

# The Effect of Periodized Core Training on Motor Skills in Volleyball Players

## Voleybolcularda Periyodlanmış Kor Antrenmanlarının Motor Beceriler Üzerine Etkisi

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<https://doi.org/10.5281/zenodo.17427401>

Received / Gönderim: 01.06.2025

Accepted / Kabul: 24.09.2025

Published / Yayın: 24.10.2025

Volume 2, Issue 3, October, 2025

Cilt 2, Sayı 3, Ekim, 2025

### Abstract

In this study, it was aimed to determine the effects of 10-week periodized core training on motor skills in adolescent male volleyball players. The experimental group (n=28) mean age (M±SD; 15,69±0,84 years), mean height (M±SD; 189,34±3,87 cm, mean weight (M±SD; 71,19±7,29 kg) and body fat percentage (M±SD; 12,03±1,47 %) and control group (n=27) mean age (M±SD; 15,88±0,86 years), height (M±SD; 188,88±3,26 cm, weight (M±SD; 67,73±6,24 kg) and body fat percentage (M±SD; 11,99±1,41 %) of 55 licensed male volleyball players who had been actively training volleyball for at least four years. The experimental group regularly participated in volleyball training for 90 minutes a day, 4 days a week for 10 weeks, and the control group participated only in volleyball training. Weight, body fat percentage, back-neck and shoulder-wrist flexibility, leg and back strength, agility, vertical jump, 3 kg medicine ball throw, 2 kg modified medicine ball throw, standing long jump, sit-up, push-up, plank and back isometric strength tests were performed before and after the training. Shapiro-Wilk and Levene's test were used to determine whether the data showed a normal and homogeneous distribution, and since it was determined that the data showed normal distribution according to the results of intergroup statistics, Independent Samples T test was used for the comparison of independent groups and Paired Samples T test was used for the comparison of dependent groups (p<0.05). When the results of the research were evaluated, it was determined that there was a significant difference in the pretest-posttest mean scores of weight, body fat percentage, back-neck and shoulder-wrist flexibility, leg and back strength, agility, vertical jump, 3 kg medicine ball throw, 2 kg modified medicine ball throw, standing long jump, sit-up, push-up, plank and back isometric strength test values of the experimental group (p<0.05). In the control group, it was determined that there was a significant difference in the pretest-posttest mean scores of weight, leg and back strength, agility, 3 kg medicine ball throwing, standing long jump, push-ups and back isometric strength test values (p<0.05), while there was no significant difference in the pretest-posttest mean scores of body fat percentage, back-neck and shoulder-wrist flexibility, vertical jump, 2 kg modified medicine ball throwing, sit-ups and plank values (p>0.05). However, when the significance levels of the development between the groups were examined, it was determined that it was more in the experimental group than in the control group. As a result, it was determined that there was a significant difference in the pretest-posttest mean scores of selected motor skill values of the athletes as a result of 10-week periodized core training in adolescent male volleyball players (p<0.05). These results suggest that core training is an effective training method for developing selected motor skills in volleyball players.

**Keywords:** Volleyball, Core Training, Motor Performance.

### Özet

Bu çalışmada adölesan erkek voleybolcularda 10 haftalık periyodlanmış kor antrenmanlarının motor beceriler üzerindeki etkilerinin tespit edilmesi amaçlanmıştır. Araştırmaya deney grubu (n=28) yaş ortalaması (M±SD; 15,69±0,84 yaş), boy ortalaması (M±SD; 189,34±3,87 cm, kilo ortalaması (M±SD; 71,19±7,29 kg) ve vücut yağ yüzdesi (M±SD; 12,03±1,47 %) kontrol grubu (n=27) yaş ortalaması (M±SD; 15,88±0,86 yaş), boy ortalaması (M±SD; 188,88±3,26 cm, kilo ortalaması (M±SD; 67,73±6,24 kg) ve vücut yağ yüzdesi (M±SD; 11,99±1,41 %) olmak üzere en az dört yıl aktif voleybol antrenmanlarına devam eden lisanslı 55 erkek voleybolcu gönüllü olarak katılmıştır. Deney grubu düzenli olarak 10 hafta boyunca haftada 4 gün günde 90 dakika voleybol antrenmanlarına ek olarak antrenmanda önce 10 hafta kor antrenman programına dahil olurken kontrol grubu ise sadece voleybol antrenmanlarına dahil olmuştur. Antrenman öncesi ve sonrasında sporcuların kilo, vücut yağ yüzdesi, sırt-boyun ve omuz-bilek esneklik, bacak ve sırt kuvveti, çeviklik, dikey sıçırma, 3 kg sağlık topu fırlatma, 2 kg modifiyeli sağlık topu fırlatma, durarak uzun atlama, mekik, sınav, plank ve sırt izometrik kuvvet testleri uygulandı. Verilerin normal ve homojen bir dağılım gösterip göstermediğini belirlemek için Shapiro-Wilk ve Levene's testi kullanıldı ve gruplar arası istatistik sonuçlarına göre verilerin normal dağılım gösterdiği tespit edildiğinden bağımsız grupların karşılaştırılmasında (Independent Samples) T testi kullanılırken bağımlı grupların karşılaştırılmasında ise (Paired Samples) T testi kullanıldı (p<0.05). Araştırma sonuçları değerlendirildiğinde deney grubunun kilo, vücut yağ yüzdesi, sırt-boyun ve omuz-bilek esneklik, bacak ve sırt kuvveti, çeviklik, dikey sıçırma, 3 kg sağlık topu fırlatma, 2 kg modifiyeli sağlık topu fırlatma, durarak uzun atlama, mekik ve sırt izometrik kuvvet test değerlerinin ön test-son test puan ortalamalarında anlamlı farklılık olduğu tespit edilmiştir (p<0.05). Kontrol grubunda ise kilo, bacak ve sırt kuvveti, çeviklik, 3 kg sağlık topu fırlatma, durarak uzun atlama, mekik ve plank değerlerinin ön test-son test puan ortalamalarında anlamlı farklılık olmadığı tespit edilmiştir (p>0.05). Ancak gruplar arasındaki gelişimin anlamlılık düzeyleri incelendiğinde kontrol grubuna göre deney grubunda daha fazla olduğu tespit edilmiştir. Sonuç olarak adölesan erkek voleybolcularda 10 haftalık periyodlanmış kor antrenmanları sonucunda sporcuların seçili motor beceri değerleri ön test-son test puan ortalamalarında anlamlı farklılık olduğu tespit edilmiştir (p<0.05). Bu sonuçlar kor antrenmanının voleybolcularda seçili motor becerileri geliştirme konusunda etkili bir antrenman yöntemi olduğu söylenilebilir.

