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The Effect of Core Training on Agility, Explosive Strength and Balance in Young Female Volleyball Players*

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Abstract

The present study aimed to determine the effect of core training on agility, explosive strength and balance in young female volleyball players. 20 young female volleyball players volunteered to participate in the study. Vertical jump, counter movement jump, pro-agility and dynamic balance tests were applied to all volleyball players before and after the core-training program. The athletes were selected randomly and divided into two groups as study group (n=10) and control group (n=10). The study group performed core exercises added to the beginning of the training sessions for 8 weeks (3days/week) in addition to volleyball training. The control group, on the other hand, continued volleyball training alone. At the end of 8 weeks, the tests applied in the pre-test were repeated and analyzed for all participants in order to determine the effect of core training on agility, explosive strength and balance parameters. In the statistical analysis of the study, Kurtosis-Skewness test was used to determine the normal distribution of the data. Mixed Anova and two-independent independent-samples t-test were used to make in-group and between-group comparisons. During the study, the level of significance was accepted as 0.05. A statistically significant difference was found in the balance precision index, static vertical jump (cm), counter movement jump (cm) and pro-agility agility test (sec) parameters when comparing the study and control groups. As a result, core exercises performed in addition to volleyball training appear to have a positive effect on agility, explosive strength and balance performances.
Keywords: Core Training, Agility, Balance, Explosive Strength, Volleyball

Genç Kadın Voleybolcularda Core Antrenmanlarının Çeviklik, Patlayıcı Kuvvet ve Denge Parametreleri Üzerine Etkisi

Öz

Bu çalışma genç kadın voleybolcularda core antrenmanlarının çeviklik, patlayıcı kuvvet ve denge parametreleri üzerine etkisini belirlemeyi amaçlamıştır. Çalışmaya 20 gönüllü genç kadın voleybolcu katılmıştır. Tüm voleybolculara çalışmanın başında (ön testlerde) dikey sıçrama, yaylanarak sıçrama, pro-agility çeviklik testi ve dinamik denge testleri uygulanmıştır. Sporcular kura yöntemi ile seçilerek çalışma ve kontrol grubu olarak ikiye ayrılmıştır. Çalışma grubunu oluşturan 10 sporcu voleybol antrenmanlarına ek olarak 8 hafta core antrenmanlarına katılmıştır. Kontrol grubunu oluşturan 10 sporcu ise sadece voleybol antrenmanlarına devam devam etmiştir. Core antrenmanları 8 hafta boyunca haftada 3 gün olacak şekilde voleybol antrenmanlarından önce uygulanmıştır. 8 haftanın sonunda core antrenmanlarının çeviklik, patlayıcı kuvvet ve denge parametreleri üzerine etkisini belirleyebilmek amacıyla ön testte uygulanan testler tüm katılımcılara tekrar edilerek analiz edilmiştir. Çalışmanın istatistiksel analizlerinde öncelikle verilerin normal dağılımlarının belirlenmesinde Kurtosis-Skewness testi kullanılmıştır. Grup içi ve gruplar arası karşılaştırılmaların yapılması için eşleştirilmiş bağımsız iki örneklem independent-samples t testi ve karışık desen anova testi yapılmıştır. Çalışma süresince anlamlılık düzeyi 0,05 olarak kabul edilmiştir. Çalışma ve kontrol grubu karşılaştırılmasında denge hassasiyeti indeksi, statik dikey sıçrama (cm), yaylanarak dikey sıçrama (cm) ve pro-agility çeviklik testi (sn) parametrelerinde istatistiksel olarak anlamlı farklılıklar bulunmuştur. Sonuç olarak; voleybol antrenmanlarına ek olarak uygulanan core antrenmanlarının çeviklik, patlayıcı kuvvet ve denge performansları üzerine olumlu yönde etkisi görülmektedir.
Anahtar kelimeler: Core Antrenmanı, Çeviklik, Denge, Patlayıcvı Kuvvet, Voleybol

