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# Effects of 12-week in-season low-intensity plyometric training on dynamic balance of pre-pubertal female volleyball players

Elif TURGUT [1], Filiz Fatma COLAKOGLU [2], Pinar SERBES [2], Cengiz AKARCESME [2], Gul BALTACI [3]

*[1] Hacettepe University, Department of Physiotherapy and Rehabilitation, Ankara, Turkey.*
*[2] Gazi University, School of Sports Sciences, Ankara, Turkey.*
*[3] Private Guven Hospital, Department of Physiotherapy and Rehabilitation, Ankara, Turkey.*
*Address correspondence to E. Turgut, e-mail: elifcamci@hacettepe.edu.tr*

**Abstract**

Investigating the effects of plyometric training on dynamic balance of prepubertal female volleyball players may enable to enhance comprehensive knowledge about neuromuscular control enhancement and may further provide basis for developing training protocols encouraging lifelong regular physical activity for prepubertal volleyball players. The aim of this study was to compare the effects of 12-week plyometric training on dynamic balance in female prepubertal volleyball players. Twenty-nine female volleyball players were recruited to participate in the study. Participants were randomly separated into two study groups; plyometric training (n=14) and control group (n=15). All participants were assessed at baseline and after 12-week training. Dynamic balance was assessed with Star Excursion Balance test (SEBT). A repeated-measures ANOVA was performed. Comparisons showed that after 12-week training, plyometric training resulted in improvements in SEBT anterior, posterolateral and posteromedial scores for both dominant and nondominant leg whereas there were no differences found in the control group. Compared to control training, plyometric training resulted in additional gains for dynamic balance in female prepubertal volleyball players. The findings of the study provide basis for developing training protocols for prepubertal volleyball players.

**Keywords:** Balance, plyometric training, prepubertal children, volleyball.

## INTRODUCTION

Young female athletes participating in the high-risk sports such as volleyball suffer from musculoskeletal injuries more than do male athletes (12,19,28). Building a high level of neuromuscular control provides further athletic performance progress and prevents sport-related injuries (25). Dynamic balance is accepted as one of the indicators of neuromuscular ability to control the center of mass during dynamic activities (2,14). The improved neuromuscular control provides an improved ability to control biomechanical deviations thus, provides decreased excessive forces on the lower extremity and decreased injury risk (26,27).

Plyometric training previously reported being effective to increase the speed of movement, increase power production, strengthen bone, improving running speed and jumping ability, and for increasing strength in children (5,6,9,17,21). This training requires the coordination of several muscle groups to sustain the precisely timed and rhythmic plyometric movements to be able to involve a high-intensity concentric contraction immediately after a rapid and powerful eccentric contraction (20). The nervous system is conditioned to react more quickly to the stretch-shortening cycle (8). Therefore, plyometric training may be an appropriate intervention for improving the neuromuscular ability to control dynamic balance.

There is limited evidence regarding the effect of plyometric training on dynamic balance. Recently, Filipa et al. (8) investigated the effect of neuromuscular training program focused on core stability, lower extremity strength and plyometric training on dynamic balance in adolescent female soccer players. The findings of the study showed that soccer players demonstrated an improved performance on dynamic balance after neuromuscular training program; however, the findings only applicable to the adolescent female soccer players and provide evidence for a combination of different exercise regimens.

Thus, investigating the effects of plyometric training on the dynamic balance of prepubertal female volleyball players may enable to enhance comprehensive knowledge about neuromuscular control enhancement and may further provide basis for developing training protocols encouraging lifelong regular physical activity for prepubertal volleyball players. Therefore, the purpose of the current study was to investigate the effects of 12-week in-season low-intensity plyometric training on the dynamic balance of prepubertal female volleyball players.

## MATERIALS & METHODS

The Institutional Review Board approved the protocol for this study, and all participants/guards were informed of the nature of the study and signed a consent form.

