Research Paper: The Relationship Between Core Endurance and Performance in National Female Badminton Athletes

Hemn Mohammadi[1*], Jalil Fathi[2]

1. Department of Physical Education and Sport Sciences, Faculty of Humanity Sciences, University of Kurdistan, Sanandaj, Iran.
2. Department of English Literature & Linguistics, Faculty of Literature and Foreign Languages, University of Kurdistan, Sanandaj, Iran.

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ABSTRACT

Purpose: A theory states that strong core stability allows athletes to fully transfer forces from the upper extremities to lower extremities, and finally to the ground. On the contrary, weak core stability causes alterations in transferring forces, reduces sport performance, and increases risk for injury, especially in the lower extremities. Therefore, the current study investigated the relationship between core endurance and performance in professional female badminton athletes.

Methods: To examine the aforementioned relationship, badminton athletes invited to the 2017 Youth National Team camp (n=16, Mean±SD age=14.9±1.2 y, height=163.0±4.5 cm, weight=57.8±4.3 kg) completed core endurance and performance tests. Badminton athletes performed 5 performance tests (Y balance, vertical jump, 20 m sprint, 4×9 agility, and single-leg triple crossover hop tests), and 4 core endurance tests (trunk flexor, trunk extensor, and bilateral side bridge tests).

Results: Data analysis indicated significant correlations between core endurance and balance (r=0.52, P=0.04), as well as between core endurance and triple crossover hop test (r=0.63, P=0.01); however, relations between core endurance and other performance tests (vertical jump, 20 m sprint, agility) were not statistically significant.

Conclusion: Considering the significant correlations between core endurance and balance and triple crossover hop test, it is suggested that personal trainers, coaches, and badminton athletes use the core stability exercises to improve balance and single-leg cutting maneuver. As a result, the chance of non-contact lower extremity injuries caused by the loss of balance or those occurring during cutting movement will be reduced.

* **Corresponding Author:**
Hemn Mohammadi, PhD.
Address: *Department of Physical Education and Sport Sciences, Faculty of Humanity Sciences, University of Kurdistan, Sanandaj. Iran.*
Phone: *+98 (913) 6240282*
E-mail: *hemn.m.64@gmail.com*

Highlights

- There was a significant correlation between core endurance and balance in professional female badminton players.
- A significant correlation also existed between core endurance and athletic performance such as triple crossover hop test.

Plain Language Summary

The purpose of this study was to examine the relationship between core endurance and athletic performance in professional female badminton players. The results revealed significant correlations between core endurance and balance, as well as between core endurance and triple crossover hop test. Nevertheless, no significant relations were found between core endurance and other performance tests. The implications of this study might suggest that personal trainers, coaches, and badminton athletes employ the core stability exercises to enhance balance and physical performance.

1. Introduction

It is estimated that the participation rate in badminton has increased by 22% from 2006 to 2016 [1]. Modern adaptations of the traditional rules, like reduction in badminton court sizes, and other factors such as jumps, lunges and unanticipated changes of direction and acceleration have turned badminton to a fast-paced sport maneuvering from mid-court to both court sides, forward, and backward to execute shots. These moves make the ankles, knees, and hip joints of badminton athletes go through flexed and extended positions [1, 2]. Badminton is performed on a hard surface; therefore, athlete's joints may be subject to high ground reaction forces [2]. During a single-leg landing, knee valgus moment increases in badminton athletes with weak trunk flexion and these conditions predispose them to ACL injury [3]. For these reasons, 63.1% of injuries occur in the lower extremities (especially the knee [37.1%] and ankle [28.3%]) in badminton [1].

Badminton requires good balance and agility; the relationship between agility and performance during a badminton game is r=0.83 [4]. Approximately 50% of injuries in badminton have occurred in females from 2001 to 2016 [1]. Players aged 5 to 18 years comprised the largest age group (58%) and most injuries (40%) occurred in schools/public properties. Strains/sprains were the most frequent sustained injuries (45%). Injuries most prevalently occurred in the trunk (56%) and lower extremity (69%) [1]. Badminton players aged 5 to 18 years had a higher risk of fractures and lacerations, than those of any other age groups [1]. The turning (34.4%), followed by general movements (22.5%) were the most common mechanisms of badminton injuries, compared to lunging (10.9%) or landing from jumps (7.3%) [5].

