Asian Journal of Education and Training
Vol. 5, No. 3, 482-487, 2019
ISSN(E) 2519-5387
DOI: 10.20448/journal.522.2019.53.482.487

Evaluation of the Effects of Core-Quick Strength and Core-Plyometric Studies on Balance, Agility and Strength Traits of Volleyball Players

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Abstract

The aim of this study is to investigate the effects and differences of two different strength training models on balance, agility and strength traits of volleyball players. 45 female athletes aged 12.08 ± 0.82 who played volleyball in a private club participated in the study. The athletes who participated in the study were divided into three groups as core-plyometric (KRP) (n=15), core-quick strength (KRC) (n=15) and control (KNL) (n=15) groups. Within the scope of the study, KRP group performed plyometric training after core training and KRC group performed quick strength training after core training. The KNL group continued their volleyball training The trainings were conducted 2 days a week for 8 weeks. Height, weight, BMI, t-test, standing long jump test, flamingo balance test and throw-in test were applied to all three groups before and after the study. The data obtained in the pre and post test were evaluated with a statistics package program and the significance level was determined as $p<0.05$. The One-Way ANOVA test and Paired-Samples t-test were used for statistical analysis. As a result, a significant difference was found in the standing long jump test in all three groups ($p <0.05$). Throw-in and flamingo balance tests showed a significant difference in the KRP and KRC groups ($p<0,01$), but not in the KNL group ($p>0,05$). T-test showed significant difference in KRP and KRC groups ($p<0.05$), but no significant difference was found in KNL group ($p>0,05$). When the differences between the groups were examined,no significant differences were found between the averages as a result of height, standing long jump, throw-in and flamingo balance tests ($p>0.05$),and the KRC group showed significantly more improvement than the KNL group in the t-test.

Keywords: Plyometric, Balance, Agility, Core, Strength, Volleyball.

Citation | Uğur DEVRİM; Kâmil ERDEM (2019). Evaluation of the Effects of Core-Quick Strength and Core-Plyometric Studies on Balance, Agility and Strength Traits of Volleyball Players. Asian Journal of Education and Training, 5(3): 482-487.
History:
Received: 26 June 2019
Revised: 1 August 2019
Accepted: 9 September 2019
Published: 11 October 2019

Publisher: Asian Online Journal Publishing Group

Acknowledgement: Both authors contributed to the conception and design of the study.
Funding: This study received no specific financial support.
Competing Interests: The authors declare that they have no conflict of interests.
Transparency: The authors confirm that the manuscript is an honest, accurate, and transparent account of the study was reported; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained.
Ethical: This study follows all ethical practices during writing.

Contents

Contribution of this paper to the literature
This study contributes to the existing literature by investigating the effects and differences of two different strength training models on balance, agility and strength traits of volleyball players.

1. Introduction

Volleyball involves movements consisted of technical and tactical skills of different intensity performed in an aerobic environment in terms of playing time (Gabbett *et al.*, 2007; Busko *et al.*, 2013). Biomotor traits such as high aerobic and anaerobic endurance, strength, flexibility, speed, agility, balance, reaction are also effective in game performance (González *et al.*, 2011; Bazyler *et al.*, 2018; Sopa and Pomohaci, 2018).

Sudden changes in direction, jumping in different positions and agility trait involving speed changes affect performance in volleyball (Sheppard *et al.*, 2008). Agility is body control and the ability to change direction suddenly (Barnes *et al.*, 2007). In another definition, it is described as a locomotor skill that enables the body to change its direction as fast, smooth, easy and controlled as possible while moving between two points (Turner, 2011). The static and dynamic balance adequacy of core area muscle groups which provide connection between body, legs and arms also affects agility (Makhlouf *et al.*, 2018). In addition, the strength development of the core area has a positive effect on the balance system of the body and provides support to the movement economy and positively affects the power output (Herrington and Davies, 2005; Carpes *et al.*, 2008; Mcgill, 2010).

The balance feature, which is one of the important parameters of physical movements (Hrysomallis, 2011) is known to play an important role in successful exhibition of many sports skills, in changing direction, stopping, moving an object, maintaining certain position of the body and preventing injury (Oliver and Di Brezzo, 2009; Shubert *et al.*, 2010). In almost all sports branches, the most successful athletes have superior control over the center of gravity and therefore their balance traits are at the highest level (Roetert, 2001).