### Participants

Thirty prepubertal, female volleyball players participated in the study (Table 1). All participants were selected from asymptomatic volunteers from same sports club who had no history of pain, injury or surgery related to upper and lower body. All participants were in an identical level of play and were exposed to similar volleyball activity. All participants had a 2 to 4-year background of volleyball training and competition experience. Sexual maturation was self-assessed with parental guidance using the standard five-scale Tanner stages for breast development (22). Participants who were classified as prepubertal (Tanner stage 1) were included in the study. Participants were excluded if they had any known systemic, neurological disorders or rheumatologic disorders, or if they failed to complete the pre or post testing, or failed to participate in a minimum of 80% of the training sessions (29 of 36 sessions). One subject in the intervention group was excluded due to lack of training compliance (Figure 1). The data from 29 subjects were used for statistical analysis. We randomly separated participants into one of the following study groups: intervention group (n=14) or control group (n=15).

Table 1. Characteristics of participants.

| | Intervention Group | Control Group | *p* |
|---|---|---|---|
| Age (years) | 11.1 (0.1) | 11 (0.7) | 0.9 |
| Height (m) | 160.7 (4.6) | 157.1 (6.2) | 0.08 |
| Weight (kg) | 42.8 (6.3) | 44.8 (9) | 0.5 |
| Body mass index (kg/m$^2$) | 16.5 (2.05) | 18.1 (2.8) | 0.1 |
| Sports age (years) | 2.4 (0.6) | 2.4 (0.7) | 0.9 |

Note: Data given as mean and standard deviation. *P* values resulting from Student-t test.

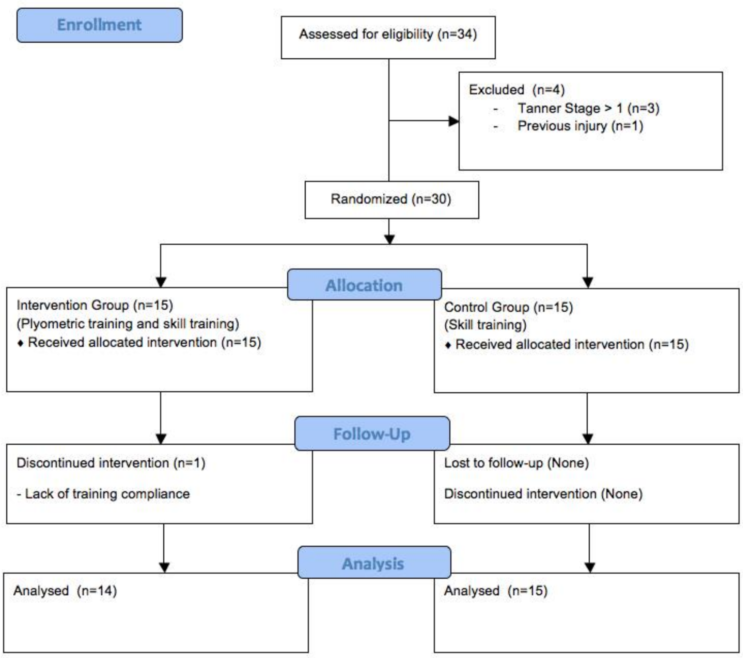



Figure 1. Flow diagram.

Table 2. The 12-week plyometric training program for the intervention group.

