Review Paper

Effect of Core Stability Exercises on Volleyball Players: A Systematic Review

Parisa Sedaghati[1], Adibeh Baharmast Hossein Abadi[1], Hamid Zolghadr[1*]

1. Department of Sports Injuries and Corrective Exercise, Faculty of Sport Sciences, University of Guilan, Rasht, Iran.

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ABSTRACT

Purpose: The purpose of current review was investigating the effect of core stability exercises (CSE) on volleyball players.

Methods: Current research was a PRISMA systematic review. It reviewed comprehensively the Impact of CSE on volleyball players. It carried out searching in Google Scholar, PubMed, Science Direct, PEDro, EMBASE, Web of Science, and Scopus databases and in Persian Google Scholar, Megapaper databases, IRANDOC, Magiran, SID, Medilib, IranMedex. The keywords in two groups including: Group 1: "Core stability exercise" OR "core stability training" OR "core stability endurance" OR "trunk stability" OR "central stability exercises" OR "core intervention" OR "core stability control" OR "core strengthening exercise" OR "trunk resistance exercise" and group 2: "Volleyball" OR "volleyball player" OR "volleyball athletes" from 2000 to February of 2023. Current research used both English and Persian languages.

Results: We got 146 articles. After removing duplicate titles, we selected 127 abstracts for review. Finally, 18 articles were included in the present review.

Conclusion: The outcomes of current review show that CSE have the ability to improve movement capabilities, performance, and sports skills as well as prevent injuries from volleyball players. Of course, to interpret the outcomes of the current research caution needs to be taken, considering the restrictions such as the difference in the sample size under study, measurement methods, and components of different core stability protocols.

*** Corresponding Author:**
Hamid Zolghadr, PhD.
Address: *Department of Sports Injury and Corrective Exercise, Faculty of Sports Sciences, University of Guilan, Rasht, Iran.*
Phone: *+98 (937) 5636180*
E-mail: *94hamidzolghadr@gmail.com*

Highlights

• Core stability exercises (CSE|) are able to enhance the sports functioning of volleyball players.

• CSE can prevent injury and improve the movement capabilities of volleyball players.

• CSE are one of the most vital training methods to enhance volleyball players physical fitness. Which can help their function and performance aspects during sports competitions and practices.

Plain Language Summary

Core stability exercises are one of the new training methods that have many fans among athletes, trainers and therapists. Because these exercises are used to improve physical fitness factors, and movement capabilities, improve the level of sports performance and prevent injuries among athletes, especially volleyball players. The sport of volleyball has a competitive nature and, like sports such as football and basketball, it has long competition seasons, which requires the athlete to be at an acceptable level in terms of physical fitness, and after that, the occurrence of sports injuries should be prevented as much as possible. Core stability training is a program that can be used both to improve movement capabilities and to prevent injuries during the competition season.