**Anahtar kelimeler:** Voleybol, Kor Antrenman, Motor Performans

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## Introduction

Volleyball is a fast-paced sport that requires high levels of mental and physical skill. In this sport, athletes must have a high level of motor skills when applying technical and tactical skills. This is because high-level performance in volleyball involves not only the development of basic technical and tactical skills but also the development of motor skills, which is an important part of this process. Motor skills such as endurance, flexibility, balance, strength, agility, and explosive power directly affect the athlete's effectiveness on the court. These motor skills work in coordination at various times in volleyball and are linked to each other through kinetic chains. This is because the movements athletes make to achieve athletic and sporting performance occur in a manner connected by kinetic chains. For example, during a spike or serve in volleyball, the force generated by the kinetic chain is transferred from the ground to the ankles, from the ankles to the knees, from the knees to the legs, from the legs to the hips, from the hips to the torso, then sequentially to the shoulders, arms, wrists, hands, and finally to the ball (Akuthota et al., 2008; Başıdağ, 2014).

At this stage, weakness in the kinetic chain will result in an incomplete movement, and the movement will not be performed at the desired level. A review of the literature shows that the core region plays a major role as the main center of all kinetic chains during movements performed in sports activities (Rosania, 2004). The core region muscles consist of stabilization muscles around the abdomen, pelvis, and back and directly affect the body's mobility, balance, and force transfer. Core muscles are not limited to maintaining body balance; they also reduce the risk of injury in high-performance movements such as sudden changes of direction, jumping, and overcoming obstacles and support effective force production. Strengthening the core muscles, which cover the abdomen, pelvis, and back, is an effective method for both improving athletes' athletic performance and reducing the risk of injury (Hibbs et al., 2008; Willardson, 2007; Yel et al., 2023).

The core region is central to all body movements and plays a crucial role in providing balance and stability in sports involving dynamic movements, such as volleyball. Strong core muscles in volleyball facilitate the athlete's ability to move quickly, plant their feet firmly, and deliver powerful hits during both offense and defense. Conversely, weak core muscles can lead to excessive strain on other muscle groups like the legs and arms, potentially resulting in issues such as muscle fatigue, lower back pain, and knee injuries (Willardson, 2007).

Studies have shown that strengthening the core muscles leads to significant improvements in motor skills such as balance, explosive power, strength, flexibility, and speed in athletes (Hibbs et al., 2008; Kibler et al., 2006) and that this plays a performance-enhancing role, particularly in many sports such as volleyball. Therefore, core training is a type of training that aims to develop the muscles in the torso region in a balanced manner, improve postural stability, and support overall athletic performance.

This study aims to investigate how core training affects motor skills in adolescent volleyball players from a broad perspective, which is important in terms of improving athletes' performance and minimizing the risk of injury. In this context, the study aims to examine in detail the effects of 10 weeks of core training on motor skills in adolescent male volleyball players. Specifically, the role of core training on parameters such as flexibility, strength, explosive power, agility, and core strength observed in volleyball players will be evaluated.

## Materials and Methods

### Research Design

The study was designed as a pre-test/post-test, experimental research with experimental and control groups to determine the effects of 10 weeks of periodized core training on motor skills in adolescent male volleyball players.

### Research Group

The experimental group (n=28) had a mean age ( $M\pm SD$ ;  $15.69\pm 0.84$  years), mean height ( $M\pm SD$ ;  $189.34\pm 3.87$  cm), mean weight ( $M\pm SD$ ;  $71.19\pm 7.29$  kg), and body fat percentage ( $M\pm SD$ ;  $12.03\pm 1.47$  %). The control group (n=27) had an average age ( $M\pm SD$ ;  $15.88\pm 0.86$  years), average height ( $M\pm SD$ ;  $188.88\pm 3.26$  cm), average weight ( $M\pm SD$ ;  $67.73\pm 6.24$  kg), and body fat percentage ( $M\pm SD$ ;  $11.99\pm 1.41$ %) for at least four years. The athletes were randomly divided into two groups. Since the athletes in both groups were under 18 years of age, they were included in the study after obtaining signed 'Informed Consent Forms' from their parents and 'Child Consent Forms' to obtain their own consent.