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INTRODUCTION

Volleyball is an anaerobic sport in which explosive movements (both in vertical and horizontal directions) are performed intensively and intermittently during short rallies. Therefore, explosive strength, defined as the ability of an individual's neuromuscular system to generate tension in the shortest possible time, is accepted as a fundamental determinant of performance in single or repeated vertical jumps when performing such techniques as spiking, blocking, serving and overhand passing (Silva et al., 2019; Yiannis, 2005). In volleyball, where fast movements and reactions are exhibited, such movements as landing from a jump and taking a defensive position to the ball coming with a different velocity and angle from the opponent, which require the athletes to maintain their balance, are repeated frequently (Wikstrom et al., 2004).

In volleyball, distinctive characteristics related to performance include speed, maximum vertical jump, change of direction and repetitive overhead movements. Volleyball players use certain movement patterns with high-level strength, high velocity rates and rapid changes of direction (Hale et al. 2019). In this regard, muscle power, reaction time, explosive strength, and coordination-related agility are important for volleyball players in terms of using and developing their defensive skills (Chuang et al., 2022). A player is always in need of changing of direction, speed and body posture on a volleyball court; therefore, needs an effective acceleration or deceleration through space in a very short time for a good performance (Gadre et al., 2019). Considering all performance components, a volleyball player should control his/her body and transfer energy from the ground before a spiking the ball (Smith et al., 2008). Moving body control, upper extremity strength and shoulder joint stability are significant for spiking speed and power. Wrist extension for a faster and more powerful spike occurs with the rotation of the shoulder (Başandaç, 2014). Thus, in addition to ensure stabilization and strength development, volleyball players should do training to protect these improving skills for a good performance on the court (Sayers, 2000). Core training is considerably important for stabilization and strength development (Mcgill, 2010).

Core training focuses on the strength development of the global and local muscles working together to maintain the spine. Global (outer) muscles are the latissimus dorsi, obliques, rectus abdominis and erector spinae while local (deeper) muscle groups include the pelvic floor multifidus and transverse abdominis muscles (Sekendiz et al., 2010). Core training supports the individual's lower and upper extremity movements (Takatani, 2012); and positive acceleration, negative acceleration, balance, stabilization and multi-directional exercises are achieved with a strengthened core (Asgharifar, 2009; Kibler et al., 2006). Core training not only has positive effects on performance, but it also decreasing back pain and rehabilitating injuries as well as preventing and decreasing lower and upper extremity injuries (McGill et al., 2003, Özmen and Aydoğmuş, 2016). Having such effects, it has recently been included in athletes' training programs.

Core training must have an important place among volleyball-specific strength training interventions. Core strength and core stabilization training would be supportive in preventing injuries with its effect on the stabilization and rotation of the body in offensive and defensive movements made by jumping and in laying physical and physiological grounds for learning the correct technique in volleyball (Bereket Yücel et al., 2020). Regarding this information, the aim of the present study was to determine the effect of core training on agility, explosive strength and balancing skills in young female volleyball players.

In this direction, the hypotheses of the study were determined as follows:

H0: Core training has no statistically significant effect on balance, strength and agility in young female volleyball players.

H1: Core training has a statistically significant effect on balance, strength and agility in young female volleyball players.

MATERIAL AND METHOD

Participants

20 young female volleyball players aged 14-16 registered in a volleyball club participated in the present study voluntarily. The volleyball players were randomly divided into two groups; 10 players composing the study group (14,70±0,82 years, 60,14±4,61 kg, 172,80±6,87 cm, 20,17 kg/m^2, 20,36±3,66%fat) and 10 players composing the control group (14,60±0,84 years, 66,07±9,84 kg, 176,10±6,15 cm, 21,24±2,34 kg/m^2, 25,48±5,05%fat). The participants had no musculoskeletal system injuries. Inclusion criteria for the study; volunteering to participate in the study, having parental consent and not having any injury. The exclusion criteria were determined as having any injury, not continuing after the 4th week of the trainings, and not participating in at least 3 consecutive practices during the trainings.

