Effect of Training on Proprioception and Balance in Female Basketball Athletes

(Comparison of Three Different Training Methods)

Abstract

Background: The most common problem in female athletes is noncontact lower extremity injuries partly related to proprioception and balance. The aim of this study is comparison of 3 training methods, namely neuromuscular, strength & combined trainings effects on proprioception, and balance in female basketball players.

Methods: The subjects were 42 female basketball athletes with mean age, height and weight of 20.73±1.88 years' 172.47±6.57 cm and 63.54±4.98 kg. The body mass index was (21.36±1.17). 3 experimental and 1 control groups completed 6 weeks and 3 times per week neuromuscular, strength and combined trainings. Knee proprioception was measured by Isokinetic Biodex Dynamometer and functional balance by star excursion balance test before and after training. Repeated measure Anova, Independent sample T test and post hoc test was used to show differences between Grou ps.

Results: Statistical analysis of data revealed a significant difference in knee proprioception and functional balance between the 4 training groups (p<0/05).

The combined trainings followed by neuromuscular trainings in female athletes improved the neuromuscular function.

Conclusion: Prescription of combined trainings and then neuromuscular trainings in female athletes' trainings can cause improvement in neuromuscular function in female basketball players.

Keywords: Basketball, Proprioception, Athletes, Female, Lower Extremity

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Introduction

Extremities injuries, especially knee injuries are the most prevalent cases among female athletes. Among various factors causing non-contact knee injuries, proprioceptive impairment in knee receptors and subsequent neuromuscular dysfunction [1-3] have been introduced as the most important factors [4-7].

Non-surgical and non-pharmaceutical procedures are highly important for preventing this injury, which is the most prevalent case. This problem still occurs in the life of female athletes despite using various exercise protocols [7-9].

According to epidemiological studies, female athletes are prone to extremities injuries 2-10 times greater than male athletes [3-5]. In addition to injury, heavy costs of treatment, the missing opportunity to participate in exercise and physical activities, secondary injuries, such as ruptured meniscus and osteoarthritis, and long-term disabilities have highlighted the importance of programs preventing these injuries [7-9]. Several theories have been proposed to describe variables about non-contact injuries in women's extremities. However, a major part of these studies has examined the effect of neuromuscular factors and their impairments on injury incidence in female athletes [5, 8, 9]. Research findings indicate that the function of knee proprioceptive receptors located in ligaments, tendons, joint capsules, and muscles around the knee keep the knee joint dynamic stability [10-13], so their suitable function can control and prevent injury [13]. Süss (2011) explains that participation in a neuromuscular training program leads to joint dynamic stability, and corrects muscle imbalances and biochemical performances. These programs reduce non-contact injuries and also decrease the

sex-depended differences in exercise sets that make these exercises more useful among women [14]. According to Myer and other researchers, improved biomechanics and neuromuscular performance after participation in training programs will reduce the risk of injury among young women and improves the exercise sets. These kinds of exercises improve technique and dynamic stability and also reduce extremities injury among female athletes [15-17]. Moreover, the results show that eight-week neuromuscular and strength exercises improve the star excursion balance test in female soccer players [18]. Other findings indicated that strength exercises with emphasis on core stability training improve proprioception, dynamic balance, and balance reflexes. These exercises also correct muscular imbalance, improve exercise sets [19-22], and possibly reduce the risk of extremities injuries [22, 23]. On the other hand, some researchers suggest that both neuromuscular and strength exercises must be done complementary to prevent non-contact extremities injuries among female athletes [24-27]. The mentioned studies confirmed the usefulness of both exercises in the improvement of balance and proprioception, while no study has compared the effects of these exercises considering their accumulative effects. According to researchers, the specific nature of basketball affects dynamic balance, and female basketball players have weaker dynamic balance rather than volleyball and soccer players. On the other hand, injury prevalence is greater among female basketball players [3, 10, 13, 28]. Therefore, the extant study was designed to compare these three techniques among female basketball players without injury.