In order to develop the explosive force which is another effective physical feature in volleyball, the force and speed relationship should be at the highest level. In this context, plyometric training is one of the most used methods (Haghighi *et al.*, 2012). Plyometric study is a kind of neuromuscular studpaly that leads to the development of explosive force to use maximum force at minimum time (Nikseresht *et al.*, 2014). In-game jumping skills should be developed sufficiently for players to practice spike and block techniques well. In a study they conducted, Reeser and Bahr (2017) reported that volleyball players jump between 30,000 and 40,000 times in a year. Therefore, it is necessary to pay attention to the parameters that affect the ability to jump in all kinds of training practices aimed at increasing the sporting performance of volleyball players.

Another training method which can be implemented on the ability to jump in volleyball is the quick strength training. The quick strength training is an important type of training used in the development of agility, strength and jump (Rodríguez *et al.*, 2017). The movements used in volleyball should be quick and the techniques should be proper. Therefore, the training practices that combine strength trainings with speed should be consistent with the volleyball technique (Bompa and Carrera, 2003). Within the framework of this approach, the aim of this study is to investigate the effects and differences of two different strength training models on balance, agility and strength traits of volleyball players.

2. Materials and Methods

45 licensed female athletes playing volleyball were included in this study. At the beginning of the training sessions, the athletes were homogeneously distributed to 3 groups according to the pre-test results by using the pairing method. There was no significant difference between the averages of the groups and the One-Way Anova test results. The athletes were divided into 3 groups as core-plyometric (KRP) (n=15, age: 12,0±0,83 years, weight: 55,6±6,2 kg, height: 168,7±4,33), core-quick force (KRC) (n=15, age: 12,1±0,79 years, weight: 40,7±3,74 kg, height: 165,7±4,39 cm) and control group (KNL) (n=15, age: 12,2±0,86 years, weight: 56,5±8,03 kg, height: 167,9±7,63 cm). The KRP group participated in plyometric training after core training and the KRC group participated in quick strength training. The KNL group continued traditional volleyball training. A total of 16 sessions were conducted for 8 weeks, 2 days a week. In the training days, the sessions consisted of 4 phases. These were; the warm-up phase, core-plyometric and core-quick force training practices, volleyball-specific technical-tactical training of the coach and finishing phase. In order to avoid differences in the study, predefined standard warm-up drills were implemented in all three groups.

Preliminary and final tests were performed in the study. Height and weight measurements were taken as the anthropometric measurements, throw-ins and standing long jumps were used as the strength test the flamingo balance test and t-test were also implemented. Care was taken to ensure that the coaches performing the tests were the same during both test periods. The participants were asked to rest completely before testing.

Height and Body Weight: Length measurements were taken with a wall-mounted wall scale. All heights were taken while the heels were in contact with the platform perpendicular to the hip and scapula and the subjects were in an upright position (Weiner and Lourie, 1969). Body weight measurements were taken using a digital display scale with a sensitivity of 0.01 kg. During the measurements, the heavy equipment of the subjects other than the shorts and t-shirts were removed (Weiner and Lourie, 1969).

Body mass index (BMI): The ratio of body weight to height was calculated by using this formula: weight (kg)/height (m)2.

Agility measurements: T-test was used (Semenick, 1990). 4 cones, tape measure and photocell were used. The athletes were asked to run a total distance of 36.57 meters in as short a time as possible. The time was recorded in seconds.

Balance measurements: The flamingo static balance test was applied (Sipal, 1989). The aim is to determine how many seconds the static balance of the subject is within one minute. The shortest execution time was discarded and the best of the two execution times was taken and recorded as the test score.

Strength tests: Throw-in and standing long jump tests were implemented.

Throw-in test: Measures the circumference of the shoulder-chest muscles and the strength of the flexor muscles. The subjects threw the medicine ball forward with both hands, from a fixed distance with both arms above their head and their feet lined up. The shot was repeated 3 times and the best result was recorded in cm (Kamar, 2008).

Standing long jump test: Subjects jumped forward with both legs without stepping on the start line and the measurements were taken at the heel of each athlete's leg behind. Each subject repeated the jump 3 times and the best value was recorded as the measurement (Ratamess, 2012).

Data analysis: At the beginning of the study, the level of significance for the whole procedure was determined as $p<0.05$ and the statistical procedures were performed using the program SPSS 23.0 for Windows. The data obtained in the pre and post tests were evaluated with the statistical package program and the significance level was determined as $p<0.05$. The Shapiro-Wilk test was used to determine the distribution of the parameters used in the study. The One-Way Anova test was used to analyze the differences between the groups, and The Paired-Samples t-test was used for statistical analysis of the differences within the groups.

3. Findings

Table-1. Descriptive statistics of KRP, KRC and KNL groups.