| | 1 to 2 weeks | | 3 to 4 weeks | | 5 to 6 weeks | | 7 to 8 weeks | | 9 to 10 weeks | | 11 to 12 weeks | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Training Duration (s) | Number of Sets | Training Duration (s) | Number of Sets | Training/ Rest Duration (s) | Number of Sets | Training/ Rest Duration (s) | Number of Sets | Training/ Rest Duration (s) | Number of Sets | Training/ Rest Duration (s) | Number of Sets |
| 1. Squat Jumps | 15 | 1 | 25 | 1 | 15/15 | 2 | 25/25 | 2 | 15/15 | 3 | 25/25 | 3 |
| 2. Tuck Jumps | 15 | 1 | 25 | 1 | 15/15 | 2 | 25/25 | 2 | 15/15 | 3 | 25/25 | 3 |
| 3. Side-to-side Tuck Jumps | 15 | 1 | 25 | 1 | 15/15 | 2 | 25/25 | 2 | 15/15 | 3 | 25/25 | 3 |
| 4. Forward Tuck Jumps | 15 | 1 | 25 | 1 | 15/15 | 2 | 25/25 | 2 | 15/15 | 3 | 25/25 | 3 |
| 5. Lateral Tuck Jumps | 15 | 1 | 25 | 1 | 15/15 | 2 | 25/25 | 2 | 15/15 | 3 | 25/25 | 3 |
| 6. Lunge Jumps (R) | 15 | 1 | 25 | 1 | 15/15 | 2 | 25/25 | 2 | 15/15 | 3 | 25/25 | 3 |
| 7. Lunge Jumps (L) | 15 | 1 | 25 | 1 | 15/15 | 2 | 25/25 | 2 | 15/15 | 3 | 25/25 | 3 |
| 8. Scissor Jumps (Consecutive R-L) | 15 | 1 | 25 | 1 | 15/15 | 2 | 25/25 | 2 | 15/15 | 3 | 25/25 | 3 |
| 9. Scissor Jumps (Nonconsecutive R-L) | 15 | 1 | 25 | 1 | 15/15 | 2 | 25/25 | 2 | 15/15 | 3 | 25/25 | 3 |

Abbreviations: R, Right; L, Left; S, Seconds.

**Interventions**

Participants in the intervention group followed a supervised 12-week plyometric training program consisting of standard rope-jump training in addition to a regular skill-training program. Low-intensity lower-extremity plyometric exercises were chosen from previously published research and included bilateral and unilateral jumps. All exercises are listed and described in Table 2. Participants in the control group followed a regular skill-training program only. Both groups trained the same skill-training program for three times in a week for 90 minutes using the same volleyball drills. Post training testing occurred 12 weeks after the pre-training test session.

The training of the intervention group was conducted and monitored by strength and conditioning specialists three times in a week for 12 weeks during a competitive season. Before training participants were informed about training principles such as proper landing posture (i.e., spine erect, shoulders back) and alignment (i.e., chest over knees), and providing a soft landing. Each session consisted of a 5-minute warm-up, plyometric training, and a 5-minute cool-down. The specialists provided the verbal and visual feedback with each exercise to the participants. The training was designed to gradually progress by an increase in training duration and number of ground contact (Table 2). Considering the stress of the plyometric training on the muscle-tendon unit, exercise intensity was progressively increased from a level classified as low to moderate, an appropriate intensity for children (15). Each plyometric session was composed of nine different exercises and 1 to 3 sets of 15 to 25 seconds training and 1:1 resting duration.

**Outcome measures**

Initial testing included all demographics and anthropometric assessments of height, mass, and limb length. The functional lower leg dominance was determined with ball kick test described by Hoffman et al. (1,31).

We assessed bilateral dynamic balance by using modified Star Excursion Balance Test (SEBT) (13) before and after 12-week training. The participants were asked to stand on a single leg stance position, with the most distal aspect of the great toe on the center of the grid while keeping the hands on the waist. The subjects were then asked to reach as much as the possible distance in the anterior, posteromedial, and posterolateral directions while maintaining their single-limb stance. Prior to testing, we allowed six practice trials to be performed for each direction (30). On the seventh trial, the distance reached to the most distal location of the foot as it contacted the grid was recorded. The trial was discarded if the participant was unable to maintain single-limb stance and lost contact with the floor, or weight was shifted onto the reach foot. The whole process was repeated on the other side.

The subject’s limb length measurements, from the most distal end of the anterior superior iliac spine to the most distal end of the lateral malleolus on each limb, were taken and recorded. Raw scores were normalized as % of leg length (16).