Methods

This was a quasi-experimental study that evaluated the effect of several specific exercises introduced by researchers for preventing extremities injuries among female athletes [18-23] on the proprioception and balance of female basketball players. The statistical population of this study comprised professional female basketball players in Shiraz, Iran. The participants were collected through a convenient sampling method and were selected based on the block randomized method and assigned to four groups (n=42) as statistical athletes. The athletes were supposed to be in the age range of 19-25 with at least 3-years experience of membership in super linguae and league 1 of Fars Province. The participants ought to have normal BMI and menstrual cycle. The selected participants were assigned to neuromuscular (n=11), strength (n=11), combined (n=10) exercise groups, and one control group (n=10).

Exclusion criteria of the study included pain and childbirth experience, fracture and dislocation and any kind of surgery in extremities and spine over the past year, joint laxity based on Bieghton test, misalignment of lower limbs (Geno Varum, Genu valgum, Genu recurvatum, Tibial torsion, thigh anteversion, flatfoot), ligament rapture and injuries, meniscus, and joint capsule damages. The author conducted the mentioned steps through physiotherapy examinations.

After the athletes were selected based on the inclusion and exclusion criteria and they signed the consent letter, they were randomly assigned to three test groups (neuromuscular, strength, and combined exercises) and one control group. All athletes then participated in a pre-test to measure the research variables, including proprioception (using dynamometer-isokinetic model 850-000-30) and dynamic balance (using balance functional test). The athletes in the control group continued their regular exercises without doing any specific training, while athletes in the test group (i.e., neuromuscular, strength, and combined exercises) took part in specific training programs under the supervision of the examiner for six weeks (three 35-50-min sessions per week: 35 min in first and second weeks, 40 min in third and fourth weeks, and 50 min in fifth and sixth weeks). In the next step, the athletes of the control group did not do any specific exercise doing their routine training, the whole athletes of the test group attended specific programs under the direct supervision of the examiner. Participants of all three exercise groups did 10-min warm-up (3-

min carioca, 3-min lateral jump, 3-min hamstring stretch, 4-min quadriceps stretch) exercises at the beginning and 10-min cool down exercises (several selected stretch exercises in lower limbs) at the end of the program. It is worth noting that athletes of the test group (neuromuscular, strength, and combined exercises) performed their specific training programs in hours and days that differed from their routine exercises (protocols included mornings of odd days and evenings of even days) to reduce fatigue effects. Finally, variables were measured for all athletes (test and control groups) 48 hours after the last session of the six-week training program. (Tests were done 48 hours after the main protocol, and athletes were asked not to do any exercise within 48 hours before the measurements).

Star Excursion Balance Test (SEBT):

The balance functional test was done to measure the dynamic balance (Figure 1). The measurement was done after athletes knew the test method. First, the examiner asked the athlete to stand on one lower limb and then move another foot forward, backward-inside, and backward-outside (anterior (ANT), postro medial (PM), and postro lateral (PL)), while holding the big toe far from the network center. Six exercise attempts were done on each leg in all three directions before doing the final test. In the seventh attempt, the farthest distance between the big toe and the network center was measured and recorded. All of the mentioned steps were repeated for another leg. The length of the athlete was measured and recorded from the bottom end of the anterior-superior vertebral column to the bottom end of the external ankle of each foot in a standing position [18] (Figure 1).

SEBT composite score:

The SEBT composite score was calculated based on the following formula: sum of maximum reach directions of anterior, postro medial, and postro lateral divided by 3 times the limb length then multiplied by 100 [18].

Active angular reconstruction test (mean error of active angular reconstruction with 5°×sec from 90 degrees of bending to 45 degrees) and isokinetic device were used in the pre-test and post-test to implement the test and measure knee proprioception sense. This test was repeated three times for each leg. Finally, the device showed the mean error value of the angle made by the athlete during these three attempts (Figure 2).

Finally, the collected data, including age, height, and weight of athletes, and research variables were analyzed within two descriptive and inferential statistics through SPSS21 software. The ANOVA test was then used based on the achieved conditions (doing the Kolmogorov-Smirnov test on data normality and Levene's test on data homogeneity) to compare the results obtained in the pre-test and post-test. (Separate repetitive analysis of variance for all factors in four groups, two tests, dominant and non-dominant limb). In inferential statistics, paired t-test was used to compare the mean values of both groups in the pre-test and post-test. After the presence or absence of difference between test groups was found (significance of test in ANOVA table), the significance of the mean difference between groups is examined. For this purpose, Tukey's post hoc test was used to compare the mean values of the groups.