1. Introduction

Volleyball is the most attractive sport in the world. Approximately two hundred million players in 105 countries are active in this sport [1]. Volleyball can be a really rivalrous game and requires high motive skills. The major bodily characteristics of flexibility, explosive power, static balance, muscular strength, speed and muscular endurance are fundamental. A player on the volleyball court always needs to change direction, speed, and body position. S/he needs effectual deceleration or acceleration in space in an instant time to perform it well [2]. As for all functioning constituents, a volleyball player must be in control of his physique and transmit energy from the ground before hitting the ball [3]. In each volleyball technique, the core muscles play a vital role in movement efficiency, keeping body posture, flexibility and endurance power during repeated execution, and supporting the stabilization and strength of arms and legs [4]. The firmness of the core region as an intermediary with the effectual transferring of the produced force in the lower extremity to the upper extremity into and out of the trunk contributes to finer athletic performance [5]. Hodges et al. (2004) provided for the first time a complete definition of core stability. They defined core stability or lumbar-pelvic stability as a dynamic process of controlling stability in functional conditions so that it allows controlled movement of the trunk in different situations [6]. Core muscles provide the stability for power generation in the lower limbs and effective control of body movements. Deficiency or imbalance in core muscles can increase fatigue and the risk of injury and also decrease endurance in athletes [7]. The core region muscles are of an effect on the activation of the muscles of the organs; so, any weakness in these muscles leads to a delay in the activation of the organs and the occurrence of various injuries [8]. The muscles weakness in the core region is associated directly with the occurrence of more injuries in the lower extremities, particularly in sports that need leaping, fast running and jumping. Increasing the core region firmness makes the neuromuscular response to increases in order to reduce back discomfort and prevent lower limb injuries [9]. As researches have shown, the reduction of strength in the core body region muscles increases body fluctuations, and consequently, it may cause a disturbance in the body's balance [10]. As Jeffreys et al. report, core stability and balance are necessary components for proper performance in athletes. The sports require this because most athletic movements are performed in all three planes of motion; they require the athlete to have optimal strength in the thigh and trunk muscles, which ensures effective core stability. According to reports, most athletes need proper balance, strength, power, endurance, and a symmetrical body, but having a stable body is an essential part of all these features. As researches show, the lack of core strength and stability causes unfavorable efficiency of athletic techniques and makes athletes prone to injury [11]. Improving the speed, agility, and strength of the lower and upper body muscles for volleyball players is vital. Besides the specified requirements physiologically considering volleyball, the core muscle groups coordination is notable if utilized effectually [12]. Core exercises

Table 1. PICOS framework

Structural Components	Description
Population	Volleyball players with an age range of 10 to 30 years.
Intervention	A variety of core stability interventions for improving the movement capabilities of volleyball players.
Comparison	A detailed report of the researches is included in the present study and then comparing the outcomes of the researches to discover the impact of the core stability interventions on some factors of the movement capabilities of volleyball players.
Outcome	The current study identified the core stability interventions and their effect on the movement capabilities of volleyball players.
Type of study	This study included those original research studies that had at least two experimental and control groups (including randomized and semi-experimental clinical trial studies). It excluded review, meta-analysis, and descriptive studies.

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are very important for stability and strength growth [13]. Exercises of the body's core region are an inseparable part of preparation and strength training. This means that stronger core stability probably supplies a foundation for create more force in the lower and upper extremities [14]. Core stability exercises are essential for volleyball and can ensure the balance and strength of the core region [15]. A simple analogy: Even with the best tires, smoothest gearbox, and simplest body, a car is only as good as its engine, and its power plant. Similarly, an athlete without stable and flexible core stability produces less than maximum efficiency and falls well short of his athletic ability [16]. CSE are able to enhance the ability of the nervous system in order to organize muscle coordination for increasing exercise performance. By neglecting core stability exercises, athletes cannot control and use whole-body muscle strength well, which may increase the risk of sports injuries [17]. According to the theoretical foundations and studies on the core stability exercises and their effects in various areas, in preventing injuries, improving the level of sports performance, and improving the movement capabilities of athletes, especially volleyball players, they can be useful in their athletic future. It seems necessary to summarize existing research until now. Therefore, the present study reviews systematically the researches on the impact of CSE on the volleyball players movement capabilities.

2. Materials and Methods

Search strategy: This study was a PRISMA systematic review [18]. It reviewed comprehensively the impact of CSE on volleyball players. It carried out searching in Google Scholar, PubMed, Science Direct, PEDro, EMBASE, Web of Science, and Scopus databases and in Persian Google Scholar, Megapaper databases, IRANDOC, Magiran, SID, Medilib, IranMedex. The keywords in two groups including: Group 1: "core stability exercise" OR "core stability training" OR "core stability endurance" OR "trunk stability" OR "central stability exercises" OR "core intervention" OR "core stability control" OR "core strengthening exercise" OR "trunk resistance exercise" and group 2: "Volleyball" OR "player" OR "athletes" from 2000 to February 2023. Sometimes, all terms were combined with no research restrictions in the search. The study performed a manual search and thorough review of article references to find articles that were not found through the electronic search. This search used both English and Persian languages. Following gathering of the outcomes of research, the researcher studied firstly the title and secondly the articles abstract. Where the articles were consistent with the criteria of exclusion and inclusion, their outcomes were utilized in the current review or were abandoned otherwise. The structure of the PICOS framework can be seen in Table 1.