All players signed the form explaining the point and scope of the study with family consent showing their voluntary participation and filled out the health and sport history inventory. The study was approved by the Aydın Adnan Menderes University, Health Science Enstitute, Non-invasive Research Ethics Committee and was conducted in accordance with the Declaration of Helsinki.

Study design

The study group was involved in an 8-week core training intervention in addition to their routine volleyball training program (Table 1). Core training interventions consisting of 5-minute jogging and 10-minute dynamic stretching exercise performed after warm up before the volleyball training were planned to be applied 3 days a week and lasted for 25 and 35 minutes in the first and the last 4 weeks respectively. The volleyball players in the control group, on the other hand, performed only volleyball training during the 8 weeks. The core training program was prepared by the researchers by scanning the training plans in the literature, taking into account the needs of volleyball. Core stabilization and core strength were planned for the first 4 weeks, and the last 4 weeks were designed for core strength. Series consisting of static and dynamic core exercises were applied to volleyball players for 8 weeks. Dynamic balance, vertical jump and pro-agility were applied to all players before and after the core training period. Before each test protocol, the athletes performed the standardized warm-up activities consisting of 10-minute (created from dynamic stretching exercises).

Table 1. Core training plan

Weeks	Movement	Loading Time /Repetition	Resting Time	Number of Sets	Rest between Sets
Week 1-4.	Sit Up (mekik)	15 Repetitions	1/1	3	2 min
	Leg Raise	15 Repetitions	1/1	3	2 min
	Side Bend	15 Repetitions	1/1	3	2 min
	Superman	15 Repetitions	1/1	3	2 min
	Plank	30 sec	1/1	3	2 min
Week 5-8	Leg Raise	15 Repetitions	1/1	3	2 min
	Flutter kicks (right-left)	15 Repetitions	1/1	3	2 min
	V-sit up	15 Repetitions	1/1	3	2 min
	Lying Hip Raise	15 Repetitions	1/1	3	2 min
	Russian Twist	15 Repetitions	1/1	3	2 min
	Plank	45 sec	1/1	3	2 min

Explosive Strength Tests

Static vertical jump and counter movement jump tests were applied to evaluate the female volleyball players' explosive strength. The jump tests were performed using Smartspeed (Fusion Sport, Austria) jump mats and a hand-held computer, the players were request to achieve the 2 maximal repetitions with three minute rests between the repetitions and the highest values were recorded. During the static vertical jump test, the volleyball players were asked to be ready on the jump mat with their hands on their knees and waist in a 90º squat position. They then jumped as high as possible from the position. For the counter movement test, on the other hand, the participants were told to be ready on the jump mat with both feet in hands-free position and then to jump swiftly as high as they could with arm swing.

Pro-agility test

For the pro-agility test, photocell gates (Smartspeed, Fusion Sport, Austria) were positioned at the start line at a height of 60 cm from the ground and two cones were placed at 4.57m distance on the left and right. The volleyball players ran as fast as possible to the right or left depending on the visual signals coming from the photocell gates at the start line, touched the cone at that direction, changed directions to touch the other cone and the test was finalized when they passed the start line again. Two trials were achieved with a three minute rest between the trials and the better score was recorded.

