the joint movement by passive, active, and resistance exercises. It is used to increase muscle strength, flexibility, and ROM[4)].

Physical fitness is a general state of health and well-being, especially the ability to perform aspects of sports or occupations. Physical fitness is generally achieved through moderate vigorous physical activities and exercises. It is a set of attributes or characteristics observed in people that relate to the ability to perform a given set of physical activities. Fitness is the capacity to perform activities of daily living. Physical fitness is now considered a person's capacity to function effectively in work and leisure activities, to be healthy, to resist hypokinetic diseases, and to respond to emergency situations.

NJF as a new physical fitness exercise may be composed of medical, health, and athletic NJF. Specific-oriented fitness is a person's ability to perform specific activities with reasonable efficiency. Specific training prepares athletes to perform well in sports. Athletic NJF as a new specific-oriented fitness intervention has been applied in specific athletes. The purpose of this study was to investigate changes in the

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Table 1. Characteristics of the subjects

	Age (yrs)	Height (cm)	Weight (kg)
NJF (n=8)	16.8 ± 1.6	176.0 ± 10.4	63.4 ± 10.1
Control (n=6)	16.3 ± 1.9	177.8 ±9.7	62.2 ±13.8

Data are presented as mean ± standard deviation. No significant differences were observed between the groups at the 0.05 alpha level. NJF: neuromuscular joint facilitation group, Control: control group

Table 2. Comparison between pre- and post-intervention values of dynamic balance performance (sec)

	Pre-intervention	Post-intervention
NJF (8)	10.9±0.9	8.1±0.8**†
Control (6)	10.9±0.8	9.5±0.8**

Data are presented as mean ± standard deviation. Significant differences after the intervention.
NJF: neuromuscular joint facilitation group, Control: control group.
$^{**}p<0.01$, comparison between before and after the intervention; $^{\dagger}p<0.05$, comparison between the groups

dynamic balance performance (measured by taking seconds of 6 repetitions of split squats on a JOINFIT balance dome) of junior soccer players after NJF progressive exercise.

SUJECTS AND METHODS

The subjects were 14 healthy males who were divided into two groups, namely a NJF group and a control group. The NJF group consisted of 8 subjects, and the control group consisted of 6 subjects. The subjects were students of the Huaiyin Soccer School of Huaian City. To be included in the study, each participant was required to have been trained at the soccer school for at least 2 years. Subjects' characteristics are detailed in Table 1. The dominant leg was determined by asking the subject which leg he preferred to step over a banana hurdle.

The subjects were excluded if they had a lower limb injury, visual problems, or vestibular problems. The exclusion criteria were assessed by using a questionnaire and through physical tests. The subjects signed an informed document approved by the ethics committee of Jangsu Province Huaian Sports School, which also approved the study. Before each testing session, all of the subjects were supervised to perform a 15-minute conventional routine warm-up. The subjects were asked to refrain from any exercise for 2 hours before testing.

We measured the dynamic balance performance by performing seconds of 6 repetitions of split squat on a JOINFIT balance dome (diameter 59 cm, peak of the dome 21 cm, Jiangsu, China) before and after the intervention. The subjects placed one foot on a weight bench, ensuring that both legs were far apart. Front-leg standing on the JOINFIT balance dome should be about 3 feet away from the bench. The hands were placed on the hips. Subjects then squat down until the knee was bent to about 90°. The upper body was kept straight during squatting. Then, the subjects return to the starting post. This procedure was performed in 6 repetitions. The performing seconds for 6 repetitions of split squat was measured by using an electronic stopwatch. Meanwhile, 3 performing seconds of 6 repetitions of split squat was used to determine dynamic balance performance.

Four knee patterns of NJF were used, namely the knee extension-tibia external rotation (E-ER), knee flexion-tibia internal rotation (F-IR), knee extension-tibia internal rotation (E-IR), and knee flexion-tibia external rotation (F-ER) patterns. The patterns were performed three times at random as a resistance exercise. An NJF intervention and a control intervention were performed. The subjects start sitting on an adjustable bench with one end of a Thera-Band wrapped around the ankle and the other end attached to something sturdy close to the floor behind the subjects. The knee was straightened against the resistance and then smoothly returned back to the starting position, maintaining full control throughout. In the NJF group, both the proximal resistance controlled with a standard volleyball, which is squeezed between the knees, and distal resistance controlled by a Thera-Band was performed. In the control group, only distal resistance controlled by a Thera-Band was performed. The subjects in both groups received the intervention three times a week for 3 weeks. The distal resistance was progressive, that is, by 6 lb in the first week, 9 lb in the second week, and 11 lb in the third week, both in the NJF and control groups. The intervention was performed by the same physical therapist to avoid individual variations in exercise. The subjects refrained from any strength and balance exercises during the intervention period in order to avoid confounding variables.

To determine whether the NJF and control groups had significant differences, the independent t-test was performed on the subjects' characteristics. Two-way analysis of variance and multiple comparisons (Bonferroni) were used to test for statistically significant differences, and the factors were the interventions and groups. If a significant interaction was found, the paired t-test was performed to compare between before and after the intervention. The independent t-test was performed to compare between the NJF and control groups after the intervention. Data were analyzed by using SPSS 18 for Windows. The level of statistical significant was set as $p = 0.05$.

RESULTS

No significant differences were observed between the subject characteristics of the NJF group and those of the control group. Table 2 shows the results of the dynamic balance performance. Two-way analyses of variance showed that the NJF and control groups had significantly increased dynamic balance performance. In the NJF group, dynamic balance performance increased significantly in comparison with that in the control group.

DISCUSSION

This study investigated the effects of NJF progressive resistance intervention on the dynamic balance performance of unilateral lower limbs. The results imply that NJF progres-

sive resistance exercise increases muscle strength, balance, and proprioception in junior soccer players. The former research studies suggested immediate effects of NJF intervention on knee muscle force and standing balance[6, 7]. Dynamic balance of the lower limbs, especially on the unilateral side, is essential in sports training to improve sensorimotor performance and postural control and perhaps to reduce the risk of injury. Although strong dynamic balance (stability) of the lower limbs are believed to help athletic performance, few scientific studies have been conducted to identify the effectiveness of dynamic balance (stability) training of the lower limbs in terms of improving athletic performance. In athletic training and events, dynamic balance (stability) plays an important role in maintaining balance by appropriately shifting the center of pressure. Increasing evidence indicates that insufficient or abnormal neuromuscular control of the lower limbs during athletic movements, particularly of the knee joints, is a primary contributor to non-contact anterior cruciate ligament injuries[5]. The knee is not an isolated joint but is part of the body's kinetic chain in which the body, as a linked system of interdependent segments, often engages in interactions to achieve efficiently the desired movement. The present study showed the effect of NJF exercises on balance control of unilateral lower limbs and thus gives the implication that the NJF intervention may improve joint dynamic alignment and the balance between muscles and soft tissues by effectively activating local stabilizing muscles of the lower limbs. Further studies are needed to investigate the change in dynamic balance of the body's kinetic chain after a long period of NJF intervention. Furthermore, the performance of athletes from different sports in balance tests has not been clarified. When prescribing balance exercises to athletes in different sports such as sprint, soccer, and gymnastics, it is important to understand performance variations. Similarly, performing different athletic NJF exercises in different sports events and training may be important.

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