### Training Protocol

In addition to classic volleyball training sessions designed for athletes in the Kor training group over 10 weeks, with each session (90 min.) with an average intensity of 50-90%. In addition to these classic volleyball training sessions, the control group athletes only participated in classic volleyball training (90 min.), while the core training group athletes also participated in the core training program 4 times a week (Monday, Wednesday, Friday, and Sunday) before training. The average intensities of the classic volleyball training sessions to be applied for 10 weeks for both groups were determined using the Polar H10 (Finland) heart rate sensor, compatible with the iPad application, and mesocycles, microcycles, and daily training plans were prepared and applied to the athletes. The intensity of the training sessions for athletes in both groups was monitored using the Polar H10 (Finland) heart rate sensor, compatible with the iPad application, to ensure that target intensities were not exceeded. Before and after training, both groups underwent weight, body fat percentage, back-neck flexibility, shoulder-wrist flexibility, leg strength, back strength, agility, vertical jump, 3 kg medicine ball throw, 2 kg modified medicine ball throw, standing long jump, sit-ups, push-ups, planks, and back isometric strength tests were administered to both groups before and after the training.

### Core Training Program

Although there is no internationally accepted common training program and optimal exercises that will increase core stabilization and athletic performance, different training methods performed on stable or unstable surfaces have emerged (Arokoski et al., 2001). A review of the literature reveals that many practitioners have stated that core exercises performed on unstable surfaces provide greater muscle activation and greater muscle involvement than core exercises performed on stable surfaces, as demonstrated in numerous studies (Willardson, 2007; Hibbs et al., 2008; Imai et al., 2010; Reed et al., 2012; Mok et al., 2015). In this context, the core training program developed by Paul J. Goodman (2003) was used to create the core training program. The training program elements, such as the exercises, number of sets, loading times, and number of repetitions specified in the training program, were applied exactly as described (Goodman, 2003).

### Classic Volleyball Training Program

When preparing classic volleyball training programs, 48 technical drills were created with input from national team coaches, national team fitness trainers, and child

development experts. After deciding with expert teams at which stage each technical drill should be used, measurements were taken using the Polar H10 (Finland) heart rate sensor, compatible with the iPad application, on athletes in the target age group to determine the target intensities of the drills before starting the research. Then, the content of each unit (90 min.) of the classic volleyball training program to be applied to both groups was determined as follows: the first 15 minutes of the training consisted of stretching, 5 minutes of general warm-up, and 60 minutes of drills targeting volleyball-specific technical-tactical (finger pass, forearm pass, serve, and teamwork) skills, and 10 minutes of cool-down. The intensity of each training unit was designed to be between 50-90% on average, and mesocycles, microcycles, and daily training plans were designed and applied to the athletes. The weekly training plan continued in the same manner, with only the training drills and intensities being modified.

