THE INFLUENCE OF A CORE FOCUSED HOME-BASED PROGRAM ON SHOULDER STRENGTH: EVALUATION ON BEACH VOLLEYBALL ATHLETES

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ABSTRACT – *Objective:* Despite the increasing interest in the use of core stability exercises in shoulder rehabilitation, the effects of this treatment on shoulder strength are still controversial, and literature is still lacking. Furthermore, no previous studies have analyzed the results of core stability exercises in beach volleyball athletes. The aim of our study is to evaluate the influence of a core-focused home-based program on shoulder strength in beach volleyball athletes.

Subjects and Methods: Sixteen beach volleyball non-professional athletes (7 males and 9 females, mean age 37.1 ± 6.5 years) were recruited and carried out a core stabilization home-based exercise program. The outcome measures evaluated before (T0) and after 4 weeks (T1) were shoulder isometric peak force in three positions (shoulder at maximal flexion, at 135° of abduction and at 90° of abduction and 90° of elbow flexion), left and right trunk rotation and countermovement jump. The shoulder isometric peak force was assessed using a dynamometer, whereas the oscilloscope was used to test the trunk rotation and countermovement jump (CMJ).

Results: The shoulder isometric peak torque values showed a statistically significant increase in all tests evaluated. Trunk rotation tests demonstrated a statistically significant increase in left speed and ROM and right ROM but not in right speed. No statistically significant differences were found in terms of countermovement jump.

Conclusions: This study demonstrated that a four-week core-based exercise program influenced shoulder strength, truck speed, and ROM in beach volleyball athletes. Further research is needed to make a core-focused program effective in improving the jump.

KEYWORDS: Range of motion, Trunk rotation, Overhead athlete.

INTRODUCTION

The mechanical link between body segments allowing the sequential transfer of forces and motions during dynamic tasks, like throwing or hitting, is known as kinetic chain[1].

The core muscles, placed in the middle of a kinetic chain system, are the regions in which forces are generated and transferred to the extremities of the body. The core includes abdominal muscles anteriorly, paraspinal and gluteal muscles posteriorly, the diaphragm muscle superiorly, and pelvic floor and hip girdle muscles inferiorly[1-3]. A good core function is essential in performing dynamic upper and lower limb movements.

A relationship between shoulder function and core through the activation of core muscles during upper extremity movements has been shown[4-7]. Muscular strength and endurance are required in the core area to maintain functional stability during glenohumeral movements.

One of the major goals in shoulder rehabilitation is the improvement of shoulder muscle strength[8]. Upper extremity kinetic chain exercises were introduced in shoulder rehabilitation programs with the aim of increasing the glenohumeral range of motion and scapular muscle strength through functional movement patterns[9].

Core stability training aims to provide muscular control of the lumbo-pelvic-hip complex, stabilizing the trunk while the upper extremity moves. Despite the increasing interest in core stability exercises in shoulder rehabilitation, evidence about their direct effects on shoulder strength is still debated[5]. Despite little evidence, many elite athletes perform core exercises in their training programs[4,5].

Overhead athletes perform complex movements in which coordination, muscle strength, flexibility, and neuromuscular control are required not only at the shoulder level but also around the lumbar spine. Most reported injuries are due to overuse caused by high joint stresses during overhead motions like "serve" and "smash"[8]. A well-functioning upper extremity kinetic chain might improve shoulder ROM and strength and decrease injuries.

It is still controversial which method should be used in overhead athletes to increase shoulder function. None of the previous studies evaluated the efficacy of a core stability home-based program in beach volleyball athletes.

The primary aim of our study was to evaluate whether a four-week home-based exercise protocol focused on core stabilization could enhance shoulder strength in beach volleyball athletes.

The secondary aim was to evaluate whether the same exercise protocol could influence trunk rotation speed, range of motion, and countermovement jump (CMJ).

The hypothesis was that a home-based program might have increased upper extremity strength.

SUBJECTS AND METHODS

Sixteen beach volleyball non-professional athletes (7 males, 9 females) were enrolled and evaluated at the FisioPoint Center (Rome, Italy).

The inclusion criteria were no history of upper limb, neck, or shoulder injuries and the absence of shoulder pain. All the athletes were considered eligible to participate and gave their written informed consent to get further with the study.

Athletes were evaluated at baseline (T0) and at 4-week follow-up (T1) and asked to add to their normal beach volleyball training a four-week home-based exercise program focused on core stabilization[8,9].