**Statistical analysis**

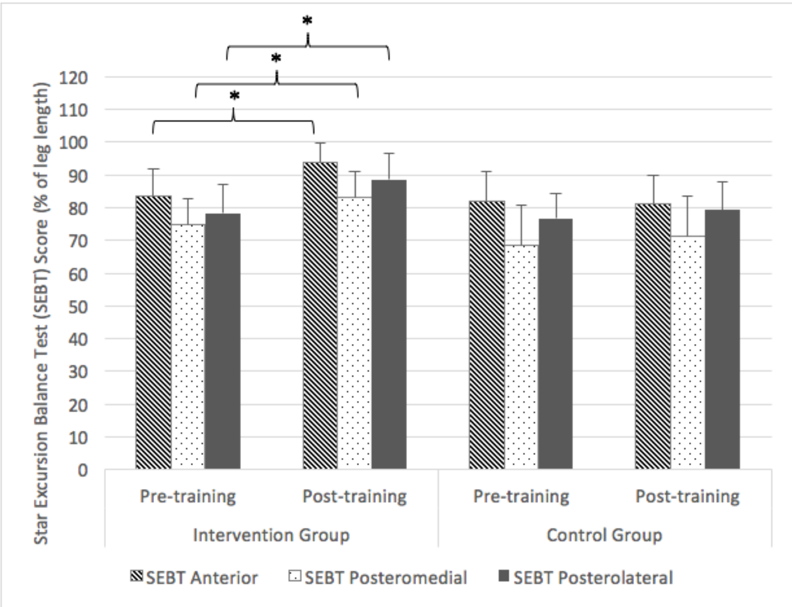
Sample size calculation was informed by the previous study that carried out with similar outcome measure comparisons (10). This study suggested the sample size would need to be large enough to detect a 10% improvement with a standard deviation of 7.5%, assuming a 5% type 1 error with a statistical power of 80%; a sample size of minimum 7 participants was required as a study population. Student *t*-test was used to assess for differences in demographic and anthropometric data between groups. Differences between the intervention and control groups were analyzed on a per protocol basis. Group comparisons were done with two separate (for each dominant and nondominant legs) 2-by-2 repeated-measures analysis of variance (ANOVA) to determine the effect of training (pre-training versus post-training), group (intervention versus control) on the outcome of the balance scores. When an interaction term was not significant, the main effect for Time and Group were evaluated. Statistical analyses were conducted in SPSS, Version 21.0 (SPSS Inc, Chicago, IL). Statistical significance was established a priori at $P < 0.05$.

**RESULTS**

The intervention group (n=14) and control group (n=15) shared similar demographics and baseline characteristics (table 1). Figure 2 and 3 show the SEBT scores at baseline and 12-week follow-up.

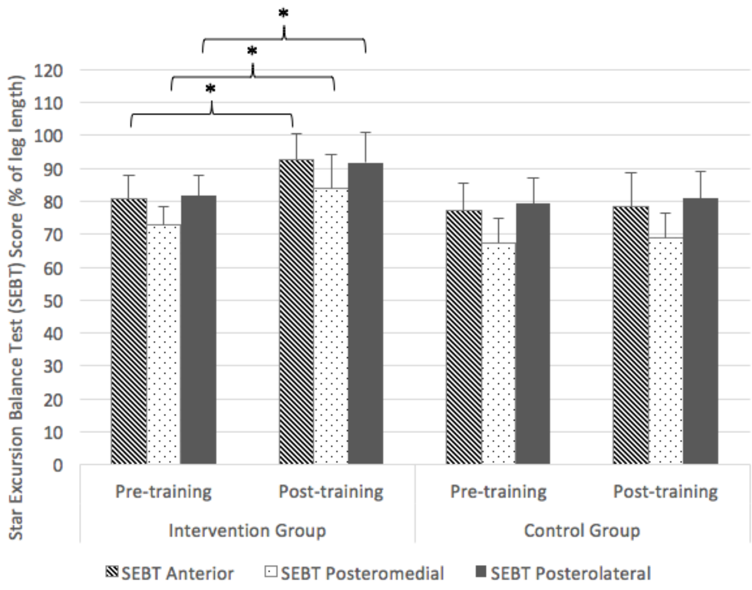
On dominant leg, there was a statistically significant training-by-group interaction for SEBT anterior score ($F_{1, 27}$ = 15.32, $p$ = 0.001), posteromedial score ($F_{1, 27}$ = 5.02, $p$ = 0.03), and posterolateral score ($F_{1, 27}$ = 7.37, $p$ = 0.01). Comparisons between the baseline and 12 week follow-up indicating that the dynamic balance was more improved in the intervention group for SEBT anterior ($p < 0.001$; mean difference (MD), 10.4%), posteromedial ($p < 0.001$; MD, 8.2%), and posterolateral score ($p < 0.001$; MD, 10.2%), whereas there were no differences found in the control group (Figure 2).