This test expresses the significant difference between groups without indicating the different sizes or values. Hence, a concept called effect size (Cohen's criteria) is used to find the difference value between groups. Moreover, the significance level of 95% with an alpha value of 0.05 was considered in this study.

Results

Findings indicated no significant difference between the mean values of age, height, weight, and BMI of athletes assigned to four considered groups (Table 1).

Figure 1: Balance test

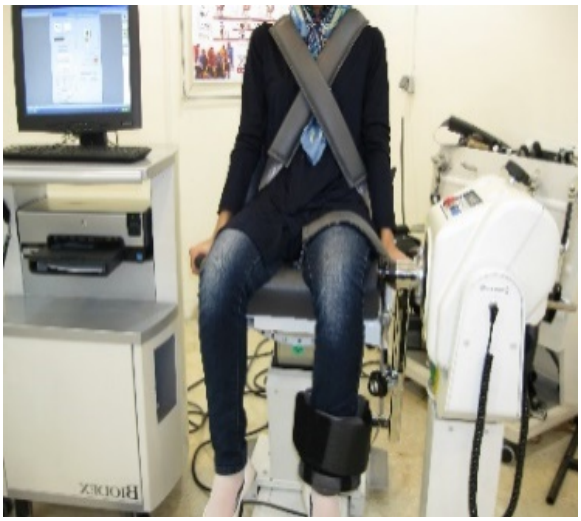

Figure 2: Measurement of proprioception using Biodexisokinetic device

Table 1. Descriptive characteristics of athletes				
Feature	**Group 1**	**Group 2**	**Group 3**	**Control group**
Age (year)	20.36±1.96	21.81±1.94	20±1.33	20.7±1.94
Height (cm)	171.09±5.64	18.9±6.26	176±6.01	170±7.63
Weight (kg)	62.63±2.9	62.81±3.9	62.40±5.03	62.5±6.98
BMI	21.43±1.35	21±0.73	21.44±1.38	21.58±1.21

According to the results of the composite test of repeated ANOVA on the mean value of the error test on knee proprioception, the interactive effect of time on the group was significant (P=0.001, F=18.7) and the interactive effect of time on the limb (leg) was insignificant (P=0.18, F=1.9).

The paired t-test was used to examine the intergroup difference between the post-test and pre-test data of each group, while the Tukey test was used to evaluate intergroup differences between the three studied groups. Moreover, the effect size was estimated based on the Cohen method when the post-training intervention difference was significant.

Table 2 reports the results of paired t-test to examine the intergroup difference. According to the Posthoc Tukey test, the mean value error test on knee proprioception indicated a significant difference between neuromuscular exercise (P=0.001, mean difference=0.55), strength-combined (P=0.001, mean difference=0.68), neuromuscular-strength (P=0.001, mean difference=0.52) groups.

According to the results of the composite test of ANOVA on repeated measures on the SEBT test, the interactive effect of time on the group was significant (P=0.003, F=4.98) and the interactive effect of time on the limb (leg) was insignificant (P=0.18, F=1.9).

Table 3 reports the results of paired t-test. According to posthoc Tukey's test, no significant difference existed between neuromuscular and strength exercise groups (P=0.30) in the SEBT test six weeks after the training program, while no significant difference existed between neuromuscular and combined groups (mean difference=-2.46, P=0.002), combined and strength groups (mean difference=-3.55, P=0.001). In this case, the SEBT score of the combined exercise group was greater than the neuromuscular and strength groups.

Table 2. Results of paired t-test on knee proprioception in four groups			
Group	**T**	**P**	**Cohen's d**
Neuromuscular exercises	6.9	0.001*	1.09
Strength exercises	3.4	0.003*	0.45
Combined exercises	7.86	0.001*	1.98
Control	1.19	0.24	-

Table 3. Results of paired t-test on balance performance in four groups			
Group	**T**	**P**	**Cohen's d**
Neuromuscular exercises	-4.22	0.001*	0.52
Strength exercises	-3.42	0.003*	0.12
Combined exercises	-6.09	0.001*	0.84
Control	-0.18	0.8	-

*Significant difference

Conclusion

The research results indicated that balance exercises could significantly reduce the error test score of proprioception among healthy people [29-31]. According to statistical data analysis, a significant improvement with high effect size occurred in the knee joint dynamic detection sense in the neuromuscular exercise group. According to the results of different studies, various exercises have been recommended to improve proprioception (including exercises that are done on a balance mat with open and closed eyes). Experimental studies have confirmed the efficiency of these exercises [31, 30, 7]. In general, it is believed that balance exercises facilitate static and dynamic stability by creating a pushing force. These exercises also increase joint coordination and retrain the proprioception receptors. The balance exercises reduce proprioception error by improving neuromuscular communications [29,32].