Core muscle endurance and stability have attracted much attention within the last 3 decades in respect of sports injuries prevention, as fitness and sports training. The scientific foundation of traditional core stability exercise has recently been questioned, particularly in sports performance. A strong core zone enables an athlete to completely transfer ground reaction forces from the lower extremities to the torso, and ultimately to the upper extremities. Weak core zone reduces sports performance and increases risk for injury. Increased core strength and endurance may improve sports performance [6, 7].

Many studies have investigated the effect of core stability exercises on performance in different sports. Tse et al. argued that an 8-week core stability training program resulted in no significant changes in any performance tests among college-age rowers [8]. Stanton et al. also demonstrated that core stability exercises do not significantly improve physical performance in high school football and basketball athletes [9]. Additionally, the results of core stability exercises on high school-aged swimmers' performance indicated that their core strength significantly increased, but their performance did not significantly change [10].

Similarly, Ozmen and Aydogmus revealed that core strength training contributed to significant improvements in dynamic balance and agility among adolescent badminton athletes [11]. It seems that in many sports, such as football and basketball [9], swimming [10], and rowing [8], core stability exercises have no significant effect on athletic performance; however, in sports like badminton, core stability exercises can significantly improve athletic performance [11]. Therefore, there seems to be a significant relationship between performance and core stability in badminton, and this was the main hypothesis of the present study. Data are conflicting about the relationship between performance and core stability. Although Nesser et al. demonstrated no relationship between football athlete performance and core stability in national collegiate athletes [12], Sharrock et al. suggested a significant correlation between the core stability and performance [13].

Few studies have investigated the role of core endurance in performance among professional female athletes, although numerous studies have investigated the importance of core stability [14, 15]. Therefore, the present study investigated the relationship between core endurance and various performances among high school female badminton athletes.

2. Materials and Methods

Sixteen national youth badminton team athletes (2017) (Mean±SD age=14.9±1.2 y, height=163.00±4.5 cm, weight=57.8±4.3 kg) were tested at the central lab of Physical Education and Sports Sciences in Shahrood University of Technology. Table 1 presents the obtained descriptive data. All of the participants provided a written informed consent prior to testing and completed an injury history form. The athletes reported no orthopedic injury in the trunk, or lower and upper extremities over the last 6 months.

All badminton athletes performed 10-15 minutes of warm-up before joining any of the athletic testing stations. Balance, power, speed, and agility are the 4 main components in badminton and most sports. The examiner explained the testing procedure and the proper technique to perform the tests. The athletes were given a practice trial for each test to understand how to perform the test correctly. Following the practice trial and before the first recorded performance, a 4-minute rest period was given to the participants. Athletes completed each testing procedure for 3 times. All tests were performed in a random order, except for the core endurance tests, due to the fatiguing nature of those [12]. Age, weight, and height were recorded prior to session one.

The performance tests consisted of Y balance, vertical jump, 20 m sprint, agility, and single-leg triple crossover hop test (Figure 1). To assess the dynamic balance of athletes, Y balance test was used. Moreover, to normalize excursion distances, leg length test was employed. Reach directions were measured by fixing 3 tape measures to the floor, one in an anterior direction and two (posteromedial, posterolateral) aligned at 135 to the anterior direction. Dominant leg was used to assess reaching distance as far as possible in each of the 3 directions [16, 17].

The vertical jump test was performed to assess power. The athletes were requested to jump as high as possible; then, they were given one trial practice to perform the technique. If the athlete performed the procedure correctly, the score was recorded [18]. To measure the distance of hop test, a tape measure with approximately 6 meters of length was fixed to the ground. In the single-leg triple crossover hop test, the athletes were asked to perform 3 crossover hops on one leg. The athletes were also requested to control and hold the landing of the third hop for 3 s. The final score of the single-leg triple crossover hop test was equal to the sum of the distance of the 3 hops [19].

The 20 m sprint test was applied to measure the speed. The athlete needed to accelerate quickly to top speed to cover the course as fast as possible. When the athlete crossed the finish line, the test was terminated and timing was recorded via a digital stopwatch [20]. To assess core endurance, the protocol established by McGill was used. In this protocol which consists of trunk flexor, trunk extensor, and bilateral side bridge tests (Figure 2), the athlete holds a static position for as long as possible [21].

A digital stopwatch was used to measure the time duration (in seconds) that the participants were able to hold each static position. The athletes laid on their side with their legs extended on a table for performing the side bridge test (left and right sides, individually), resting on their forearm, then they were asked to lift their hip off the table. The uninvolved arm was held across the chest with the hand placed on the opposite shoulder. The test was terminated when the straight body position could no longer be maintained. In the trunk flexor test, athletes were seated with their back resting against a wedge and maintained a 60˚ flexion horizontally on the table.