This home-based program consisted of isometric exercises to be performed in a static position (Figure 1) for the first two weeks and in a dynamic position (Figure 2) for the following two weeks. Exercises had to be performed three times per week.

Athletes were asked to fill out a diary to test their compliance with the home-based program, reporting the perceived intensity of the training during the exercises using the Rating of Perceived Exertion (RPE) scale, with a score from 0 (no effort) to 10 (maximum effort)[10].

Athletes were evaluated using specific instruments to measure shoulder isometric peak force, trunk rotation speed, and ROM. The countermovement jump test was also used.

The shoulder isometric peak force was assessed in three different positions with a dynamometer placed on the ventral aspect of the dominant wrist (Figure 3). The force was gradually increased until reaching the maximum voluntary strength over a 10-second period (the time duration for test assessment). The peak force obtained was measured and recorded in Newton (N).

Athletes were in standing positions, with open hands and feet in line with shoulders, and trunk forward compensation was not allowed. They were asked to push forward with the shoulder in maximal flexion, at 135° of abduction, and in the ABER position (90° abduction and elbow at 90° of flexion).

Trunk rotation ROM and speed were evaluated with an oscilloscope placed at the level of the mammillary line under the xiphoid process. The test was performed in a standing position with the hand behind the head and feet in line with the shoulders, and it was mandatory to keep the feet attached to the floor during the movements. Three repetitions at maximum ROM and speed for each side were performed, and the best value was recorded (Figure 4).

