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Original Article

Effect of a Neck Proprioceptive Neuromuscular Facilitation Training Program on the Body Postural Stability in Elite Female Basketball Players

Homa Naderifar[1], Hooman Minoonejad[2*], Amir Hossein Barati[3], Alireza Lashay[4]

[1]Department of Sports Injuries and Corrective Exercises, Kish International Campus, University of Tehran, Iran
[2]Department of Health and Sport Medicine, Faculty of Physical Education and Sport Sciences, University of Tehran, Tehran, Iran
[3]Department of Exercise Physiology, Shahid Rajaee Teacher Training University, Iran
[4]Eye Research Center, Farabi Eye Hospital, Tehran University of Medical Sciences, Tehran, Iran

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ABSTRACT

Background: Balance is an indispensable part of daily activities and is considered important in examining the performance of athletes especially in basketball. Despite the advantages of neck proprioceptive neuromuscular facilitation (PNF) training on neck proprioception, it has remained understudied. Neck proprioception is very important for performance in exercise. Therefore, the aim of this study was to evaluate the effect of neck PNF training on neck proprioception on postural stability and limit of stability in elite female basketball players.
Methods: In this study, 30 female basketball players with at least three years of basketball activity were randomly assigned into two groups: experimental group (neck PNF training) and control group. The experimental group participated in 4-week neck PNF training sessions (12 sessions per week). On the other hand, the control group performed only daily routine exercises. Limit of stability and postural stability index of the participants were determined by the Biodex balance test before and after the exercise program. Independent t-test (between the two groups) and paired t-test (in each group) were applied using the SPSS-18 software to analyze the obtained data, with a significance level of $p<0.05$ adopted.
Results: The results indicated that after 4 weeks of neck PNF training, the means of overall stability index in the exercise group decreased from 1.47±0.27 to 0.92±0.07 ($P<0.001$). Also, for mediolateral index, it declined from 1.17±0.37 to 0.85±0.35 ($P=0.04$), and for the anteroposterior index it fell from 1.14±0.13 to 0.92±0.08 ($P<0.001$). However, there were no significant differences between pre-post training in the control group.
Conclusion: These results provide evidence that neck PNF training can be used to enhance the postural stability and limit of stability indices of basketball players. The neck proprioception may be improved with training programs, and neck PNF training improved postural stability index can reduce sports injuries and enhance athletic performance.

Introduction

Basketball is one of the dynamic sports, in which all players are present throughout the court and move constantly. Basketball players change directions, jump and run, exerting a great deal of overload to the lower limbs. Therefore, balance and neuromuscular control are important factors affecting the performance of these players [1]. Postural stability is an essential factor to reduce sports injuries and improve the performance of

**Corresponding author:* Hooman Minoonejad, Associate Professor of Department of Health and Sport Medicine, Faculty of Physical Education and Sport Sciences, University of Tehran, Tehran, Iran.
Tel: +98 9123487425
E-mail: h.minoonejad@ut.ac.ir

basketball players [2]. Balance can be defined as the ability to maintain the body's center of gravity over the base of support which results from neuromuscular actions in response to continuous visual, vestibular, and somatosensory feedback [3]. To obtain awareness about the position of the head in space and on the trunk, information should be obtained from vestibular and visual systems and from the neck proprioceptive sensory feedback [4]. This information comes from the structures of the neck, including muscles, joints, and skin [5]. Cervical afferents play an important role in providing proprioceptive input [6,7], with the abundance of cervical mechanoreceptors in the neck [7]. In the neck's upper area , there is a high density of tiny muscles providing neck proprioception entrances [8]. The neck sensory-motor system has an important role in the postural control [9, 10]. Studies have shown that the neck muscle fatigue has a negative effect on postural control and visual acuity, thereby increasing extensor cervical muscle fatigue and sway posture [11]. Researchers have paid much attention to evaluating the effect of different training methods on improving postural stability in athletes [12]. The neck proprioception may be improved with training programs [13].

One of the trainings that can be effective in the neck proprioception is PNF training. Indeed, PNF training is based on some movement patterns to facilitate and correct sensory function [14]. Neck PNF improves the functions of the muscles and tendons by stimulating the proprioceptive sense, enhancing muscle strength, flexibility, and balance [15]. Neck pattern exercises are known to increase the stability of the head and neck [16]. Herman Kabat, during the years of 1949-1959, used a method called PNF training, which is defined as "facilitating the neuromuscular response through stimulating pathways and neck proprioception receivers" [17]. These exercises use deep receptors and other sensory data to facilitate movement and movement learning responses [18, 19]. These exercises facilitate and control neuromuscular systems through two mechanisms. Generally, these exercises consist of two parts including the movement patterns and techniques [Autogenic and reciprocal inhibition). There are principles in patterns and techniques by which a person is helped to improve [19, 20]. The adduction and stretching of the articular surface during exercises stimulate the neck proprioception receptors of the cervical spine. The adduction is applied at the beginning of the movements performed in the direction of gravity, while the stretching is applied at the start of movements performed in the opposite direction of gravity. During each exercise, the performer should look at the hand on which it is practiced [19, 21]. Neck proprioception is very important for optimal neck performance in exercise [7]. Although some studies have investigated the effects of neuromuscular training on improving balance and postural control, there is no study evaluating the effect of neck PNF training in athletes. Therefore, the development of an effective training program for the neck proprioception can result in a major improvement on postural stability. To the best of our knowledge, there is no study on the effect of neck PNF training on postural stability in athletes. Accordingly, the aim of this study was to investigate the effect of neck PNF training on body postural stability and limit of stability index among female basketball players.