Inclusion criteria and selection of studies: In the first stage, the title and abstract of the studies were screened by Hamid Zolghadr and Adibeh Baharmast Hossein Abadi focusing on the impact of CSE on the volleyball players movement capabilities, it was published in Farsi and English the second stage of all the text of the articles by Hamid Zolghadr and Adibeh Baharmast Hossein Abadi It was investigated according to the publication criteria and the specificity of the target community. Another senior researcher Parisa Sedaghati checked the last list of selected articles to ensure the alignment of all articles with the study aims. Inclusion criteria included volleyball players, core stability interventions, original research articles, experimental, and semi-experimental studies, randomized clinical trials, English and Farsi articles, and studies as published full text. Exclusion criteria comprised articles published as a summary in congresses and seminars, single case studies, pilot studies, and reviews. Based on the stated criteria, we extracted 146 articles, of which only 18 articles were under review.

Quality of the reviewed researches: The research evaluated the methods quality of the relevant studies through the Pedro scale [19]. Current scale encompasses 11 modules. They measure the following criteria: 1) Determination of eligibility criteria for participants, 2) Participants random allotment, 3) Allotment of concealment, 4) Similarity among groups in relevant variables in the pretest stage, 5) Deprive of understanding of the participator, 6) Deprive of understanding of the researcher who implemented the exercise programmed, 7) Deprive of understanding of the evaluators to measure the dependent variables, 8) The ratio of participator, who have not less than one key outcome in the measured dependent variable, 9) Complaisance of participators with the intervention, 10) Comparison among groups statistically, and 11) Measures of point and variability for not less than one dependent variable. Satisfaction of a criterion had a score of 1, and making a summary of the outcomes got out of items 2 to 11 provided an overall score [20]. Studies whose total score is less than 5 and over 6 were of "low" and "high" quality, respectively [19, 20]. Table 2 reports the outcomes of the evaluation of quality of the reviewed researches.

3. Results

Figure 1 shows selecting studies. We got 146 articles. After removing duplicate titles, we selected 127 abstracts for reviewing. Following analysis of the abstracts of the papers, 87 papers got removed and 40 papers got chosen for studying the whole text. Following reviewing all of the papers, the current study removed 22 articles and included 18 articles. Table 3 summarizes the findings of the articles.

Training period

The duration of core stability exercises varied between 6 and 12 weeks. In only one study, core stability exercises were performed for 12 weeks [27]. In two studies, the duration of their exercises was 10 weeks [23, 28]. The