	KRP	KRC	KNL	
Parameters	**Avg±Sd**	**Avg±Sd**	**Avg±Sd**	**p**
Age (years)	12,06±0,83	12,1±0,79	12,2±0,86	0,80
Height (cm)	168,7±4,33	165,7±4,39	167,9±7,63	0,61
Weight (kg)	55,6±6,2	50,7±3,74	56,5±8,03	0,32
BMI (kg/m²)	19,5±1,85	18,2±1,15	19,9±1,72	0,01

p<0,5 BMI: Body mass index.

In Table 1, as a result of the statistical analysis, it was concluded that there was a significant difference only in the BMI values of the participants in terms of demographic data and there was no significant difference between the other traits ($p>0.05$).

Table-2. The One-Way Anova test results: Preliminary test for biomotor traits between KRP, KRC and KNL groups.

	KRP	KRC	KNL	
Parameters	**Avg.±Sd**	**Avg±Sd**	**Avg±Sd**	**p**
T-test (sec)	10,5±0,39	10,3±0,32	10,6±0,45	0,06
Throw-in (cm)	665,3±97,2	647±96,3	725,6±104,2	0,18
Flamingo (sec)	6,7±1,1	6,2±0,8	6,2±0,9	0,29
Horizontal jump (cm)	164,0 ±17,1	176,0±14,3	172,2±12,8	0,12

In Table 2, there was no statistically significant difference between the KRP, KRC and KNL groups in any of the pretest values ($p>0,05$).

Table-3. The averages of differences in biomotor traits related to physical fitness of the KRP group, standard deviation values, percentages of variation and paired t-test values.

Parameters	N	Avg±Sd	%	p
T-test (sec)	15	0,13±0,24	1,00	0,04
Throw-in (cm)	15	25,3±26,9	3,8	0,03
Flamingo (sec)	15	1,8±1,3	26,9	0,00
Horizontal jump (cm)	15	4,0±5,75	2,9	0,01

**p<0,01; *p<0,05: T-test, throw-in, flamingo, horizontal jump.

In Table 3, according to the paired t-test results, there was a statistically significant difference in the pre- and post-test values of the t-test, throw-in and horizontal jump tests of the KRP group ($p<0.05$). There was a statistically significant difference in pre- and post-test values of the Flamingo test ($p<0,01$).

Table-4. The averages of differences in biomotor traits related to physical fitness of the KRC group, standard deviation values, variation percentages and the paired t-test values.

Parameters	N	Avg±Sd	%	p
T-test (sec)	15	0,15±0,24	1,9	0,04
Throw-in (cm)	15	56,2±60,3	8,9	0,003
Flamingo (sec)	15	1,6±1,6	25,8	0,002
Horizontal jump (cm)	15	6,7±10,4	3,9	0,02

**p<0,01; *p<0,05: T-test, throw-in, flamingo, horizontal jump.

Table-5. Averages of differences of biomotor traits related to physical fitness of KNL group, standard deviation values, percentages of variation and paired t-test values.

Parameters	N	Avg±Sd	%	p
T-test (sec)	15	0,02±0,39	0,2	0,80
Throw-in (cm)	15	8,5±12,6	1,2	0,02
Flamingo (sec)	15	0,6±1,3	11	0,08
Horizontal jump (cm)	15	1,5±3,04	0,8	0,07

*p<0,05: Throw-in.

In Table 4, when the pre and post tests of the KRC group were evaluated, a significant difference was found in t-test and horizontal jump tests (p<0.05), and a significant difference was found in throw-in and flamingo tests (p<0.01).

In Table 5, when the pre and post tests of the control group KNL were evaluated, a significant difference was found only in the throw-in test (p<0.05). No significant difference was found in other biomotor traits (p>0,05).

Table-6. The biomotor traits between the KRP, KRC and KNL groups and the last one-way anova test results.

Parameters	KRP Avg±Sd	KRC Avg±Sd	KNL Avg±Sd	p
T-test (sec)	10,4±0,51	10,1±0,32	10,6±0,37	0,01
Throw-in (cm)	690,6±96,1	703,2±106,7	734,2±106,2	0,55
Flamingo (sec)	4,9±1,7	4,6±1,6	5,5±1,6	0,27
Horizontal jump (cm)	168,8±17,4	182,8±17,2	173,7±12,3	0,06

*p<0,05: T-test.

In Table 6, ın the post-test values of the KRP, KRC and KNL groups, only the t-test results showed that the KRC group was significantly more developed than the KNL group (p <0.05). There was no significant difference between the groups in terms of other biomotor traits in post-test values (p>0,05).