Both knees and hips joints were flexed 90˚, the arms were folded across the chest and the feet were stabilized by the researcher. The examiner pulled back the wedge for approximately 10 cm; then, the athlete held the isometric posture of torso as long as possible. If any parts of the athlete's back touched the wedge, failure was determined. For performing the trunk extensor test, the athlete lied in a prone position on a table and upper body was cantilevered out over the end of the table. Athlete maintained a horizontal body position and the arms were held across the chest while lower extremities were stabilized. The test was terminated when the upper body dropped below the horizontal position [21].

3. Results

After ensuring the normality of obtained data, multiple bivariate correlations represented by Pearson's correlation coefficients, were conducted to examine the relationship between core endurance and performance. Descriptive statistics were performed for all data. The data were analyzed by SPSS. The significance level was set at P<0.05. A number of significant correlations were identified between core endurance and performance measures. The Mean±SD scores of endurance and performance variables are listed in Table 2. Correlations between core endurance variables and core endurance, as well as performance variable correlations are listed in Tables 3 and 4. Figure 3 shows the linear and quadratic regressions of total core endurance and total Y balance test, as well as linear and quadratic regressions of total core endurance and triple crossover hop test.

4. Discussion

Investigating the effect of core stability exercises on performance revealed that this exercise could significantly improve dynamic balance [22-25]. Sandrey and Mitzel (2013) suggested that a 6-week core stability training program significantly improved dynamic balance in high school track and field athletes [22]. Ibrahim Hassan also demonstrated that an 8-week core stability training program significantly improved the dynamic balance and performance level of smash stroke in young badminton players [24]. In addition, Rajiv Sighamoney et al. indicated that core stability exercises significantly increased (P=0.02) dynamic balance and agility among badminton players [25]. Therefore, balance and core stability may be correlated in badminton.

We investigated the relationship between core endurance and performance in professional young female badminton athletes. The obtained results indicated significant correlations between core endurance and dynamic balance (r=0.52, P=0.04), as well as triple crossover hop (r=0.63, P=0.01). In addition, badminton is a non-contact sport and most of the lower extremity injuries in this sport occur due to the loss of balance. The achieved results revealed significant correlations between core endurance and balance (P=0.04). Thus, it seems that by improving core muscles endurance, young badminton players can prevent the majority of non-contact lower extremity injuries that occur due to the loss of balance [26].

Improving core muscle endurance cannot prevent upper extremity injuries in badminton players. This is because there are no significant differences in core stability (or balance) between athletes with and without upper extremity injury [27]. For this reason, lower extremity examinations (e.g. Y balance test) were used to assess performance in the present study. Furthermore, because of the significant correlation between core endurance and triple crossover hop, badminton players can prevent ACL injury by improving their core muscle endurance. When badminton players jump and land in the lateral direction, knee valgus movement is larger and the risk of knee injury is higher [28].

Improving core stability could lead to smaller displacement in the mediolateral center of pressure and center of mass. By Improving core endurance/stability, the motion at the level of the trunk and hip is controlled and significantly improves balance [29]. Moreover, improving core muscles, like other skeletal muscles, results in enhancing the ability of neuromuscular system to stabilize contractions in response to gravity and momentum and leads to improved synchronization of motor units [30]. Dynamic balance is the ability of the body to maintain position after disturbances [31, 32]. Having a stable spinal body posture can improve neuromuscular system ability to maintain position and dynamic balance control. In other words, a weak core or a defect in controlling the neuromuscular system can lead to the loss of dynamic balance [31, 32].

Overall, our obtained results suggested significant correlations between core endurance and balance; however, we found no significant relationships between core endurance and other performance variables (such as agility, sprint, and power). Core stability is a complicated concept that relates to different components, including endurance, strength, flexibility, motor control, and function [33].