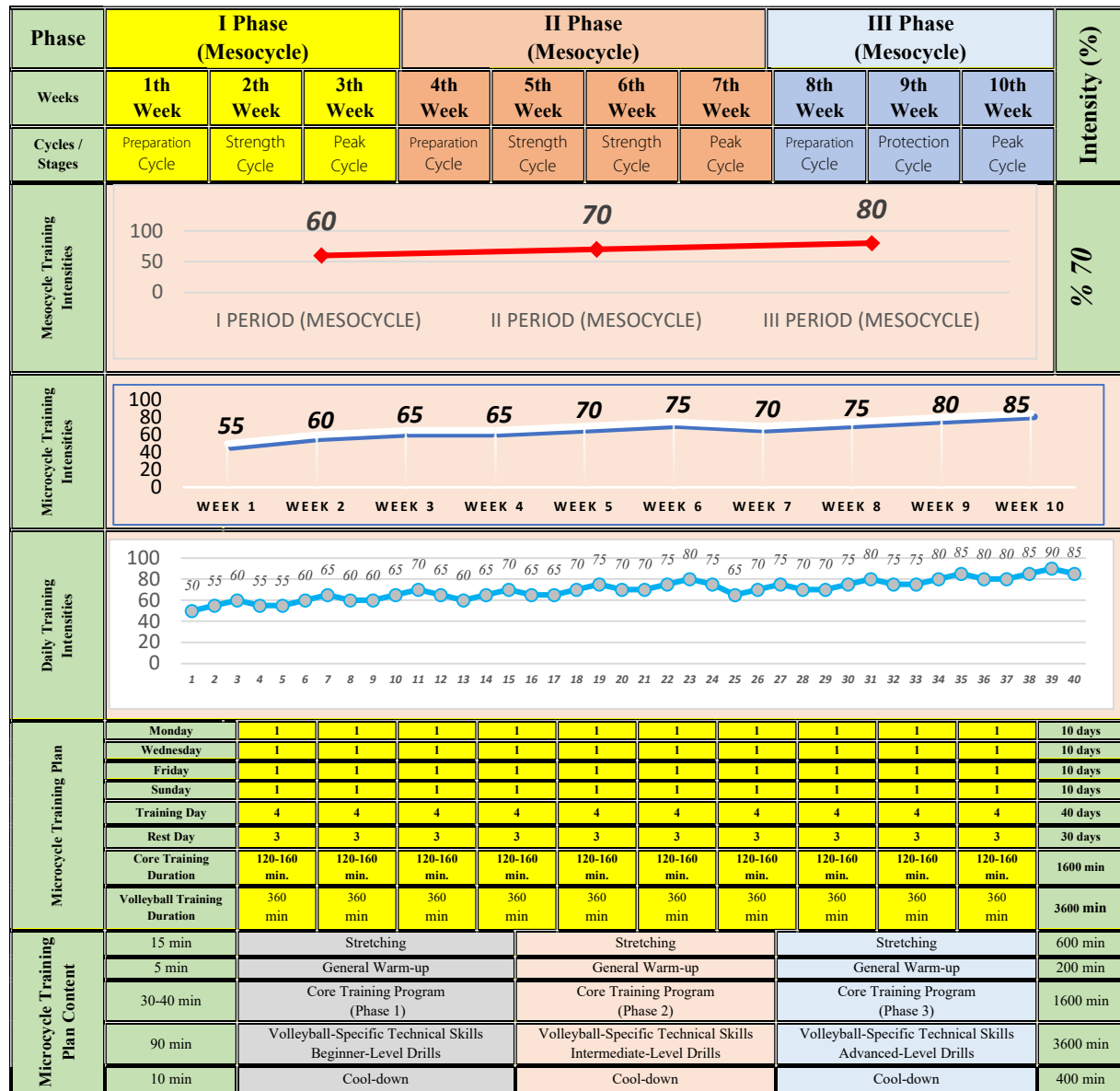


Figure 1. Core and Volleyball Training Plan

| PERIODS | PERIOD / DAILY TRAINING PLAN CONTENT |                   |                   |                   |
|---------|--------------------------------------|-------------------|-------------------|-------------------|
|         | MONDAY                               | WEDNESDAY         | FRIDAY            | SUNDAY            |
|         | Stretching 15 min                    | Stretching 15 min | Stretching 15 min | Stretching 15 min |

|                                       |                                            |                                            |                                |                                            |
|---------------------------------------|--------------------------------------------|--------------------------------------------|--------------------------------|--------------------------------------------|
| WEEKLY VOLLEYBALL<br>TRAINING CONTENT | General Warm-up 5 min                      | General Warm-up 5 min                      | General Warm-up 5 min          | General Warm-up 5 min                      |
|                                       | Forearm Passing Drills 10'min              | Forearm Passing Drills 10'min              | Overhand Passing Drills 10'min | Serve Drills 10'min                        |
|                                       | Forearm and Overhand Passing Drills 15'min | Forearm and Overhand Passing Drills 15'min | Forearm Passing Drills 10'min  | Forearm and Overhand Passing Drills 15'min |
|                                       | Serve Drills 15'min                        | Serve Drills 15'min                        | Serve Drills 20'min            | Serve Drills 15'min                        |
|                                       | Team Drills 20 min                         | Team Drills 20 min                         | Team Drills 20 min             | Team Drills 20 min                         |
|                                       | Cool-down 10 min                           | Cool-down 10 min                           | Cool-down 10 min               | Cool-down 10 min                           |

Figure 2. Content of the Volleyball Training Microcycle Plan (Microcycles)

### Data Collection Method

Identity information was used to determine the subjects' ages. Height measurements were taken using a portable stadiometer (SECA, Germany) with a resolution of 0.01 m, and the results were recorded in centimeters. Subjects' body mass indexes and body fat levels were measured using a Tanita (Type BC-418 MA) device. To determine body weight, the same device was used to measure the subjects while they were barefoot and in an anatomical standing position wearing standard sports clothing (shorts, leggings, T-shirt), and the resulting value was recorded in 'kg' (Özer, 2016).

### Back-Neck Flexibility Test

The back-neck flexibility test was used to determine the back-neck flexibility of the athletes (Özer, 2016; Barak et al., 2016).

### Shoulder-Wrist Flexibility Test

The shoulder-wrist flexibility test was used to determine the shoulder and wrist flexibility of athletes (Özer, 2016; Barak et al., 2016).

### Back and Leg Strength Test

Measurements were taken using a Takkei brand back and leg dynamometer to determine athletes' back and leg strength (Özer, 2016).

### Agility Test (ProAgility)

To determine athletes' agility performance, the Pro Agility agility test protocol was applied using the Fusion Sport brand photocell (Fusion Sport Smart Speed Timing Gates, Brisbane, Australia) software (Harman et al., 2000; Baechle & Earle, 2008). Due to the test protocol being included in the device's software, a single photocell gate was used, which served as both the start and finish gate.

### Vertical Jump Test:

The "Opto Jump Next" device was used to determine the athletes' vertical jump performance. The Counter Movement Jump = CMJ test protocol, one of the software protocols included in the device, was applied as the test protocol. To isolate the lower extremity, eliminate the contribution of technique and the swing of the arms during the Counter Movement Jump = CMJ protocol, (Hara et al., 2008).

### 3 kg Chest Pass Health Ball Throw Test

The 3 kg chest pass health ball throw test was used to assess athletes' upper extremity open kinetic chain function and measure explosive power levels (Stockbrugger & Haennel, 2001) (Sharrock et al., 2011). The athlete stood upright on a mat with knees at the reference point (90-degree knee flexion and neutral torso) while a long measuring tape was placed perpendicular to the reference point on the floor. The athlete was then

asked to grasp the 3 kg medicine ball with both hands and throw it as far as possible in the direction of the tape in front of them, using a chest pass so that the ball touched the chest wall. In accordance with the test protocol, the point where the ball first touched the ground was marked, and the throw was repeated three times, with the best score recorded.

### **2 kg Crown Throw (Modified Crown Throw) Medicine Ball Throw Test**

A 2 kg modified crown throw test was used to determine the explosive power of the athletes' arm muscles. The athlete was asked to kneel on a mat with knees parallel and knees as the reference point, hold the 2 kg medicine ball with both hands, bend the torso backward, then quickly swing the arms forward and throw the ball over the head as far as possible. The athlete performed three throws with a two-minute interval, and the best score was recorded (Gozzoli, 2006; Pekel, 2007).