Dynamic balance test

Libra dynamic balance system (EasyTech, Italy) (a 42 cm long, 42 cm wide platform) was used to evaluated dynamic balance. Libra dynamic balance system, which consists of a card and a computer to control the system, works systematically by connecting a USB interface 2.2001-2.0 computer software. There is an apparat on the bottom surface of the dynamic balance system to adjust the level of difficulty (10 cm, 25 cm and 40 cm). Difficulty was set with the 40 cm apparatus in the current study. The test was performed at level 9 for 30 seconds with both feet. Easy tech software detects the angular changes in the device position against the surface and against time due to the swing of the balance platform in both directions. The following values are used to calculate the balance precision index value with the formula given below. These are: total area (the area between the subject's movement path line and example line), external area (the area between the subject's movement path line and the line of the set degree of difficulty), external time (total time of the subject beyond the set degree of difficulty) and recovery time (the longest single period of time beyond the set degree of difficulty). Tchorzewski et al. (2013) used the following formula to calculate the Indexing of balancing precision.

IBP: Indexing of balancing precision = (EA/TA) *100.

EA= √External area left +√External area right, TA= √Total area left + √Total area right (Tchorzewski et al., 2013).

Statistical Analyses

The statistical analyses were conducted on SPSS (version 25.0, SPSS Inc, Chicago, IL, USA) package program. Descriptive statistics are presented in means and standard deviations. The related data were tested for normal distribution using Kurtosis-Skewness. Independent-samples t test was analysed to compare the data between groups.

The effect size was analyzed according to Cohen's d. Cohen's effect size was categorized as minor effect (0-0.2), small effect (0.2-0.5), moderate effect (0.5-0.8), and large effect (>0.8) has been done. Pre-test and post-test values were analyzed with mixed anova test to observe separately the changes in the performance tests of the study and control groups over time. Kolmogorov-Smirnov was used to assess the normality of the distribution of test results. Levene's test was used to evaluate the homogeneity of variance between groups. Level of statistical mean was accepted as p<0,05.

FINDINGS

When pre and post-test results pertaining to each group are compared, it was seen that vertical jump height and counter movement jump height as well as agility and balance abilities increased significantly in the study group, while only vertical jump height increased in the control group (Table 2).

Table 2. Difference between the agility, balance precision index and explosive strength performance pre-test results of the experimental and control groups

	Study Group (n=10)				**Control Group (n=10)**			
	Pre-tests	**Post-tests**	***p***	**Effect size**	**Pre-tests**	**Post-tests**	***p***	**Effect size**
Vertical jump (cm)	32,20±4,56	35,61±3,99	,000*	0.79	27,67±3,20	29,10±2,91	,022*	0.46
Counter Movement Jump (cm)	37,40±5,17	41,75±4,81	,000**	0.87	32,48±3,40	33,66±2,53	,060	0.39
Pro-agility (sec)	5,88±0,27	5,71±0,31	,000**	0.58	6,26±0,27	6,40±0,32	,122	0
Balance Precision Index (IBP) (%)	54,87±4,93	34,88±7,86	,001**	3	46,05±10,11	54,27±9,43	,125	0.8

*$p<0.05$, ** $p<0.01$

Considering the difference between the pre-test and post-tests in the study and control groups, there was a statistically significant difference in VJ values in both the study and control groups; Only the experimental group showed improvement in CMJ, pro-agility and IBP values. As a result of the analyzes made with Cohen's d, it is seen that the changes in the study group have a higher effect size than the control group in all evaluated parameters.

The difference in development levels between the pretests and posttests between the study and control groups was evaluated with Mixed anova. CMJ values of the study group and control group were compared as pre-test and post-test (Table 3).

Table 3. The difference between the pre-test and post-test development levels of the CMJ values of the study and control groups

	Sum of Squares	df	Mean Square	F	p	Partial Eta Squared
Between subjects						
CMJ	211,543	1	211,543	12,858	0,002	0,417
Error	296,134	18	16,452			
Within Subjects						
Time	76,425	1	76,425	72,355	<0.001	0.801
Time*CMJ	25,361	1	25,361	24,01	<0.001	0,572
Error	19,012	18	1,056			

It was found that the common effect of being in different groups and the factors showing the measurement at different times on the CMJ scores of the participants was significant $F_{(1,18)}$= 24.01 (p< 0.001).

Vertical Jump values of the study group and control group were compared as pre-test and post-test (Table 4).