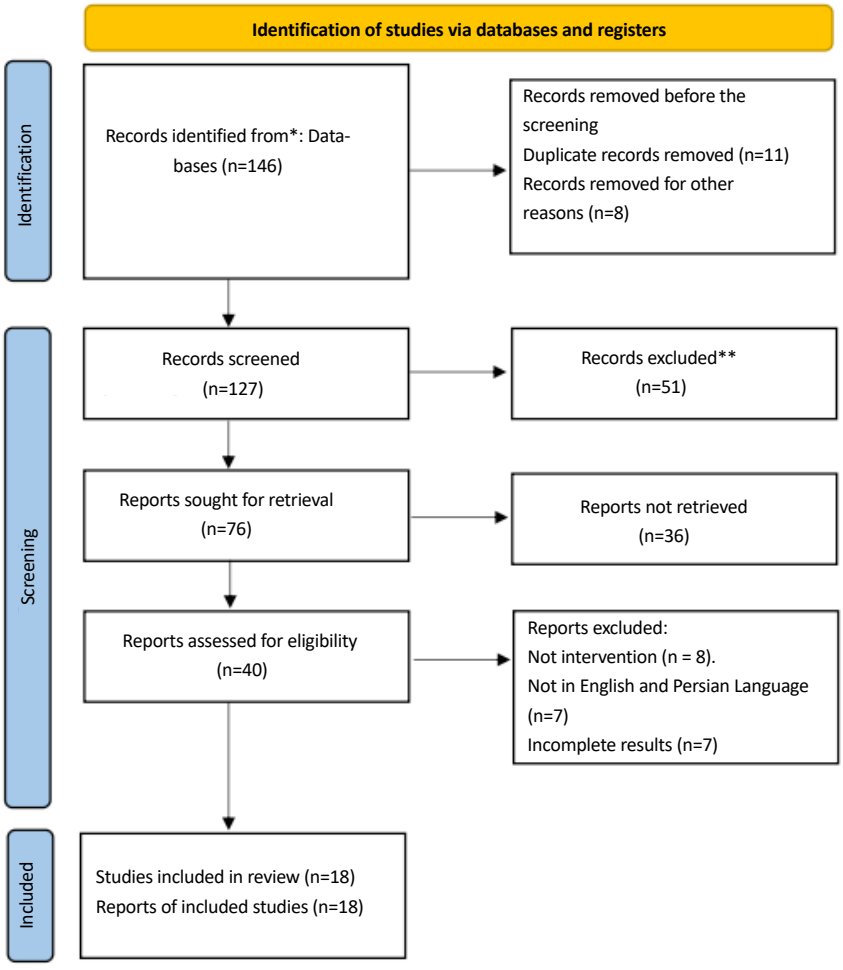

Figure 1. Flow diagram for eligible studies

remaining 15 studies administered the exercises between 6 and 8 weeks. Also, 456 subjects (experimental group: 274 people and control group: 182 people) were present in these studies. The largest number of subjects (60 people) and the number of training weeks were related to the study by Sazvar et al. [23].

Evaluation groups and interventions

Two studies had three groups of subjects [24, 32]. And in other studies, two groups participated. All training groups received the intervention of core stability exercises. CSE were executed on two types of stable and unstable surfaces.

Dependent variables under the impact of CSE

Throughout 18 studies included in this review paper, the impact of CSE on variables such as agility, explosive power, dynamic and static balance, aerobic and anaerobic power, speed, endurance of muscle, proprioception, range of motion, landing mechanism, rate of control Breathing, lower limb strength, flexibility, jump-landing pattern, service speed and accuracy, spike skill, and kinematic variables were investigated.

4. Discussion

This review investigated the impact of CSE on the movement capabilities of volleyball players. According to the inclusion and exclusion criteria, the present review included 18 articles. Therefore, it discussed the results of 18 studies in different groups.