### **Standing Long Jump Test**

The standing long jump test was used to measure the explosive strength level of the athletes' lower extremity leg extensor muscles. Standing on a non-slip, hard surface, the athlete jumped forward from behind the starting line of the standing long jump mat marked with 'cm', with feet in a bilateral plane and hands free, and was asked to land without losing balance at the point where they landed. The distance between the starting line and the athlete's heels was recorded in 'cm'. If the two heels were not aligned on the mat, the measurement was taken from the rear heel (Baechle & Earle, 2008; Ramírez-Vélez et al., 2017).

### **Sit-Up Test:**

A 60-second sit-up test was used to assess muscular endurance in athletes (Mikkelsen et al., 2006; Henderson et al., 2007; Esco et al., 2008).

### **Plank Test:**

Athletes lie face down, elbows and forearms shoulder-width apart, toes touching the starting point on the floor, pushing against the floor, pelvis elevated, gluteal and abdominal muscles engaged, spine in a neutral position, head following the spine in a neutral position, forming a line close to parallel. The test and stopwatch were started with the "Start" command, and the time elapsed until the athlete became fatigued was recorded in seconds without breaking the stabilization rules (Barwick et al., 2012).

### **Push-up Test**

A 60-second push-up test was used to evaluate the athletes' whole-body muscle strength and upper extremity endurance (ACSM, 2013). After assuming the push-up position, the athletes were asked to bend their elbows to 90° until their chests were approximately 12 cm from the ground. Once the athletes' chests were 12 cm from the mat, the push-up was counted as complete when their elbows returned to a straight position, and the number of repetitions achieved in 1 minute without resting, maintaining the correct posture, was recorded as the maximum push-up score (ACSM, 2013).

### **Back Isometric Endurance Test**

The Biering Sorenson Test, an isometric back extensor muscle endurance test, was used to assess back extensor endurance in athletes (Moreau et al., 2001).

### **Data Analysis**

The SPSS 21.0 statistical package program was used for statistical analyses and calculations. The Shapiro-Wilk test was used to determine whether the data were normally distributed, and Levene's test was used to determine whether the data showed a homogeneous distribution. It was determined that the subscale values of the data were not significant. Since the data showed a normal distribution in intergroup statistics, the T test was used for the comparison of independent groups (Independent samples), and the T test was used for the comparison of dependent groups (Paired Samples). In this study, the significance level was accepted as  $p < 0.05$ .

## Results

**Table 1.** Participants' Physical Characteristics

| <i>Pyysical</i>     | <i>Groups</i> | <i>n</i>  | <i>Age (years)</i> | <i>Height (cm)</i> | <i>Weight (kg)</i> | <i>Body Fat V.Y.Y.</i> | <i>Sport Experience (years) X±Ss</i> |
|---------------------|---------------|-----------|--------------------|--------------------|--------------------|------------------------|--------------------------------------|
|                     |               |           | <i>X±Ss</i>        | <i>X±Ss</i>        | <i>X±Ss</i>        | <i>X±Ss</i>            |                                      |
| <i>Participants</i> | <i>VKG</i>    | <i>28</i> | 15,69±0,84         | 189,34±3,87        | 71,19±7,29         | 12,03±1,47             | 4,63±0,56                            |
|                     | <i>VG</i>     | <i>27</i> | 15,88±0,86         | 188,88±3,26        | 67,73±6,24         | 11,99±1,41             | 4,82±0,42                            |

According to Table 1, the mean age of the VKG group (n=28) was 15.69±0.84 (years), their sports experience was 4.63±0.56 (years), their height was 189.34±3.87 (cm), body weight 71.19±7.29 (kg), and body fat percentage 12.03±1.47 (kg). The VG group (n=27) had an average age of 15.88±0.86 (years), sports experience of 4.82±0.42 (years), height of 188.88±3.26 (cm), body weight of 67.73±6.24 (kg), and body fat percentages of 11.99±1.41 (kg).

**Table 2.** Pre-test comparison results of participants' motor skill scores

| Motor Skills                          | Groups | n  | Pre-Test X±SD | Between-Groups (t) | Between-Groups (p) |
|---------------------------------------|--------|----|---------------|--------------------|--------------------|
| Weight (kg)                           | VKG    | 28 | 71,19±7,29    | 1,880              | ,066               |
|                                       | VG     | 27 | 67,73±6,24    |                    |                    |
| V.Y.Y.                                | VKG    | 28 | 12,03±1,47    | ,114               | ,910               |
|                                       | VG     | 27 | 11,99±1,41    |                    |                    |
| Back–Neck Flexibility (cm)            | VKG    | 28 | 50,24±7,78    | ,023               | ,982               |
|                                       | VG     | 27 | 50,19±8,03    |                    |                    |
| Shoulder–Wrist Flexibility (cm)       | VKG    | 28 | 66,07±14,22   | ,164               | ,870               |
|                                       | VG     | 27 | 65,54±8,84    |                    |                    |
| Back Strength (kg)                    | VKG    | 28 | 53,07±14,22   | ,572               | ,570               |
|                                       | VG     | 27 | 54,16±3,06    |                    |                    |
| Leg Strength (kg)                     | VKG    | 28 | 50,21±4,24    | -,402              | ,690               |
|                                       | VG     | 27 | 50,02±5,79    |                    |                    |
| Agility (sn)                          | VKG    | 28 | 5,43±0,39     | ,080               | ,937               |
|                                       | VG     | 27 | 5,42±0,21     |                    |                    |
| Vertical Jump (cm)                    | VKG    | 28 | 41,01±10,03   | -,338              | ,737               |
|                                       | VG     | 27 | 41,69±4,05    |                    |                    |
| 3 kg Medicine Ball Throw (m)          | VKG    | 28 | 3,89±0,56     | -,563              | ,576               |
|                                       | VG     | 27 | 3,96±0,41     |                    |                    |
| Modified 2 kg Medicine Ball Throw (m) | VKG    | 28 | 4,43±0,46     | ,150               | ,881               |
|                                       | VG     | 27 | 4,41±0,50     |                    |                    |
| Standing Long Jump (m)                | VKG    | 28 | 2,27±0,26     | -1,213             | ,231               |
|                                       | VG     | 27 | 2,24±0,15     |                    |                    |
| Sit-up (repetitions)                  | VKG    | 28 | 30,66±8,82    | ,081               | ,936               |
|                                       | VG     | 27 | 30,50±5,03    |                    |                    |
| Plank (seconds)                       | VKG    | 28 | 1,03±0,35     | -,503              | ,617               |
|                                       | VG     | 27 | 1,10±0,53     |                    |                    |
| Push-up (repetitions)                 | VKG    | 28 | 22,83±8,36    | ,209               | ,835               |
|                                       | VG     | 27 | 22,35±8,73    |                    |                    |
| Back Isometric Endurance (seconds)    | VKG    | 28 | 1,09±0,61     | ,393               | ,696               |
|                                       | VG     | 27 | 1,04±0,33     |                    |                    |