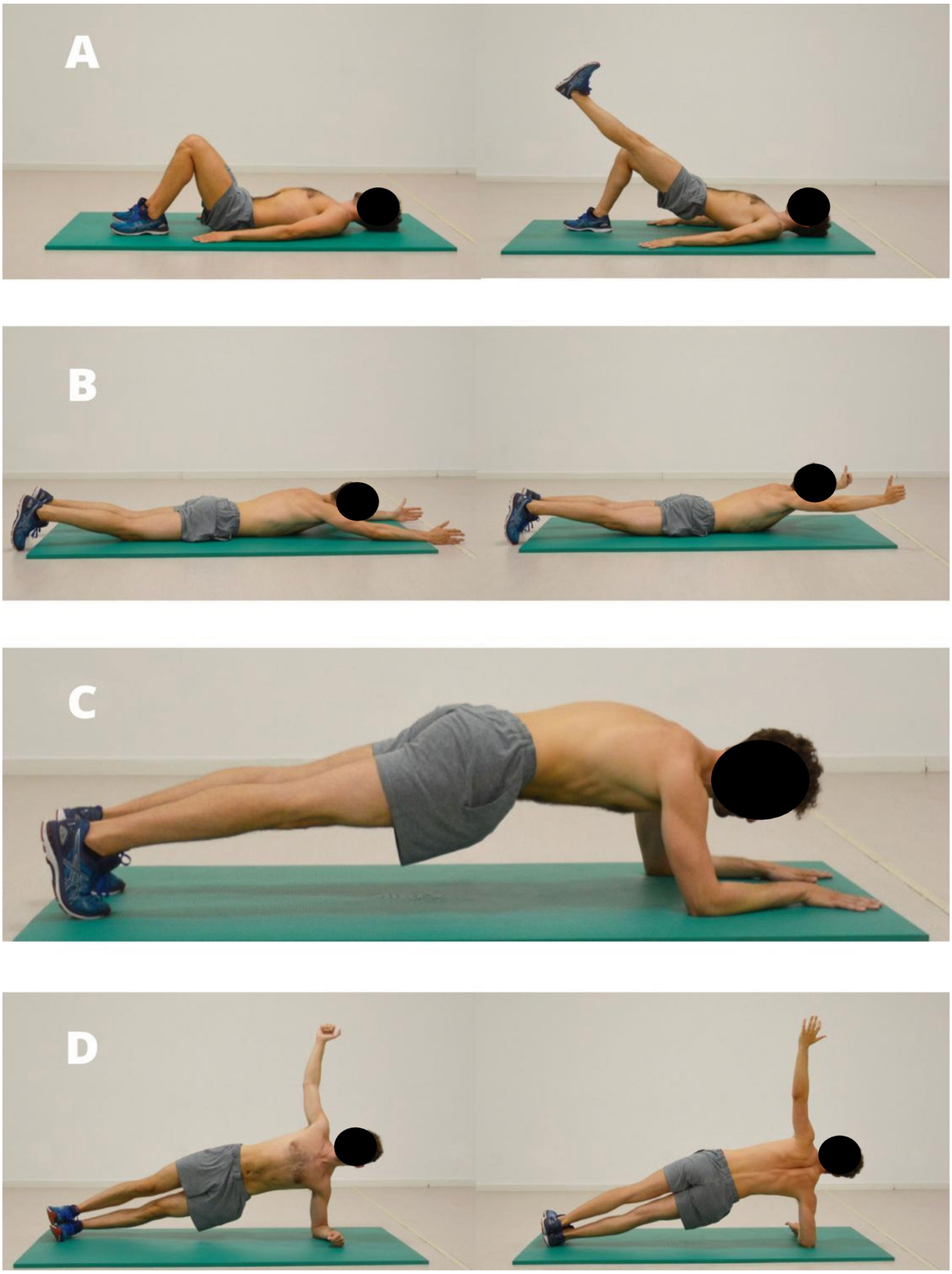

Figure 1. First- and second-week exercises. **A**, Monopodalic Bridge: the athlete was in a supine position with flexed knees. The athlete was asked to raise the pelvis, extend one leg, and hold this position for 15-20 seconds (2 series, 5 repetitions per side). **B**, Scaption: the athlete was in a prone position with arms extended and thumbs upward. The athlete was asked to contract the gluteal muscles while bringing the thumbs toward the ceiling for 8-10 seconds (2 series, 6-8 repetitions). **C**, Plank: the athlete is asked to lift the body on forearms and toes and keep the back straight with gluteal muscles contracted. The athlete was asked to hold the position for 45-60 seconds (4 series). **D**, Side Plank: the athlete was in a side-lying position. He was asked to lift the body on the forearm and foot while keeping the back straight and to hold the position for 30 seconds (2 series per side).