Table 2. The outcomes of the quality evaluation of the reviewed researches

Researches	1	2	3	4	5	6	7	8	9	10	11	Overall Score	Quality
Çakir & Ergi (2022) [21]	■	□	□	□	□	□	□	■	■	■	■	4	Low
Bora & Dağlıoğlu (2022) [22]	■	□	□	□	□	□	□	■	■	■	■	4	Low
Sazvar & Khodaveisi (2022) [23]	■	□	□	□	□	□	□	■	■	■	■	4	Low
Alizamani et al. (2023) [24]	■	□	□	□	■	□	□	■	■	■	■	5	Low
Mirghmali et al. (2022) [25]	■	□	□	□	□	□	□	■	■	■	■	4	Low
Solanki (2021) [26]	■	■	□	□	□	□	□	■	■	■	■	5	Low
Fatahi et al. (2021) [27]	■	□	□	□	□	□	□	■	■	■	■	4	Low
Şahin & Özdal (2020) [28]	■	□	□	□	□	□	□	■	■	■	■	4	Low
Lestari et al. (2020) [29]	■	□	□	□	□	□	□	■	■	■	■	4	Low
Tafakoriollah et al. (2020) [30]	■	□	□	□	□	□	□	■	■	■	■	4	Low
Yapıcı (2019) [31]	■	□	□	□	□	□	□	■	■	■	■	4	Low
Devri & Erdem (2019) [32]	■	□	□	□	□	□	□	■	■	■	■	4	Low
Tsai et al. (2020) [33]	■	□	□	□	□	□	□	■	■	■	■	4	Low
Mirjamali et al. (2019) [34]	■	□	□	□	□	□	□	■	■	■	■	4	Low
Rezvankhah Golsefidi et al. (2019) [35]	■	□	□	□	□	□	□	■	■	■	■	4	Low
Moustafa Mabrouk Mohammad Shahin (2016) [36]	■	□	□	□	□	□	□	■	■	■	■	4	Low
Mohamed & Rezk (2015) [4]	■	□	□	□	□	□	□	■	■	■	■	4	Low
Sadeghi et al. (2013) [37]	■	■	□	□	□	□	□	■	■	■	■	5	Low

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*PEDro scale for measuring the quality of studies, items 1 to 11 are mentioned in the research methodology section. The sum of items 2-11, ■1 point, □0 point.

Table 3. Reports the studies on the impact of CSE on the movement capabilities of volleyball players

Researcher	Type of Study	Gender	Sample Size	Age Range (y)	Study Variables	Assessment Tool	Results
Çakir & Ergi (2022) [21]	Semi experimental	Female	Exp=10 Con=10	14-16	Pro-agility	Photocell Gates (Smart Speed, Fusion Sport, Austria)	A notable dissimilarity statistically was discovered in the balance precision index, static vertical jump (cm), counter movement jump for explosive strength (cm) and agility pro-agility test (sec) parameters during comparison of the control and study groups.
					Explosive strength	Static vertical jump and counter movement jump tests	
					Balance (dynamic)	Libra Dynamic Balance System (Easy Tech, Italy)	
Bora & Dağlıoğlu (2022) [22]	Semi experimental	Male	Exp=9 Con=9	18-22	Anaerobic power	Vertical jump test	There was a notable dissimilarity between the groups in speed, anaerobic power and static balance scores in support of the experimental group
					Speed	30 m speed test	
					Static balance	Biodex Balance System (Biodex Inc., Shirley, NY)	
Sazvar & Khodaveisi (2022) [23]	Semi experimental	Female	Exp=30 Con=30	20-30	Balance	Biodex Balance System	In this study, a notable dissimilarity was found in the pain level and balance scores some physical fitness factors of the experimental group compared to before the training period
					Agility	Shuttle run test	
					Muscular endurance performance	Sit-up	
					power	Vertical jump	
					aerobic power	Step test	
Alizamani et al. (2022) [24]	Semi experimental	Female	Exp 1=10 Exp 2=10 Con=10	18-30	muscular torque	The Isokinetic Biodex System	in each one of computed parameters, the UG was notably dissimilar from the SG and CG The outcomes too revealed that the SG had a notable enhancement in the parameters of torque dorsiflexion and muscle range of motion measured against the CG. nevertheless, in the proprioception, wasn't there any notable dissimilarity between the SG and the CG.
					Proprioception	The Isokinetic Biodex system	
					Dorsiflexion range of motion	A standard 360 goniometer	
Mirghmali et al. (2022) [25]	Semi experimental	Female	Exp=15 Exp=15	22-28	Core zone endurance	Mc Gill and Sorensen	The outcomes revealed a notable change in the scores of tests attributed to trunk endurance and landing mechanics after 6 weeks of training in both unstable and stable level training groups in other tests excluding the Planck test and in the training group athletes, unsteady level of finer functioning was seen
					Landing mechanics	LESS test	
Solanki (2021) [26]	Semi experimental	-	Exp=10 Con=10	18-23	Breath holding time and respiratory rate	Nostril hold method (2nds) and the rise and fall observing of the chest (numbers)	It was resolved that the core stability training group had revealed notably enhancement in breath holding time and respiratory rate.