Table 1. Descriptive characteristics of badminton athletes (Mean±SD)

Background (yr)	Age (yr)	Height (cm)	Weight (kg)	BMI (kg/m²)
7.0±1.6	14.9±1.2	163.0±4.5	57.8±4.3	21.7±1.3

PHYSICAL TREATMENTS

Figure 1. Balance and athletic performance test

(A) Performance tests of vertical jump, (B) Y balance, (C) single-leg triple crossover hop test, (D) 20 m sprint, and (E) agility

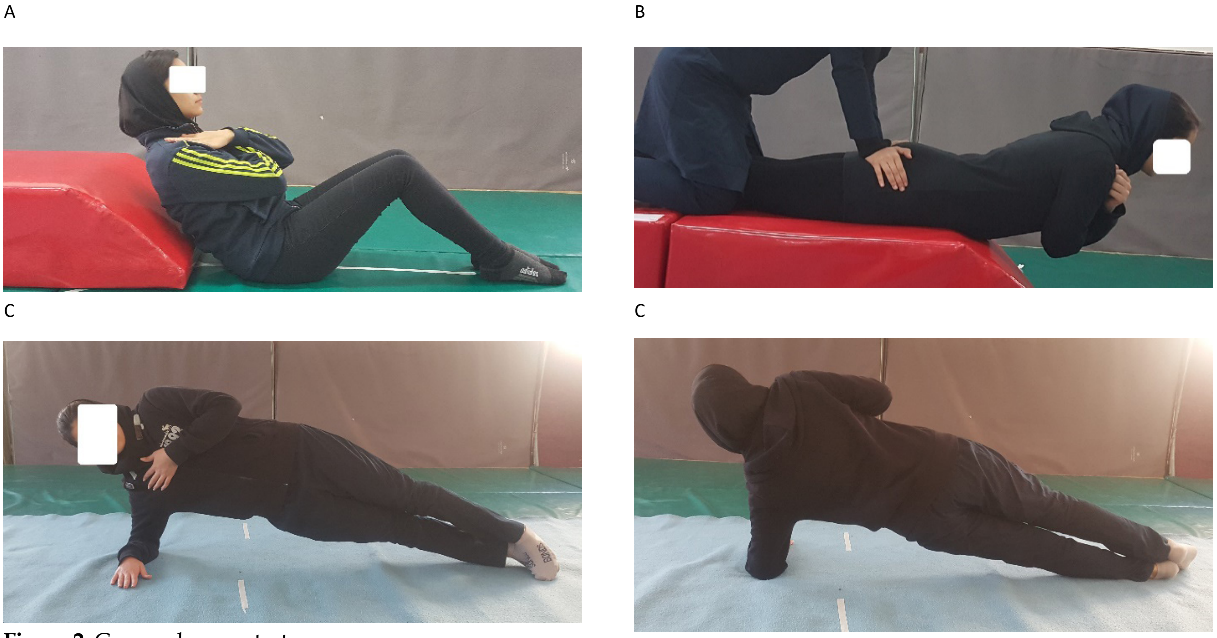

Figure 2. Core endurance test

(A) Core endurance tests of trunk flexor, (B) trunk extensor, (C) and bilateral side bridge

Table 2. Core endurance and performance variables (Mean±SD)

Performance Test		Core Endurance	
Triple crossover hop test (cm)	497.3±58.9	Total core	332.0±84.6
4×9 (s)	10.9±0.6	Left side bridge	50.3±17.5
20 m sprint test (s)	3.8±0.7	Right side bridge	46.9±18.3
Vertical jump test (cm)	32.7±4.2	Trunk extensor	97.3±23.9
Total Y balance test (cm)	99.9±9.2	Trunk flexor	137.4±44.3
Anterior Y balance test (cm)	82.1±8.1	-	-
Posterolateral Y balance test (cm)	93.4±58.9	-	-
Posteromedial Y balance test (cm)	84.3±10.4	-	-

PHYSICAL TREATMENTS

Table 3. Correlations between core endurance variables

Core Endurance Test	Left Side Bridge	Right Side Bridge	Trunk Extensor	Trunk Flexor
Left side bridge	1	-	-	-
Right side bridge	0.93**	1	-	-
Trunk extensor	0.64**	0.63**	1	-
Trunk flexor	0.63**	0.57*	0.19	1

*P<0.05, **P<0.01

PHYSICAL TREATMENTS

Thirsty-five tests used to assess the core stability (core endurance, flexibility, strength, neuromuscular control, and functional tests) were examined. The obtained data suggested that core endurance test group is the most reliable examination method for measuring the core stability, followed by the flexibility, strength, neuromuscular control, and functional tests, respectively [33]. For this reason, lower extremity tests (e.g. Y balance test) were used to assess performance in the present study.