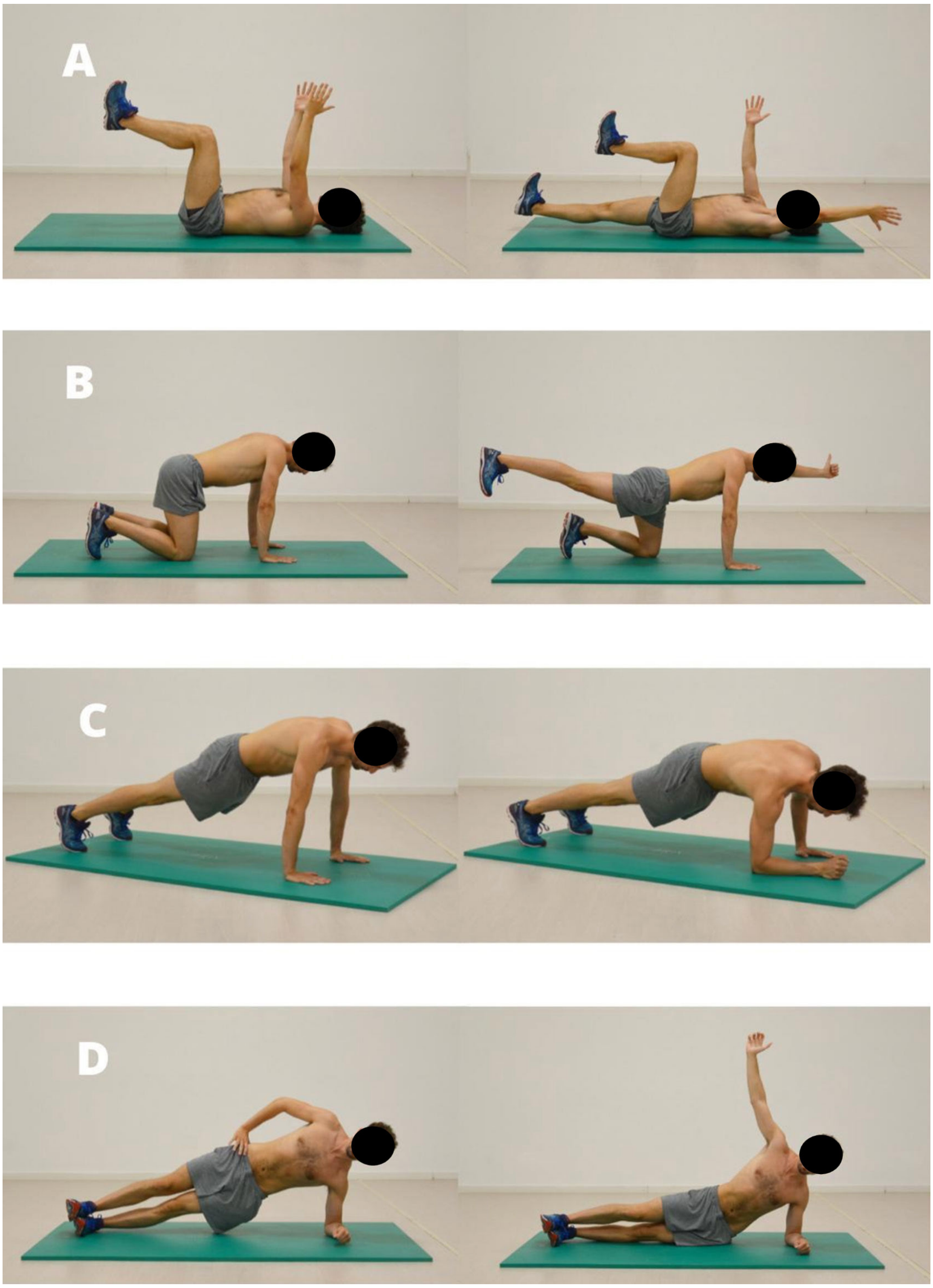

Figure 2. Third- and fourth-week exercises. **A**, Deadbug: the athlete was in a supine position with hip and knee flexed at 90°. The athlete was asked to extend one leg without touching the floor while extending the contralateral arm and came back to the starting position. Then, the same exercise was performed on the other side (4 series, 15-20 repetitions). **B**, Bird dog: the athlete was in a quadruped position with the arm in line with the shoulder. He was asked to extend one leg and the contralateral arm and then come back to the starting position. Then, the same exercise was performed on the other side (2 series, 20 repetitions). **C**, Dynamic plank: the athlete was in a prone position. He was asked to lift the body on his hands and toes. From this position, the athlete was asked to go first on one elbow and then on the other one, then return first on one hand and then on the other one in a dynamic movement (4 series, 10-12 repetitions). **D**, Dynamic side plank: the athlete was in a side-lying position. He was asked to elevate and depress the pelvis while lifting the body on the forearm and foot (2 series, 12-15 repetitions).