Researcher	Type of Study	Gender	Sample Size	Age Range (y)	Study Variables	Assessment Tool	Results
Fatahi et al (2021) [27]	Semi experimental	Male	15	17-19	Strength of lower extremity Upper extremity endurance Trunk endurance Flexibility	Three-step jump tests and Sargent jump Chest press, back arm press Sit-ups Sit and reach tests	The current research outcomes revealed a notable dissimilarity statistically in the variables of upper extremity and muscle flexibility and trunk muscle endurance, but in the lower extremity strength variable, this dissimilarity was not seen in both pre-test and post-test level
Şahin & Özdal (2020) [28]	Semi experimental	Female	Exp=12 Con=12	12-14	Balance test Vertical jump	Stork tests of eye closed eye opened Vertical jump test	There was a notable dissimilarity between the pre-test and the post-test in terms of balance and vertical jump values of the experimental group
Lestari et al (2020) [29]	Semi experimental	Male	22	18-19	Core muscle strength	One-minute sit-up test	Hypothesis test statistically revealed a notable increment in core muscle strength
Tafakoriollah et al (2020) [30]	Semi experimental	Male	Exp=11 Con=11	14-19	Pattern of Landing-jumping Muscular endurance of trunk	LESS McGill protocol	A notable dissimilarity was seen in the jumping-landing pattern and trunk muscular endurance between the two experimental and control groups
Yapıcı (2019) [31]	Semi experimental	Female	Exp=16 Con=16	15-17	Velocity of the serve Service accuracy score Core Strength Static balance Dynamic balance	Bushnell sports radar (Bushnell, USA) Russel-Lange volleyball service test Sport-specific core muscle strength & stability plank test) One-leg standing balance SEBT test	There was a statistical notable dissimilarity between values of the experimental group between right-left leg dynamic balance, core strength values, service accuracy score test performance and velocity of the service performance values There was no statistically notable dissimilarity between static balance values
Devri & Erdem (2019) [32]	Semi experimental	Female	Exp 1=15 Exp 2=15 Con=15	11-13	Agility Balance Strength	T-test The flamingo static balance test tests of standing long jump and throw-in	As an outcome, a notable dissimilarity was discovered in the standing long jump test in all three groups throw-in and flamingo balance tests showed a notable dissimilarity in the KRP and KRC group but not in the KNL group. T-test revealed notable dissimilarity in KRP and KRC groups, but no notable dissimilarity was discovered in KNL group

Researcher	Type of Study	Gender	Sample Size	Age Range (y)	Study Variables	Assessment Tool	Results
Tsai et al. (2018) [33]	Semi experimental	Male	16	12-14	Trunk and lower extremity kinematics Functioning of volleyball-connected sports Muscular strength of the knee and hip.	Box landing and spike jump landing Vertical jump, agility-T, and 10-m shuttle run Isokinetic	The participators showed reduced trunk flexion angle, throughout the box landing task and decreased the highest knee internal rotation angle throughout the spike jump landing task. The average isokinetic strength of hip flexors and external rotators, and knee flexors and extensors also notably were increased nevertheless, sports functioning did not reveal notable changes.
Mirjamali et al. (2018) [34]	Semi experimental	Female	Exp 1=15 Exp 2=15	22-28	Static balance Dynamic balance	BESS Tests of Y balance	The outcomes of the research indicated a notable effect of both training protocols on static and dynamic balance the outcomes of covariance analysis showed that training on unstable level had larger efficiency on static and dynamic balance
Rezvankhah Golsefidi et al. (2018) [35]	Semi experimental	-	Exp=13 Con=14	10-12	Kinematic variables Kinetic variable	Six Bonita 240 Hz cameras Force plate made in Iran (Danish Salar Iranian) with a frequency of 400 Hz	The outcomes revealed that kinetic variables in the experimental group had a notable change, but no notable change was seen in the ankle kinematics.
Moustafa Mabrouk Mohammad Shahin (2016) [36]	Semi experimental	Female	Exp=7 Con=7	16-17	Biomechanical analysis Physical component Spik skill	Used video recorder Physical test Smash spike	The research outcomes included greater improvement in biomechanical and physical variables and in the level of spike functioning for the experimental group in comparison to the control group that indicates the effectiveness of the core training
Mohamed & Rezk (2015) [4]	Semi experimental	-	Exp=8 Con=8	17-19	The accuracy of the rear spiking test	Test (T)	The experimental programme that contains skill preparedness exercises which core stability training is added to in the section of bodily preparedness that utilized to the experimental group was more effectual than in the absence of adding the identical exercises there conducted to enhance the precision functioning of spike from back row attack.
Sadeghi et al (2013) [37]	Semi experimental	Male	Exp=15 Con=15	19-22	Dynamic balance	Star excursion balance test (SEBT)	These outcomes also represented there were notable dissimilarity in the scores for pre-test and post-test of whole administration according to SEBT in the experimental group.