Because somatosensory information received by joint mechanoreceptors is an important factor in keeping dynamic stability [12] and input-output interconnection exists in the status control system, any change in proprioception can affect the motion function. Therefore, the results of two current hypotheses indicated that knee proprioception and balance changes after imposing the exercise interventions were similar in the three groups. This finding is in line with the research results. Moreover, improved proprioception and balance performance was seen in the combined exercise group. This improvement was aligned and had a large effect size.

Holm et al. (2004) conducted a prospective study to examine the effect of neuromuscular training on the proprioception, dynamic balance, and possible incidence of injuries in healthy female handball players and explained that these exercises are done to prevent injury and improve the dynamic balance and current joint proprioception. They also found an association between dynamic joint detection sense and dynamic balance [31]. The results of the present paper were matched with the findings obtained by Holm. Moreover, simultaneous improvement

in proprioception and balance function that occurred in combined exercises may be affected by the effect of simultaneous interventions of balance exercises, strength training, and core stability.

Regarding the importance of status control in keeping dynamic stability and reducing possible injuries in extremities, the extant study assigned two groups of athletes to two balance-centered exercises, including neuromuscular and combined exercise groups. These athletes did the balance and perturbation training on the mat and slides, which are regular strength exercises done to prevent extremities injuries.

Strength exercises affect the mechanoreceptors of muscle spindles and the Golgi tendon organ, improve balance and neuromuscular communications, and reduce knee proprioception error [12].

A significant increase occurred in the balance function with a small effect size in the strength exercise group after doing six-week training. This was an expected result due to the type of exercises because strength exercises strengthen the muscles of lower limbs. These training programs included some exercises designed to improve the power of the upper body and core stability (bridging and sit-ups). McCaskey (2011) also confirmed the positive effect of core stability on the Star Excursion Balance Test [30].

The results of this study indicated increased balance performance in the combined exercise group with a high effect size. This result was matched with findings obtained by the abovementioned studies.

According to the obtained results, the combined exercises with high effect size could improve the balance performance. In inter- and intra-group comparisons, the only preference was seen in the combined exercises that improved the balance performance. This is a debatable issue regarding the importance of balance performance in the risk for incidence of non-contact extremities injuries.

It was expected to reach improved balance performance following the type of combined exercises (plyometric, perturbation balance, extremities strength, and core stability). According to Robinson and Gribble (2008), an increased score on the balance performance test was obtained due to increased bending in the hip and knee joints of the stance leg. Their results found a correlation between hip and knee bending that increases the reach distance in the balance performance test with the strength of lower limbs [31]. Moreover, Filipa et al. (2012) assume that a combined training of neuromuscular, extremities strength, and core stability exercises can improve the star excursion balance test's score [18]. The present study indicated that a training program that included polymeric, balance, extremities strength, and core stability exercises could highly improve the star excursion balance test, while this score was not greater in the group of neuromuscular exercises that did not include strength exercises for lower limbs. This indicates the importance of lower limb power and core muscle stability along with neuromuscular coordination in dynamic stability control. No difference was seen in SEBT scores of dominant and non-dominant legs after applying training interventions in three groups; hence, it can be stated that training interventions had similar effects on two limbs (because exercises were done symmetrically). This finding was in line with results obtained by other studies [18, 31, 32]. This is a substantial point because asymmetry in the lower limb dynamic balance is a risk factor that causes extremities non-contact injuries.

Limitations beyond the examiner's control

Athletes' diets that can affect neuromuscular function and mental moods that may affect performance were out of the examiner's control. On the other hand, the examiner could not control the medicines that could interfere with the neuromuscular performance and exercise function of athletes. It should be noted that a two-week washout interval was considered for those athletes that consumed painkillers, anti-inflammatory drugs, or muscle relaxant tablets. They were retested after the washout. Another factor that was beyond the control of the examiner was the athletes' lifestyle which varies based on the culture, job, and living standard.

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