According to Table 2, no significant differences were found in the pre-test mean scores of participants' weight, body fat percentage, back-neck flexibility, shoulder-wrist flexibility, leg strength, back strength, agility, vertical jump, 3 kg medicine ball throw, 2

kg modified medicine ball throw, standing long jump, sit-ups, push-ups, planks, and back isometric strength test values in the pre-test mean scores ( $p>.05$ ). These results indicate that the groups are equivalent.

**Table 3.** Comparison of participants' motor skill scores between pre-test and post-test

| Motor Skills                             | Groups | n  | Pre-Test<br>X±Ss | Post-Test<br>X±Ss | Difference | Within-Group<br>Change (%) | Between<br>groups (t) | Between<br>Groups (p) |
|------------------------------------------|--------|----|------------------|-------------------|------------|----------------------------|-----------------------|-----------------------|
| Weight (kg)                              | VKG    | 28 | 71,19±7,29       | 68,69±6,97        | -2,50      | -3,53                      | 10,483                | ,000*                 |
|                                          | VG     | 27 | 67,73±6,24       | 67,27±6,29        | 1,47       | 2,06                       | -13,112               | ,000*                 |
| V.Y.Y.                                   | VKG    | 28 | 12,03±1,47       | 10,49±0,92        | -1,54      | -14,67                     | 10,636                | ,000*                 |
|                                          | VG     | 27 | 11,99±1,41       | 11,84±1,03        | -0,15      | -1,24                      | ,678                  | ,504                  |
| Back–Neck Flexibility (cm)               | VKG    | 28 | 50,24±7,78       | 62,69±6,79        | 12,45      | 19,24                      | -16,626               | ,000*                 |
|                                          | VG     | 27 | 50,19±8,03       | 54,27±11,77       | 4,08       | 7,25                       | -7,081                | ,100                  |
| Shoulder–Wrist Flexibility (cm)          | VKG    | 28 | 66,07±14,22      | 80,93±13,35       | 14,86      | 17,92                      | -12,198               | ,000*                 |
|                                          | VG     | 27 | 65,54±8,84       | 70,23±11,30       | 4,69       | 6,50                       | -8,180                | ,060                  |
| Back Strength (kg)                       | VKG    | 28 | 53,07±14,22      | 70,91±4,18        | 17,84      | 21,52                      | -46,125               | ,000*                 |
|                                          | VG     | 27 | 54,16±3,06       | 62,42±3,59        | 8,26       | 11,10                      | -5,558                | ,000*                 |
| Leg Strength (kg)                        | VKG    | 28 | 50,21±4,24       | 67,09±4,23        | 16,28      | 20,58                      | -6,276                | ,000*                 |
|                                          | VG     | 27 | 50,02±5,79       | 56,42±3,59        | 6,39       | 9,34                       | -12,525               | ,000*                 |
| Agility (sn)                             | VKG    | 28 | 5,43±0,39        | 4,76±0,26         | -0,66      | -13,93                     | 18,367                | ,000*                 |
|                                          | VG     | 27 | 5,42±0,21        | 5,23±0,17         | -0,19      | -3,69                      | 5,447                 | ,000*                 |
| Vertical Jump (cm)                       | VKG    | 28 | 41,01±10,03      | 49,70±8,48        | 8,70       | 16,82                      | -22,728               | ,000*                 |
|                                          | VG     | 27 | 41,69±4,05       | 43,54±5,23        | 1,85       | 4,06                       | -5,503                | ,086                  |
| 3 kg Medicine Ball Throw (m)             | VKG    | 28 | 3,89±0,56        | 4,66±0,54         | 0,78       | 13,70                      | -38,056               | ,000*                 |
|                                          | VG     | 27 | 3,96±0,41        | 4,14±0,43         | 0,17       | 3,37                       | -2,744                | 0,011*                |
| Modified 2 kg Medicine Ball<br>Throw (m) | VKG    | 28 | 4,43±0,46        | 5,03±0,49         | 0,61       | 10,06                      | -9,875                | ,000*                 |
|                                          | VG     | 27 | 4,41±0,50        | 4,55±0,43         | 0,14       | 2,48                       | -2,400                | ,260                  |
| Standing Long Jump (m)                   | VKG    | 28 | 2,27±0,26        | 2,81±0,24         | 0,54       | 19,05                      | -52,831               | ,000*                 |
|                                          | VG     | 27 | 2,24±0,15        | 2,45±0,12         | 0,10       | 4,23                       | -4,712                | ,000*                 |
| Sit-up (repetitions)                     | VKG    | 28 | 30,66±8,82       | 43,93±8,98        | 13,28      | 27,70                      | -47,365               | ,000*                 |
|                                          | VG     | 27 | 30,50±5,03       | 33,27±3,17        | 2,77       | 7,43                       | -3,326                | ,063                  |
| Plank (seconds)                          | VKG    | 28 | 1,03±0,35        | 2,10±0,52         | 1,07       | 46,01                      | -11,813               | ,000*                 |
|                                          | VG     | 27 | 1,10±0,53        | 1,32±0,41         | 0,22       | 14,45                      | -2,747                | ,100                  |
| Push-up (repetitions)                    | VKG    | 28 | 22,83±8,36       | 35,10±7,48        | 12,28      | 31,39                      | -35,365               | ,000*                 |
|                                          | VG     | 27 | 22,35±8,73       | 25,35±7,80        | 3,00       | 10,22                      | -2,017                | ,050                  |
| Back Isometric Endurance<br>(seconds)    | VKG    | 28 | 1,09±0,61        | 2,19±0,59         | 1,10       | 44,24                      | -24,786               | ,000*                 |
|                                          | VG     | 27 | 1,04±0,33        | 1,28±0,34         | 0,25       | 15,67                      | -8,511                | ,000*                 |