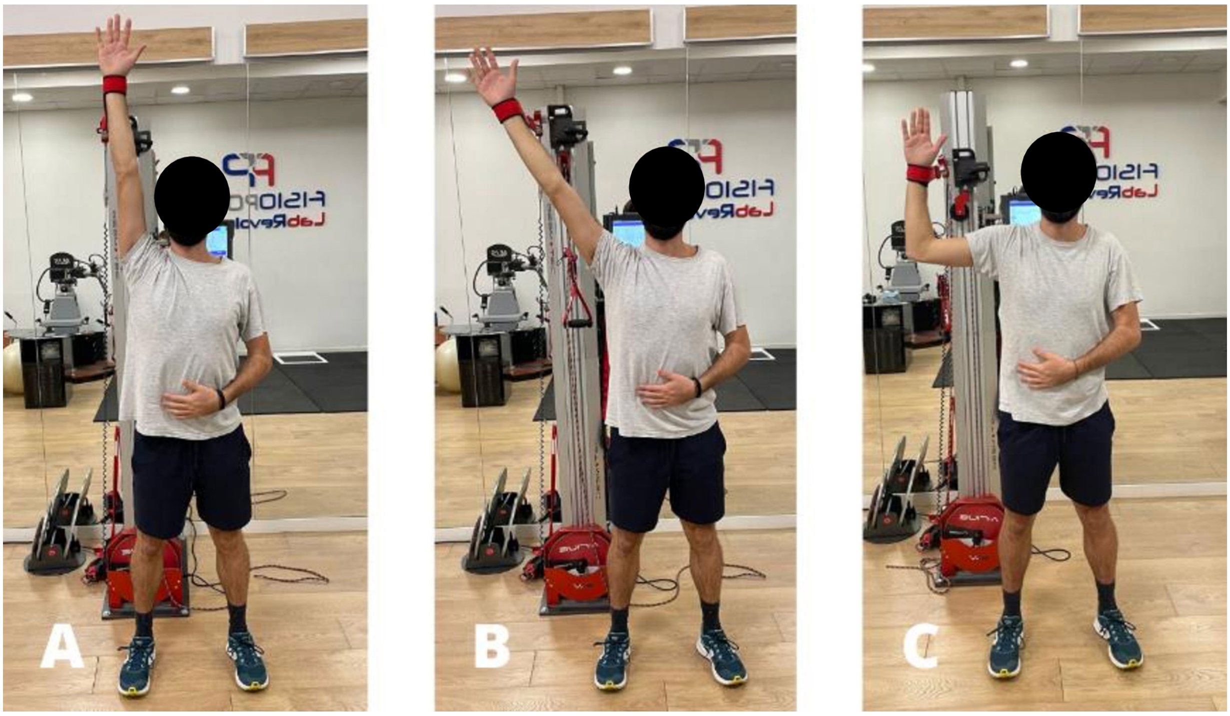

Figure 3. Shoulder isometric peak force. Maximal shoulder flexion (**A**); 135° of abduction with the elbow in extension (**B**); ABER position (**C**).

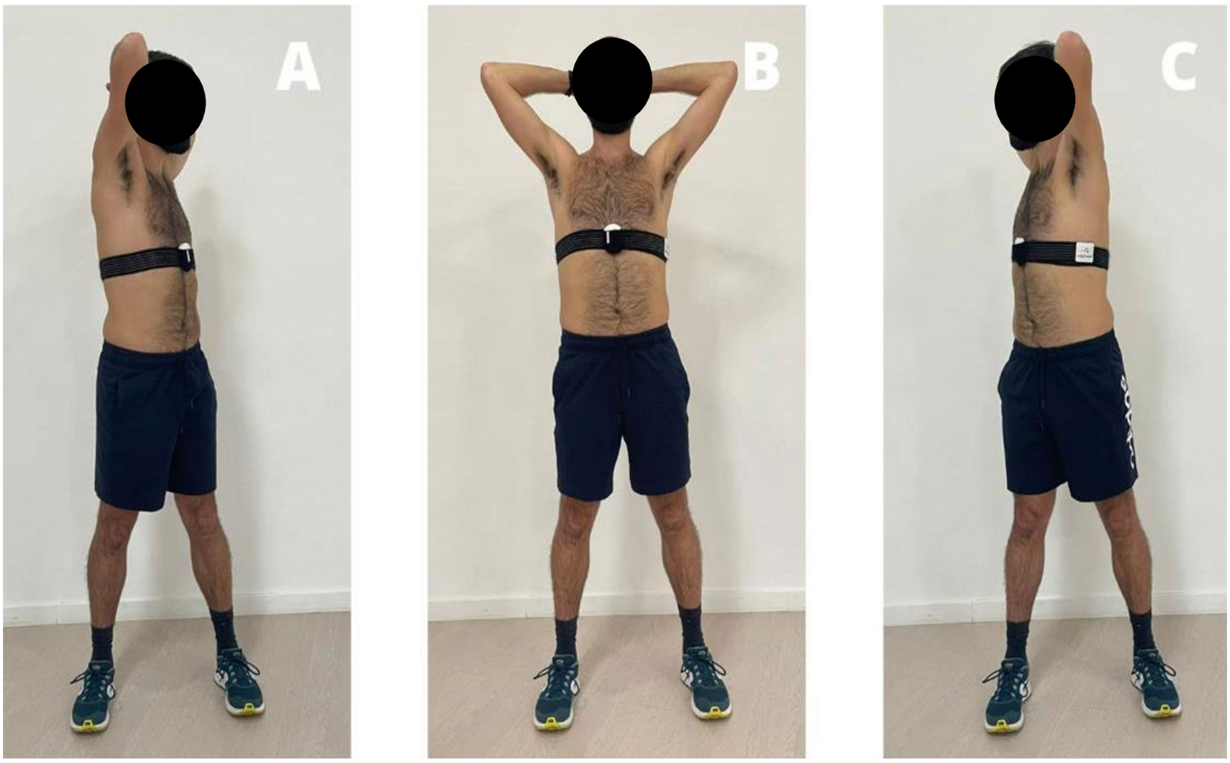

Figure 4. Trunk rotation assessment. Left trunk rotation (**A**); Starting position (**B**); Right trunk rotation (**C**).