On nondominant leg, there was a statistically significant training-by-group interaction for SEBT anterior score ($F_{1, 27}$ = 14.83, $p$ = 0.001), posteromedial score ($F_{1, 27}$ = 7.82, $p$ = 0.009), and posterolateral score ($F_{1, 27}$ = 13.73, $p$ = 0.01). Comparisons between the baseline and 12 week follow-up indicating that the dynamic balance was more improved in the intervention group for SEBT anterior ($p < 0.001$; mean difference (MD), 11.7%), posteromedial ($p < 0.001$; MD, 11.1%), and posterolateral score ($p < 0.001$; MD, 10.1%), whereas there were no differences found in the control group (Figure 3).




Note: Data were presented as Mean and Standard Deviation.
* indicates statistically significant training-by-group interaction.

Figure 2. Results of Star Excursion Balance Test for dominant leg evaluated at baseline and after 12-week training.




Note: Data were presented as Mean and Standard Deviation.
* indicates statistically significant training-by-group interaction.

Figure 3. Results of Star Excursion Balance Test for nondominant leg evaluated at baseline and after 12-week training.

**DISCUSSION**

This study has investigated the effects of a 12-week plyometric training program over control group on dynamic stability in female prepubertal volleyball players. Twelve-week plyometric training resulted in more improvements in dynamic balance scores when compared to control training. The findings of this study supported the idea that plyometric training elicits additional gain in dynamic balance and neuromuscular control in female prepubertal volleyball players.

Volleyball is a complex sport with both landing and jumping components and requires sport-specific skills. To be able to enhance performance characteristics and prevent injuries, plyometric training has been recommended to integrate into the training program for athletes of all ages because of the effect of long-term training on muscle-activation strategies and performance (4). The findings of this study showed additional plyometric training to skill training for volleyball players can be suggested to have potential advantages for gaining balance. Lee (18) suggested that improved skilled movements with jump training may also improve endurance and provide synergy between explosive power, agility and reaction time which is accepted as key performance skills for volleyball players. Similarly, the previous research in prepubertal children has shown that plyometric training is effective in increasing running velocity, sprint time, agility, kicking distance and overall physical fitness (3).

Although common skill training includes regular plyometric activities such as running and jumping, without progressively implemented plyometric training, skill training was found no additional effect on dynamic balance score. In this study, the method followed was previously recommended as the safest and most effective method for progressing exercise load and to clarify the need for strength or motor skill prerequisites for participating in plyometric training in children (7,17,24,32). Regular participation in sports alone without preparatory conditioning could not appear to improve balance and reduce the risk of injury in young athletes.

In this study, the dynamic balance was assessed with using previously defined SEBT that is a functional screening tool developed to assess lower extremity dynamic balance or stability, monitor rehabilitation progress, assess deficits following injury, and identify athletes at high risk for lower extremity injury (1,15). The test was suggested as a useful tool to assess the efficacy of training programs designed to reduce injury risk (10,11,16,23,29,30). Improvement in the star excursion test score in the intervention group appeared to be independent in a direction of the reach tested. In addition, all improvements were consistent in the dominant and nondominant side of the participants in the intervention group. Therefore, central and peripheral factors such as muscle activation strategies and proprioception may have a stronger relative relationship to the dynamic balance performance as suggested from Thorpe & Ebersole (33). Our findings were consistent with the study from Witzke & Snow (34). In this study, post-pubertal freshmen participants were followed 9-month exercise training consisting of strength and plyometric training and were compared with a control group. The exercise training group displayed significant improvement in medial-lateral stability during static balance testing, which did not occur in the controls group.