Table-7. Correlation table of the development rates between parameters.

Parameters	Throw-in	Flamingo	T-test	Horizontal jump
Throw-ins	1	-0,171	0,051	-0,011
Flamingo		1	0,101	0,182
T-test			1	0,101
Horizontal jump				1

n=45, *p<0,05.

When Table 7 is examined, the difference between pre-tests and post-tests, i.e. developmental values, does not show a significant relationship when looking at the relationship between each other. No relationship was found between the developing and non-developing dimensions according to the analysis.

4. Results

The aim of this study was to investigate the effects of two different strength training models on balance, agility and strength traits as well as the differences of volleyball players. In volleyball, motoric traits such as strength, quickness, agility, balance directly affect performance. In order to have an effective performance during the game, it is necessary to make proper training programming in accordance with the development of these traits which are the requirements of volleyball.

Volleyball is a sport where high jumps, falls and movements involving sudden changes of direction are quite present. Having the body at the most balanced position during the execution of these movements is very important for the achievement of these skills. In this context, it is known that balance skill, which forms the basis of performance and which is at the center of conditional abilities, plays an important role in successful performance of many technical skills and in maintaining certain positions of the body (Agostini *et al.*, 2013; Erdoğan *et al.*, 2017; Sarto *et al.*, 2019). With core training, the body control and balance are improved, strength of many large and small muscle groups is increased, the risk of injury is reduced and efficiency in or between movements is increased due to increased balance (McGill, 2006; Willardson, 2007). This study is in parallel with the presented study. In another study, the improvement in balance performance was not significant after a nine-week core training program applied to volleyball players (Sharma *et al.*, 2012). This study differs from our study, as core training is used as the single training method. In the present study, it was found that plyometric and quick force studies combined with core applications both had an effect on balance.

The relationship between force and speed plays an important role in the performance of volleyball. Agility development can be achieved by plyometric and strength training applications. Agility performance shows the greatest change between the ages of 12-13 and with the plateau reached, is known to develop less until the age of 15-16 (Vescovi *et al.*, 2011). This was taken into account in the age preference of the working groups.

Research shows that plyometric and strength training practices are linked to agility development (Bozdoğan and Kızılet, 2017; Can *et al.*, 2017; Furqoni and Sudijandoko, 2019). In another study, Pamuk and Ozkaya (2017) concluded that resistant plyometric training was effective in the development of agility. Schultz *et al.* (2015) concluded that there is an important relationship between strength and agility. There are studies with different opinions that are not similar to the studies that show parallelism in the correlations with the literature results related to the presented study. Bozdoğan and Kızılet (2017) examined the effect of coordination and plyometric studies on agility, jump and endurance traits and found no significant difference in agility traits in the plyometric training group.

Volleyball is a sport in which the vertical and horizontal jumps are very frequent. Volleyball player's ability to jump is an important factor in the success of the team in terms of performance (Bompa and Carrera, 2003). It is necessary to have the necessary muscle strength in order to perform explosive skills or defensive movement correctly. Muscle strength required in sports branches can be achieved by plyometric and strength training (Neagu *et al.*, 2018). Therefore, strength and plyometric trainings are used to increase the jumping skills (Harmandeep *et al.*, 2015). Research on the subject has shown that plyometric training is effective in jumping and agility skills (Fathi *et al.*, 2018; Voisin and Scohier, 2019). In a study conducted with volleyball players, it was reported that plyometric training significantly improved leap and agility values (Hale *et al.*, 2019). In another study, Abade *et al.* (2019) concluded that horizontal and vertical strength training they implemented had a positive effect on the jump performance. In a similar study, Fathi *et al.* (2018) applied plyometric training to adolescent volleyball players. As a result of the study, it was concluded that strength development was changed positively with plyometric training. In another study examining upper and lower extremity strength, Ateş and Ateşoğlu (2007) concluded that plyometric training had a positive effect on both upper and lower extremity strength. In the presented study, the practice groups, similar to the literature, shown improvement in the horizontal jump and throw-in values. In this respect, it can be said that core, strength and plyometric trainings have positive effects on jump, balance and strength.

In the presented study, the effects of plyometric and quick strength training, when combined with the core training, on agility, strength and balance traits were investigated. Plyometric and quick strength training combined with core training improves balance, agility and strength. When applied to the adolescent athletes, the plyometric and quick strength trainings used to increase volleyball-specific performance yields higher development compared to the adult athletes. The biomotor traits of strength, agility and balance, which are important parameters of performance in volleyball, should be implemented in a planned way by taking into consideration the requirements of the game.

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