Methods

Subjects

In this study, 30 female basketball players with 18-24 years of age were selected through purposeful sampling. They must have done at least three years of basketball activity continuously. Furthermore, they had not participated in other professional sports; they did not have any history of direct trauma to the neck or head during last month, and lower limbs, in the last six months. Further, they did not have any history of taking medications which affected neuromuscular function [22], audio-visual disorder such as refractive errors, musculoskeletal disorders, neuropathy, diabetic foot, surgery or illness which affected postural stability, record of surgery, neurological and musculoskeletal disorders in lower limbs, and history of ankle problem (fracture, an ankle sprain, ankle injury) and knee ACL injury in the 6 months prior to the time of study, or participation in other rehabilitation programs which coincided with the current research [23]. The informed consent forms were filled out by the subjects before the study. The study gained the ethical approval from Tehran University of Medical Sciences.

Methods of Data Collection and Design Performance

These subjects were randomly assigned into two groups. The first group was the experimental group (15 basketball players) who took part in neck PNF training while the second group (15 basketball players) was considered as the control group, according to previous studies [12].

The anthropometric variables of the subjects were recorded in the form of individual information. Before starting the research, the height and weight of each subject were measured by a meter and digital scale. The Biodex Balance System (BBS) was used to measure postural stability and limit of stability. BBS calculate three separate measures: anteroposterior, mediolateral, and overall stability axes. High OSI score represents poor balance [16]. The stability platform allows for varying levels of the difficulty of stability testing. The reliability of BBS at level 4 in ICC value was found to be 0.72 for the total stability, 0.77 for AP stability, and 0.81 for ML stability [24].

In this study, we assessed bilateral stance with open eyes with a BBS over three 20-s periods on level 4 stability. In each trail, there was a 10-s rest. The postural stability and limit of stability all of the subjects in two groups were measured before and after the training.

Before starting the exercises, they were trained to the subjects. Then, all the movements were performed by the participants under the supervision of the researcher.

The experimental group conducted 12 exercise sessions in each week [six days per week in the morning and afternoon) for four weeks. During the study, the control group maintained the level of their activity before participating in the study. The control group just performed their routine exercises and maintenance level of training (Table 1).

The subjects sit down on the chair where their head and neck were out of the chair, while performing their training program and following all patterns by their eyes. Each training was performed 3 sets with 10 repetitions in the first week in the morning and afternoon for 6 days a week, and in each week, two repetitions were added. In the second week, the subjects performed any of the trainings 12 times and rested between them for 5 seconds. Further, 14 and 16 repetitions were performed in the third and fourth weeks, respectively.

They rested for 5 seconds in each exercise and 10 seconds in each set. For four weeks, they performed these trainings (12 sessions a week). The researcher was sent SMS each morning to ensure that the training program was performed. Also, she participated in athletic training sessions three days a week in the afternoon. The duration of the training program was 4 weeks.

Statistical analysis: After ensuring the assumptions of normal data distribution and the equality of variance with two tests, paired t-test (internal) and independent t-test (between groups) were used for within and between-group comparisons All analyses were performed by IBM *SPSS* Statistics version 19.0. The significant level was considered as less than (P≤0.05)

Results

The results for this study indicated that there was no statistical difference in terms of demographic characteristics including age, height, weight, and BMI

Table 1: Training program (13):

No.	Training
First	They performed flexion, adduction, and external rotation movement of the right shoulder and upper limb simultaneously with the extension and rotation of the head and back toward the opposite side. The trainings were repeated by the same pattern for the opposite side (Figure 1).
Second	The subjects performed extension, abduction, and internal rotation movements of the right shoulder and upper limb with the head and neck flexion and rotation toward the same side (Figure 2).