Table 4. The difference between the pre-test and post-test development levels of the VJ values of the study and control groups

	Sum of Squares	df	Mean Square	F	p	Partial Eta Squared
Between subjects						
VJ	152,324	1	152,324	11,526	0,003	0,39
Error	237,878	18	13,215			
Within Subjects						
Time	58,685	1	58,685	42,096	0	0,7
Time*VJ	9,811	1	9,811	7,038	0,016	0,281
Error	25,093	18	1,394			

It was found that the common effect of being in different groups and the factors showing the measurement at different times on the VJ scores of the participants was significant $F_{(1,18)}$= 7.038 (p< 0.016).

Pro-agility values of the study group and control group were compared as pre-test and post-test (Table 5).

Table 5. The difference between the pre-test and post-test development levels of the pro-agility values of the study and control groups

	Sum of Squares	df	Mean Square	F	p	Partial Eta Squared
Between subjects						
Proagility	1,407	1	1,407	18,168	0	0,502
Error	1,394	18	0,077			
Within Subjects						
Time	0,002	1	0,002	0,118	0,735	0,007
Time*Proagility	0,245	1	0,245	12,045	0,003	0,401
Error	0,366	18	0,02			

It was found that the common effect of being in different groups and the factors showing the measurement at different times on the Proagility scores of the participants was significant. $F_{(1,18)}$= 12,045 (p< 0.003).

Balance Precision Index values of the study group and control group were compared as pre-test and post-test (Table 6).

Table 6. The difference between the pre-test and post-test development levels of the IBP values of the study and control groups

		Sum of Squares	df	Mean Square	F	p
Between subjects						
IPP	84,996	1	84,996	1,773	0,2	0,09
Error	863,114	18	47,951			
Within Subjects						
Time	1914,902	1	1914,902	50,645	0	0,738
Time*IBP	379,21	1	379,21	10,029	0,005	0,358
Error	680,584	18	37,81			

It was found that the common effect of being in different groups and the factors showing the measurement at different times on the IBP scores of the participants was significant $F_{(1,18)}$= 10.029 (p< 0.005).

DISCUSSION

The current research investigated the effects on an 8-week core exercises on balance, agility and explosive strength performance in young female volleyball players. The results showed that a statistically important improvement was observed in the jump performance, which is used in determining explosive strength, in both control and core training groups at the end of the 8-week core training, while only the core training group showed a statistically significant improvement in counter movement jump, pro-agility and balance test results. Statistical analyzes show that core training has a positive effect on all parameters measured in young female volleyball players. The interaction in biomotor abilities has been proven by numerous studies. It is possible to suggest that core training would contribute to explosive strength, agility and balance performance in young female volleyball players, which in turn will enhance volleyball performance.

Volleyball is a branch that consists of different techniques and tactics involving short-term high-intensity exercise and low-intensity exercise. Together with the game duration, the players need to have developed aerobic and anaerobic alactic systems during high-intensity exercise. Thus, such performances as strength, endurance, flexibility, agility, balance and reaction time are needed during training and competitions. In conclusion, improved speed, agility and upper and lower body muscle power are important for volleyball players. In addition to the physiological requirements specified for volleyball, coordination and core muscle groups are also significant when used effectively (Gabbet and Georgieff, 2007; McGill, 2010).