According to Table 3, there were significant differences in the pre-test and post-test mean scores for the following tests among athletes in the control group: weight, body fat percentage, back-neck flexibility, shoulder-wrist flexibility, leg strength, back strength, agility, vertical jump, 3 kg medicine ball throw, 2 kg modified medicine ball throw, standing long jump, sit-ups, push-ups, plank, and back isometric strength test values showed significant differences in pre-test and post-test mean scores ( $p<.05$ ). Again, according to Table 3, significant differences were found in the pre-test and post-test mean scores of the volleyball group participants for weight, leg strength, back strength, agility, 3 kg medicine ball throw, standing long jump, push-ups, and back isometric strength test values ( $p<.05$ ). On the other hand, no significant differences were found in the pre-test and post-test mean scores for body fat percentage, back-neck flexibility, shoulder-wrist flexibility, vertical jump, 2 kg modified medicine ball throw, sit-ups, and plank ( $p>.05$ ). Furthermore, in terms of development levels, it was found that the development level of the core training group was higher than that of the control group in all motor skills.

## Discussion and Conclusion

This study was conducted to investigate the effects of 10 weeks of periodized core training, in addition to volleyball training, on motor skills in adolescent male volleyball players. The findings of this study indicate that core training has a significant effect on motor skills in volleyball players. Strengthening the core muscles leads to positive developments in motor skills such as endurance, strength, balance, agility, and power.

Kibler et al. (2006) reported that core stability plays a critical role in power transfer in athletes and that this leads to an increase in their performance. The positive effect of core training on agility observed in the study is also consistent with the literature (Afyon et al., 2017; Dilber, 2016; Balaji & Murugavel, 2013; Yapıcı Öksüzoğlu & Egesoy, 2020; Axel, 2013; Willardson 2007).

In this context, it is believed that core training positively contributes to performance by increasing agility, quick movement, and stability in sudden movements for volleyball players. However, the study also highlights the contribution of core training to explosive strength and power development, particularly in the 3 kg chest pass, 2 kg modified crown throw medicine ball throw, and standing long jump test results. Explosive strength is a critical parameter for volleyball players and is of great importance when serving, spiking, blocking, jumping to pass, and performing sudden movements.

The increase in explosive strength associated with the strengthening of core regions can be linked to the musculoskeletal system becoming more efficient at force transmission. This finding is consistent with the results of the study conducted by Nadler et al. (2002). Similar studies have also shown that core training results in improvements in medicine ball throw (Ender, 2019; Boyacı, 2016; Başandaç, 2014; Tortum, 2017; Barak, 2019; Kır, 2018; Afyon & Boyacı, 2016) and standing long jump (Arı & Çolakoğlu, 2021; Dedecan, 2016; Baş, 2018; Boyacı & Bıyıklı, 2007; Civan, 2019) performance. Numerous studies have reported that core training improves core region function and body control (Harrington & Davies, 2005), positively affects the body's flexibility by increasing functional flexibility and lumbo-pelvic stabilization (Segal et al., 2004) (Sekendiz et al., 2010; Kloubec, 2010; Phrompaet et al., 2011; Amorim et al., 2011; Dilber, 2016).

In our study, although flexibility training was applied to both training groups, it is thought that the increase in trunk flexibility values in the experimental group athletes was due to the increase in muscular strength in the trunk muscles. Similarly, Doğan et al. (2016) reported that the change in the flexibility performance of athletes was significant as a result of the core training they applied to football players. In the study, positive effects on vertical jump performance were observed as a result of core training. Similar findings in the literature reveal the relationship between core muscle strength and vertical jump. Hibbs et al. (2008) stated that core training increases efficiency in lower extremity power production and thus improves jumping performance in athletes.

Similarly, in their study, Saeterbakken and Fimland (2013) stated that core strength training contributes to increased performance in explosive power movements such as vertical jumps by supporting lower extremity force transfer. Similarly, many studies have reported that core training programs increase the vertical jump performance of sedentary individuals and athletes (Butcher et al., 2007; Cressey et al., 2007; Sekendiz et al., 2010; Balaji & Murugavel, 2013; Afyon, 2014; Dedecan, 2016; Eren, 2019; Atıcı, 2013; Sharma et al., 2012; Doğan et al., 2016; Tortum, 2017; Özcan, 2018; Özdoğru, 2018; Baş, 2018; Yapıcı Öksüzoğlu & Egesoy, 2020). The results of the study are consistent with theories suggesting that strengthening the core muscles allows the lower extremity muscles to work more efficiently during jumping and enables the kinetic chain to transfer power more effectively.