There are some limitations of this study. First, the findings of this study are only applicable to the female pre-pubertal volleyball players and do not provide information about other populations. Also, there was no passive control group participated in monitoring changes due to maturation. Further longitudinal studies are necessary to investigate the effect of plyometric training on in-season injury rates.

In conclusion, the findings of this study showed that the effects of 12-week plyometric training program over control group on dynamic balance in female prepubertal volleyball players. Given the improvements in neuromuscular control and stability, plyometric training can be recommended to add the training program for prepubertal volleyball players.

**REFERENCES**

1. Behm DG, Faigenbaum AD, Falk B, Klentrou P. Canadian society for exercise physiology position paper: Resistance training in children and adolescents. Applied physiology, nutrition, and metabolism, 2008;33(3):547-561.
2. Bscher MH, Zech A, Pfeifer K, Nsel FH, Vogt L, Banzer W. Neuromuscular training for sports injury prevention: A systematic review. Medicine and Science in Sports and Exercise, 2010; 42(3):413-421.
3. Chimera NJ, Swanik KA, Swanik CB, Straub SJ. Effects of plyometric training on muscle-activation strategies and performance in female athletes. Journal of Athletic Training, 2004;39(1):24-31.
4. Cronin JB, Bressel E, Finn L. Augmented feedback reduces ground reaction forces in the landing phase of the volleyball spike jump. Journal of Sport Rehabilitation, 2008;17(2):148-159.
5. De Villarreal ES-S, Requena B, Newton RU. Does plyometric training improve strength performance? A meta-analysis. Journal of Science and Medicine in Sport, 2010;13(5):513-522.
6. Diallo O, Dore E, Duche P, Van Praagh E. Effects of plyometric training followed by a reduced training programme on physical performance in prepubescent soccer players. Journal of Sports Medicine and Physical Fitness, 2001;41(3):342-348.
7. Faigenbaum AD, Farrell AC, Radler T, Zbojovsky D, Chu DA, Ratamess NA, Kang J, Hoffman JR. " Plyo play": A novel program of short bouts of moderate and high intensity exercise improves physical fitness in elementary school children. Physical Educator, 2009;66(1):37-44.
8. Filipa A, Byrnes R, Paterno MV, Myer GD, Hewett TE. Neuromuscular training improves performance on the star excursion balance test in young female athletes. Journal of Orthopaedic & Sports Physical Therapy, 2010;40(9):551-558.
9. Greene DA, Naughton GA. Adaptive skeletal responses to mechanical loading during adolescence. Sports medicine, 2006;36(9):723-732.
10. Gribble PA, Hertel J, Denegar CR, Buckley WE. The effects of fatigue and chronic ankle instability on dynamic postural control. Journal of Athletic Training, 2004;39(4):321-329.
11. Hale SA, Hertel J, Olmsted-Kramer LC. The effect of a 4-week comprehensive rehabilitation program on postural control and lower extremity function in individuals with chronic ankle instability. Journal of Orthopaedic & Sports Physical Therapy, 2007;37(6):303-311.
12. Hewett TE, Myer GD, Ford KR, Heidt RS, Colosimo AJ, McLean SG, van den Bogert AJ, Paterno MV, Succop P. Biomechanical measures of neuromuscular control and valgus loading of the knee predict anterior cruciate ligament injury risk in female athletes: A prospective study. The American Journal of Sports Medicine, 2005;33(4):492-501.
13. Hoffman M, Schrader J, Applegate T, Koceja D. Unilateral postural control of the functionally dominant and nondominant extremities of healthy subjects. Journal of Athletic Training, 1998;33(4):319-322.
14. Hrysomallis C. Balance ability and athletic performance. Sports Medicine, 2011;41(3):221-232.
15. Johnson BA, Salzberg CL, Stevenson DA. A systematic review: Plyometric training programs for young children. The Journal of Strength & Conditioning Research, 2011;25(9):2623-2633.
16. Kinzey SJ, Armstrong CW. The reliability of the star-excursion test in assessing dynamic balance. Journal of Orthopaedic & Sports Physical Therapy, 1998;27(5):356-360.