When the related literature was reviewed, several studies have been found with similar sample groups to the one in the present study which support the study findings. In the study they examined the effect of a 10-week core training intervention on motor characteristics and jump strength of 14-16 year-old volleyball players, Bilici and Selçuk (2018) observed improvement in the vertical jump, lower extremity strength and body muscle strength of the 17 athletes composing the study group. Similarly, at the end of the core training interventions performed with the university volleyball team for 9 weeks, Sharma and colleagues (2012) found that the athletes' vertical jumping performance improved ($p<0,05$) and based on this finding, they stated that core training could enhance athletes' jumping performance. Şahin and Özdal (2020) studied the chronic effect of core exercises on vertical jump and balance in 12-14 year-old female volleyball players and implemented an 8-week (3 days/60 min) core exercises program and regular volleyball training with the athletes who participated in the study. They reported positive improvement in the vertical jumping performance of the athletes in the study group at the end of the training. It is seen in the studies that training effects, particularly in volleyball players, are limited to jumping and strength effects. However, considering its effect on volleyball performance, it is possible to mention the significant contribution of agility and balance as well. Agility is important for carrying the technical skills needed for offense and defense to a higher level in volleyball. In addition, there is a connection between balance and strength. Balance development is known to improve the body's core strength and stability as well (Bereket Yücel et al., 2020). Rokkaya et al., (2021) stated that balance and agility measurement values are related to each other. It is known that balance has an effect on teaching and implementation of technical skills in volleyball (Bereket Yücel et al., 2020). Agility is perceived as the ability to change direction quickly and easily at start and stop. Recently, it has also been defined as the ability to maintain and regulate the correct positions of the body while rapidly changing direction with a series of movements. Balance ability should be considered as one of the main features of improving agility (Rokkaya et al., 2021). For this reason, it is concluded that the improvement in balance performance with core training will contribute to agility. Yapıcı (2019) examined the effect of a 6-week core training intervention on balance, strength and serving performance in volleyball players. A significant difference was found between the pre-test and post-test values of the study groups in terms of right-left dynamic balance, core strength, service accuracy and service speed performances ($p<0.05$). Sadeghi et al., (2013) stated that muscles that are strengthened by core stability training for 8 weeks could considerably improve dynamic postural control during a fall in volleyball players. Yıldız (2012) showed the contribution of core stabilization exercises to balance development in adolescent female volleyball players. Durna (2017) examined the effect of an 8-week core training program on flexibility, balance, and agility levels of wrestlers. The study revealed that the core training had positive effects on the wrestlers' agility and both-leg dynamic balance skills.

On the other hand, Ceylan (2019) found no correlation between core stabilization and horizontal and vertical jumps. Ozmen and Aydoğmuş (2016) observed significant results in the core endurance test as a result of the core strength training in badminton players, but no remarkable change in their agility performance. Aslan (2014) stated that football-specific core training of 8 weeks may not affect young footballers' agility performance. Kır (2017) examined the effects of core training on balance, agility, strength and speed in tennis players aged 11-15 years old by implementing core training with tennis players for ten weeks and 3 times a week and found that agility performance of the participating athletes did not change significantly. The differences in the sample groups are noticeable in the studies that report different results to the present study. Changes in the time of reaching Peak High Velociy in young female volleyball players and the possible effect of developmental differences may have been a limitation for this study. For this reason, it is recommended that this time be taken into account for the participants in future similar studies. Adaptation and gains are related with the training content in strength training. Core strength plays an important role in technical application and development in volleyball. The differences coming up in core training programs may be associated with these contradicting results. Additionally, in experiment-control studies, branch-specific training is carried on by both groups. In the planning of core training, it is recommended to create the training content by taking into account the variables related to volleyball, such as technical elements, for future studies. In addition, as mentioned above, the contribution of core strength development to technical development can be evaluated in future studies. Therefore, improvement continues depending on the physical and physiological requirements of the branch, which may restrict the differences that could occur.

CONCLUSION

In conclusion, core training performed in addition to the regular volleyball training appears to have positive effects on balance, agility and explosive strength performances. With the increase in explosive balance, agility and explosive strength performance, it is seen that inter-connected training methods are needed and it does not solely depend on regular volleyball training. Based on the findings obtained from the present study, we believe that core training interventions added to regular volleyball training would be beneficial for strength development.

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Information on Ethics Committee Permission

Committee: Aydın Adnan Menderes University, Health Science Enstitute, Non-invasive Research Ethics Committee

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