To assess core endurance, McGill's tests were used in this study. These tests were designed to measure muscle

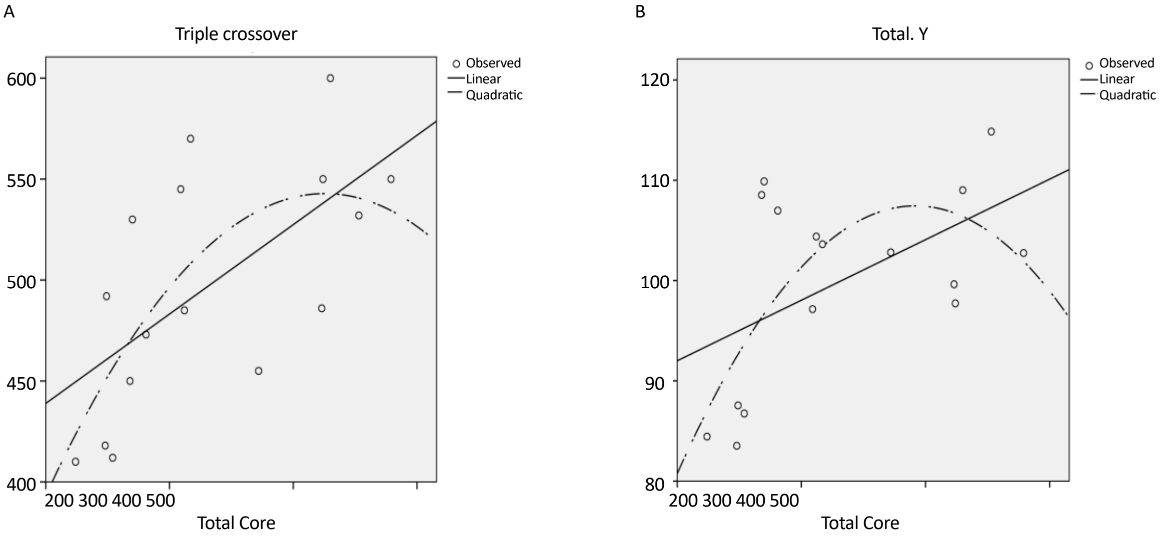

Figure 3. The correlation between core endurance and performance test

PHYSICAL TREATMENTS

(A) The regressions of core endurance and total Y balance test, and (B) the regressions of core endurance and triple crossover hop

Table 4. Correlations between core endurance and performance variables

Core Endurance Test	Total Y Balance Test		Vertical Jump Test		20 m Sprint Test		4×9 Agility Test		Triple Crossover Test	
	r	Sign	r	Sign	r	Sig.	r	Sign	r	Sign
Total core	0.52*	0.04	0.07	0.78	-0.27	0.30	-0.20	0.44	0.63**	0.01
Left bridge	0.52*	0.04	0.31	0.24	-0.26	0.32	-0.28	0.30	0.73**	0.01
Right bridge	0.61*	0.02	0.26	0.32	-0.20	0.45	-0.24	0.36	0.76**	0.01
Trunk extensor	0.14	0.60	0.17	0.51	-0.06	0.81	-0.36	0.16	0.50*	0.05
Trunk flexor	0.46	0.07	-0.18	0.49	-0.29	0.26	0.01	0.96	0.33	0.20

*P<0.05; **P<0.01

PHYSICAL TREATMENTS

core endurance. The weak or insignificant correlations between the core stability and other performance tests (such as agility, sprint, and power) might be due to the specificity of tests. The performance tests applied in this study were quick and explosive lasting less than 10 s that involved primarily fast twitch muscle fibers; however, the McGill's core endurance tests mostly focus on slow twitch muscle fibers. In-line with the results of Sharrock et al. another possible reason is that core endurance does not significantly contribute to athletic performance [13].

The obtained results indicated that triple crossover hop and dynamic balance are significantly correlated with core endurance. The role of core endurance in performance, as well as injuries prevention in badminton is important. Thus, further research is required to determine a definitive answer on the nature of this relationship. The obtained results could be helpful for coaches, players, and athletic trainers who are in contact with professional female badminton athletes.

Ethical Considerations

Compliance with ethical guidelines

All athletes read and signed a written informed consent before testing and completed a detailed injury history form. The study participants were informed about the purpose of research and its implementation stages; they were also assured about the confidentiality of their information. Moreover, they were allowed to discontinue participation in the study as desired. Finally, if desired, the results of the research would be available to them.

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Authors' contributions

Conceptualization, Methodology, Investigation, Resources, Data gathering, Writing – Original draft, Preparation, Project administration: Hemn Mohammadi; and Statistical Analysis, Language refinement and Editing: Jalil Fathi.

Conflict of interest

The authors declared no conflict of interest.

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