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Abbreviations: SD: Stable surface training; UG: Unstable surface training; CG: Control; KRP: Core-plyometric; KRC: Core-quick strength; KNL: Control; LESS: Landing error scoring system; BESS: Balance error scoring system; SEBT: Star excursion balance test.

Impact of CSE on the volleyball players' balance

On the impact of CSE on the of volleyball players balance, there were eight studies [21-23, 28, 31, 32, 34, 37]. These studies investigated the impact of balance on dynamic and static balance. As the results showed, CSE can enhance both dynamic and static of volleyball players' balance. All the studies showed the positive effect of CSE on the volleyball players' balance. Sports like volleyball, in which players perform jumping and landing movements during the game, make it necessary to have proper balance to maintain the landing position followed by a successful jump. As the studies reported in this review showed, having a strong core region can improve balance in volleyball players. Therefore, balance is the most important movement skill in volleyball players, and its improvement can improve the level of athletic performance and prevent injuries. According to Kibler's findings, the activation of the core region muscles in the movement pattern of the end organs improves posture control; the body uses the activation of the core stabilizing muscles to generate rotational force around the body and create the movement of the limbs [38]. Stabilizing muscles of the hip and thigh undertake to hold the accurate alignment of the lower extremity during dynamic movements [39].

Impact of CSE on endurance and strength of muscles of volleyball players

About the impact of CSE on the muscular endurance and strength of volleyball players, there were eleven studies [21, 23-25, 27-33]. These studies investigated the impact of CSE on the muscular endurance and strength of the trunk muscles, the strength, and power of the of the upper and lower extremities muscles. As the results showed, CSE can enhance the strength and endurance of the muscles of the trunk, and the power and strength of the upper and lower extremities. Thus, all the studies showed the positive the impact of CSE on the improvement of the relevant variables. Only the study of Fatahi et al. [27] revealed that CSE improved the muscular endurance of the trunk and upper limbs, but did not improve the strength of the lower limbs. Seemingly, the tests for evaluating the strength of the lower limbs were not suitable for this study and they could have used better and more accurate tests, such as Isokinetic tests. Having the endurance and strength of the muscles of the trunk, consequently having the muscle power and strength of the lower limbs, is an essential factor in volleyball players. Because of the long duration of the volleyball, having proper muscle endurance and strength can maintain a player's athletic performance. Therefore, the weakness and reduced endurance of the posterior, anterior, and lateral stabilizing muscles of the trunk causes reduced strength and efficiency of the muscles around the thigh. The thigh muscles play an important role in transferring power from the lower limb to the upper spine during vertical or standing activities [39]. The weakness of the core stabilizing muscles can disrupt the accurate alignment of the lower extremity in dynamic movements and disturb the movement pattern in the lower limb [39].