This study found that core training has positive effects on back and leg strength performance. Although the contribution of core muscles to body stabilization is limited to isolated exercises targeting specific muscle groups, it also enables a broader level of

strength development. For example, Behm et al. (2002) reported in their study that core training increased not only dynamic stability but also functional strength performance. In this context, the improvement in intermuscular coordination due to the strengthening of the core muscles can be explained as one of the main reasons for the positive effects of training on strength development.

Similar studies have reported that core training results in significant changes in athletes' leg and back strength performance (Atıcı, 2013; Doğan et al., 2016; Kaçar, 2019; Kara & Çelik, 2021; Dedecan, 2016). Consistent with the literature, the results of this study show that core training increases trunk stability and improves core muscle endurance (Behm et al., 2002; Cosio-Lima et al., 2003; Stanton et al., 2004; Mills et al., 2005; Cowley et al., 2007; Nesser & Lee, 2009; Sato & Mokha 2009, Keogh et al., 2010; Saeterbakken et al., 2011; Basset & Leach, 2011; Cuğ et al., 2012; Yıldız, 2012; Afyon & Boyacı, 2013; Rahmat et al., 2014; Başandaç, 2014; Brilla & Kauffman, 2014; Kır, 2018; Dilber, 2016; Parkhouse & Ball, 2011; Allen et al., 2014; Dedecan, 2016; Afyon & Boyacı, 2013; Boyacı, 2016; Özcan, 2018; Özdoğru, 2018; Yaprak, 2018).

Furthermore, based on these studies, it is thought that the core training applied may positively contribute to the 1-minute push-up test performance. A review of the literature suggests that increases in strength in the rectus abdominis muscle and surrounding areas, transferred to the upper extremities with the help of connective tissues (Akuthota & Nadler, 2008), may lead to improvements in push-up performance. Therefore, it is thought that this may explain the significant increase observed in the experimental group in the 60-second push-up test.

In conclusion, after 10 weeks of periodized core training in adolescent male volleyball players, a significant difference was found in the pre-test and post-test mean scores for selected motor skill values ( $p<.05$ ). These results suggest that core training is beneficial for developing selected motor skills.

## Beyanlar / Declarations

### Etik Onay ve Katılım Onayı / Ethics approval and consent to participate

Bu çalışmanın hazırlanma ve yazım sürecinde "Yükseköğretim Kurumları Bilimsel Araştırma ve Yayın Etiği Yönergesi" kapsamında bilimsel, etik ve alıntı kurallarına uyulmuş olup; toplanan veriler üzerinde herhangi bir tahrifat yapılmamış ve bu çalışma herhangi başka bir akademik yayın ortamına değerlendirme için gönderilmemiştir. Makale ile ilgili doğabilecek her türlü ihlallerde sorumluluk yazara aittir. Bu çalışma, etik araştırma standartlarına uygun olarak yürütülmüş olup Gazi Üniversitesi Rektörlüğü Etik Komisyonu tarafından onaylanmıştır (Onay No: E-77082166-604.01-1229359; Tarih: 29 Nisan 2025; Karar No: 07).

During the preparation and writing of this study, all scientific, ethical, and citation principles outlined in the "Higher Education Institutions Scientific Research and Publication Ethics Directive" were strictly followed. No manipulation or falsification was carried out on the collected data, and this study has not been submitted to any other academic publication medium for evaluation. The author bears full responsibility for any potential violations that may arise in connection with this article. This study was conducted in accordance with ethical research standards and was approved by the Ethics Committee of the Presidency of Gazi University (Approval No: E-77082166-604.01-1229359; Date: April 29, 2025; Decision No: 07).

### Veri ve Materyal Erişilebilirliği / Availability of data and material

Bu çalışmanın bulgularını destekleyen veriler, makul talepler üzerine sorumlu yazardan temin edilebilir. Veri seti yalnızca akademik amaçlar için erişilebilir olacak ve verilerin herhangi bir kullanımı, orijinal çalışmayı referans gösterecek ve katılımcıların gizliliğini koruyacaktır.

The data that support the findings of this study are available from the corresponding author upon reasonable request. The dataset will be accessible only for academic purposes, and any use of the data will recognize the original study and maintain the confidentiality of the participants.

### Çıkar Çatışması / Competing interests

Yazarlar, bu makalede sunulan çalışmayı etkileyebilecek herhangi bir çıkar çatışması veya kişisel ilişkiye sahip olmadıklarını beyan etmektedirler.

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

### Yazar Katkıları / Authors' Contribution Statement

Bu çalışmada yazarların katkı oranı eşittir.  
All authors contributed equally to this work

### Fon Desteği / Funding

This Bu çalışma, kamu, özel veya kar amacı gütmeyen sektörlerdeki fon sağlayıcı kurumlardan herhangi bir özel destek almamıştır.

This research received no external funding.

### Teşekkür / Acknowledgements

None.

### APA 7 Citation

Uslu, S., Barak, R., Mahmutović, I., İşgüzar, M. G., Arda, K. K., & Barak, İ. (2025). The effect of periodized core training on motor skills in volleyball players. *International Journal of Health, Exercise, and Sport Sciences*, 3(2), 306–319.

<https://www.ijoss.org/Archive/issue2-volume3/ijoss-Volume2-issue3-25.pdf>

<https://doi.org/10.5281/zenodo.17440985>

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