17. Kotzamanidis C. Effect of plyometric training on running performance and vertical jumping in prepubertal boys. The Journal of Strength & Conditioning Research, 2006;20(2):441-445.

18. Lee B. Why Rope Jumping Works, Jump Rope Training. Second Edititon, Human Kinetics, 2010.

19. Lidor R, Ziv G. Physical and physiological attributes of female volleyball players-a review. The Journal of Strength & Conditioning Research, 2010;24(7):1963-1973.

20. Malisoux L, Francaux M, Nielens H, Theisen D. Stretch-shortening cycle exercises: An effective training paradigm to enhance power output of human single muscle fibers. Journal of Applied Physiology, 2006;100(3):771-779.

21. Markovic G. Does plyometric training improve vertical jump height? A meta-analytical review. British Journal of Sports Medicine, 2007;41(6):349-355.

22. Marshall WA, Tanner JM. Variations in pattern of pubertal changes in girls. Archives of Disease in Childhood, 1969;44(235):291-303.

23. McKeon P, Ingersoll C, Kerrigan DC, Saliba E, Bennett B, Hertel J. Balance training improves function and postural control in those with chronic ankle instability. Medicine and Science in Sports and Exercise, 2008;40(10):1810-1819.

24. Meylan C, Malatesta D. Effects of in-season plyometric training within soccer practice on explosive actions of young players. The Journal of Strength & Conditioning Research, 2009;23(9):2605-2613.

25. Myer GD, Faigenbaum AD, Ford KR, Best TM, Bergeron MF, Hewett TE. When to initiate integrative neuromuscular training to reduce sports-related injuries in youth? Current Aports Medicine Reports, 2011;10(3):155-166.

26. Myer GD, Ford KR, Hewett TE. Rationale and clinical techniques for anterior cruciate ligament injury prevention among female athletes. Journal of Athletic Training, 2004;39(4):352-364.

27. Myer GD, Paterno MV, Ford KR, Quatman CE, Hewett TE. Rehabilitation after anterior cruciate ligament reconstruction: Criteria-based progression through the return-to-sport phase. Journal of Orthopaedic & Sports Physical Therapy, 2006;36(6):385-402.

28. Noyes FR, Barber-Westin SD, Smith ST, Campbell T. A training program to improve neuromuscular indices in female high school volleyball players. The Journal of Strength & Conditioning Research, 2011;25(8):2151-2160.

29. Olmsted LC, Carcia CR, Hertel J, Shultz SJ. Efficacy of the star excursion balance tests in detecting reach deficits in subjects with chronic ankle instability. Journal of Athletic Training, 2002;37(4):501-506.

30. Plisky PJ, Rauh MJ, Kaminski TW, Underwood FB. Star excursion balance test as a predictor of lower extremity injury in high school basketball players. Journal of Orthopaedic & Sports Physical Therapy, 2006;36(12):911-919.

31. Plyometric training for children and adolescents. ACSM Position Statement. Indianapolis, IN: Lippincott Williams & Wilkins, 2001.

32. Rubley MD, Haase AC, Holcomb WR, Girouard TJ, Tandy RD. The effect of plyometric training on power and kicking distance in female adolescent soccer players. The Journal of Strength & Conditioning Research, 2011;25(1):129-134.

33. Thorpe JL, Ebersole KT. Unilateral balance performance in female collegiate soccer athletes. The Journal of Strength & Conditioning Research, 2008;22(5):1429-1433.

34. Witzke, KA, Snow CM. Effects of polymetric jump training on bone mass in adolescent girls. Medicine and Science in Sports and Exercise, 2000;32:1051-1057.