Figure 1: The subject's position while performing head and neck movement with her right arm in the first direction

Figure 2: The subject's position while performing head and neck movement with her arm in the second direction

Table 2: The demographic characteristics of the two groups

Variable	Groups		P value
	Control group	Experimental group	
Age	20.35±1.27	20.13±1.54	0.30
Height (CM)	1.87±169.1	1.55±169.1	0.63
Weight (kg)	62.33±3.71	62.4±3.94	0.95
BMI (Kg/m2)	1.31±21.68	1.1±21.29	0.45

Table 3: Comparison of changes in the postural stability index before and after exercises in the experimental and control groups

Variable Statistics	Groups	Pre-test Mean±SD	After test Mean±SD	P value
Overall stability	Experimental Control	1.47±0.27 1.3±0.25	0.92±0.07 1.1±0.09	0.00 0.07
Media-lateral index	Experimental Control	1.17±0.37 0.85±0.43	0.85±0.35 0.77±0.27	0.04 0.69
Anterior- posterior index	Experimental Control	1.14±0.13 0.97±0.05	0.92±0.08 0.93±0.10	0.00 0.70

Table 4: Comparison of changes in the limit of stability index before and after exercises in the experimental and control groups

Variable Statistics	Groups	Pre-test Mean±SD	Post-test Mean±SD	P value
Overall stability	Experimental Control	28.66±7.23 29.40±9.14	51.60±6.38 31.93±8.54	0.00 0.80

between the experimental and control groups (P>0.05).

Changes in the postural stability index before and after exercises in two groups are presented in Table 2. As can be observed, the overall stability, mediolateral, and anteroposterior indices diminished significantly after 4 weeks of neck proprioceptive neuromuscular facilitation exercises (P<0.05). For the overall stability, the means of this index decreased from 1.47+ to 0.92+ (P<0.001) in the exercise group; for mediolateral index, it dropped from 1.17±0.37 to 0.85±0.35 (P=0.04); and for anteroposterior index it declined from 1.14±0.13 to 0.92±0.08 (P<0.001).

Tables 3 and 4 compares the changes in limit of stability index before and after exercises in the two groups. The overall stability increased significantly in the exercise group after the test (28.66± 7.23 vs. 51.6±6.38) (P<0.001), while there was no significant increase for this index in the control group (P=0.809).

Discussion

The purpose of this study was to investigate the effect of the neck PNF training on the postural stability and limit of stability index among female basketball players. The results suggested that the training had a significant effect on the overall stability, AP, and ML index. Indeed, PNF training stimulates the muscle and tendon through the neuromuscular system [25]. Previous studies have shown that neck muscle proprioception has a significant role in maintaining proper orientation, balance, and motor coordination of the body [26]. Further, proprioceptive information plays a crucial role in maintaining postural stability [12]. It is important to improve the performance of neck proprioception in athletes through special neck proprioception trainings. Among several balance training programs, PNF training involves different patterns of movements and provides a proper neuromuscular function through stimulating the proprioceptive system [21]. The patterns of movement are rotational, multi-axial and multidirectional in PNF training. These movements are more effective than single axial movements and are used to enhance the joint range of motion, muscle endurance, and muscle harmony [13].

Ebrahimi et al. stated that balance training can improve the postural stability and limit of stability [27]. However, to the best of the authors' knowledge, no study has assessed the effect of the neck PNF training among athletes. Contrary to our findings, the results of Letafatkaret al. suggested no significant difference in neck proprioception performance before and after neck muscular fatigue between elite athletes and non-athletes [28].

Furthermore, the study by Afhami et al. indicated that that neck PNF proprioception training can improve compensatory postural stability and enhance head and neck stability against external perturbation in karate athletes [12]. Further, a significant relationship has been found between fatigue and proprioception [29]. Previous studies have evaluated the effect of neck fatigue on the stability, the effect of neck proprioception [30], and the effect of neck PNF training on the neck pain [13, 31]. Rezasoltani et al. found that the neck PNF training could be more appropriate than other rehabilitation programs in neck pain [13]

Indeed, neck muscle fatigue leads to changes in the sensory receptors of the neck muscles and proprioception, thereby increasing postural sway. There is a significant correlation between neck muscle fatigue and postural stability [31].

Our findings are similar to the results of some other researchers who found that the PNF training program improves the total and anteroposterior single-limb postural stability in female athletes [20]. As a justification, we can state that proprioception has a crucial role in balance and postural control [8]. The neck PNF training is one of the basic principles to prevent head and neck injuries in athletes [2, 3].

Therefore, it seems that 4-week neck PNF training can cause a significant improvement in overall, AP, and ML postural stability in female basketball players. Further, our results revealed significant differences between the two groups. Our results suggest that further studies are required to evaluate the effects of this training on male athletes as well as on static sports. Many studies have suggested that training can improve the effect of visual, vestibular, and sensory systems [22]. Therefore, we suggest the evaluation of the effects of vision and neuromuscular training on the stability and postural control in athletes.

Conclusion

This study suggested that the use of the neck PNF training, for 4 weeks 2 sessions per day and for 6 days a week, could have a significant effect on postural stability and could ameliorate the limit of stability indexes. Neck proprioception may also be improved by the neck PNF training, which can have a significant impact on the performance and reduce sport injuries in female basketball players.

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Conflict of interest: None declared.

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