Impact of CSE on volleyball players agility, anaerobic power and speed

About the impact of CSE on speed, anaerobic power and agility of volleyball players, there were four studies [21-23, 32]. These studies investigated the impact of core stability training on speed, anaerobic power and agility of volleyball players. The results showed that stability exercises improve volleyball players speed, anaerobic power and agility of agility and high speed, and having the right anaerobic capacity in the execution of techniques and consecutive rallies in volleyball, is a fundamental factor. Since the speed of throwing a ball is very high in volleyball, having agility and speed in implementing defensive and offensive techniques is very important for a volleyball player. Therefore, as the results of the present review show, core stability exercises can improve these vital factors in volleyball players.

Impact of CSE on kinetic and kinematic variables of volleyball players

About impact of CSE on kinetic and kinematic variables of volleyball players, there were five studies [25, 28, 30, 33, 35]. These studies investigated the impact of CSE on the jump-landing pattern, landing mechanism, trunk and trunk kinematics, kinetic and kinematic variables, as well as biomechanical analyzes. The results showed that core stability exercises correct and improve the kinetic and kinematic variables of the trunk and lower limbs of volleyball players. Because many jumps and landings occur in volleyball, it is essential to consider the mechanism and patterns of jump and ford of volleyball players. Therefore, the results of the current review emphasize the impact of CSE on improving the jumping and landing patterns of volleyball players.

Impact of CSE on volleyball players athletic performance

About impact of CSE on volleyball players athletic performance, there were four studies [4, 28, 31, 33]. These studies investigated impact of CSE on the speed and ac-

curacy of service skills, athletic performance, and spike skills. As the results showed, CSE improve the athletic performance and skills of volleyball players. Only in the study of Tsai et al. [33], core stability exercises did not improve the athletic performance of volleyball players. Seemingly, the low number of subjects and the use of general tests to evaluate the athletic performance of volleyball players causes insignificance in this study. By improving balance, strength, endurance, agility, and other relevant factors in volleyball players, core stability exercises can improve their athletic functioning. The outcomes of the current review confirm this finding as well.

Impact of CSE on other movement capabilities of volleyball players

About impact of CSE on other movement capabilities of volleyball players such as proprioception, range of motion, flexibility, and breathing patterns, there were three studies [24, 26, 27]. These studies investigated the impact of CSE on proprioception, range of motion, flexibility and volleyball players breathing rate. The results of these studies show that core stability exercises can improve relevant variables in volleyball players. Some core stability exercises are necessary to control the lumbopelvic chain, which causes breathing control in performing the movements accurately in these exercises and improves the breathing rate and the function of the diaphragm muscle.

Of course, caution need to be taken in order to interpret the conclusions of the current study, considering the restrictions. Such as the difference in the number of samples under study, measurement methods, and components of different core stability protocols. However, these outcomes can assist sports teachers, coaches, therapists and physiotherapists to enhance the movement capabilities of volleyball players. Comprehensive researches are necessary. Limitations in the studies: 1. No research investigated the durability of the impact of the exercises after the completion of the follow-up exercise period. Consequently, in the future researches, after the follow-up exercises, examining the effect of their durability is necessary for several weeks. 2. Most of the studies did not clearly explain the method of blinding and preventing bias in the research. 3. They did not clearly state the training environment and supervising these exercises. 4. Finally, all the studies reported in the current review were at a low level in terms of quality according to Pedro's scale. Therefore, future studies should conduct high-quality research with accurate reports so that we can see the effectiveness of the studies, the improvement of the balance and endurance of female athletes.

5. Conclusion

The outcomes of current review show that CSE can improve movement capabilities, performance, and sports skills as well as prevent injuries from volleyball players. Because of the diversity of its movements, we can easily level the core stability exercises according to the level of the players for achieving their training goals.

Ethical Considerations

Compliance with ethical guidelines

There were no ethical considerations to be considered in this research. This article is a systematic review with no human or animal sample.

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Authors' contributions

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Conflict of interest

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