The oscilloscope was also used to assess the countermovement jump test, in which both the explosive force (W*kg) and height (cm) of the jump were evaluated. The device was placed at the level of the mammillary line under the xiphoid process, and the test was performed in a standing position. The hands were at the level of the pelvis, and the feet were in line with the shoulders. A single repetition of the test was required, and values were recorded. The length of countermovement during the jump was not previously defined (Figure 5).

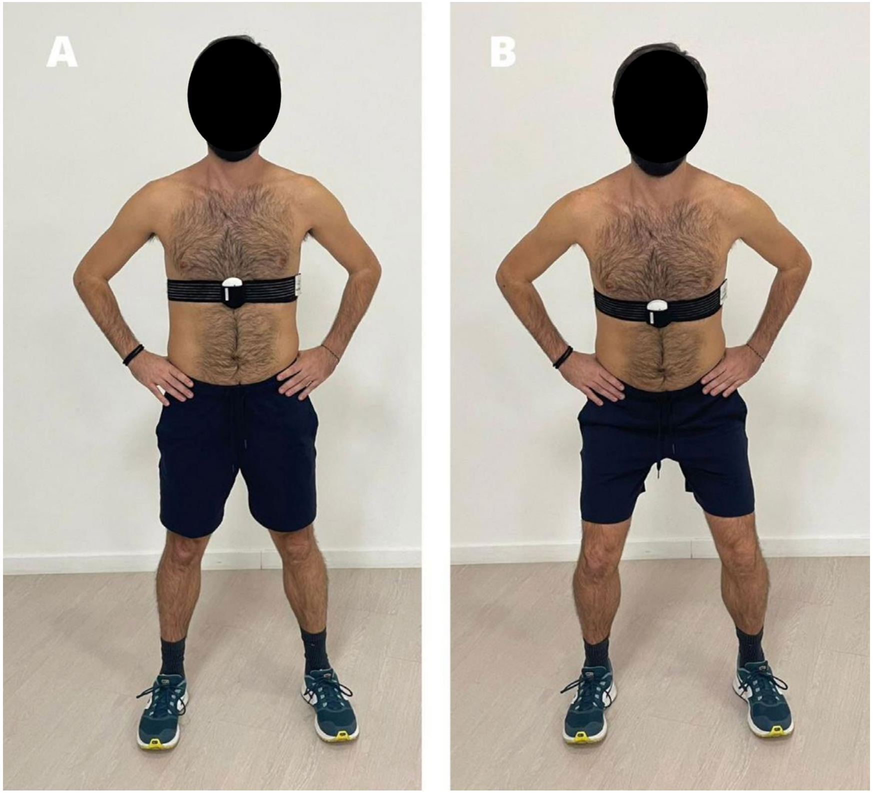

Figure 5. Countermovement jump test. Starting position (**A**); Countermovement position (**B**).

Statistical Analysis

Unpaired *t*-tests were used to compare parametric variables. Mean and standard deviation (SD) were calculated. A *p*-value of 0.05 was regarded as statistically significant. Excel (Microsoft, Redmond, Washington) was used to analyze the data.

RESULTS

All the athletes enrolled in this study completed the experimental design. The mean age, height, weight, and BMI were 37.1 ± 6.5 years, 178.5 ± 8.2 cm, 74.6 ± 13.1 cm, and 23.29 ± 2.55, respectively (Table 1).

Shoulder isometric peak force increased significantly in all the positions assessed, as shown in Table 2: in maximal flexion from 4.63 ± 1.33 to 6.46 ± 2.32 (p=0.000713), in 135° of abduction from 4.79 ± 1.39 to 5.76 ± 1.61 (p=0.000684), and in ABER from 5.45 ± 1.81 to 6.48 ± 1.82 (p=0.000378) (Table 2).

Trunk rotation ROM increased significantly on both sides. The mean left trunk rotation ROM increased from 108.25 ± 13.14 to 117 ± 9.87 (p=0.00403), whereas the mean right trunk rotation range of motion increased from 105.06 ± 11.54 to 117.93 ± 12.99 (p=0.00750).

Table 1. Demographics data of the athletes.

Variable	Mean value ± SD
Age (yrs)	37.1 ± 6.5
Height (cm)	178.5 ± 8.2
Weight (Kg)	74.6 ± 13.1
BMI (Kg/m^2)	23.29 ± 2.55

SD, standard deviation; BMI, body mass index.

Table 2. Shoulder isometric peak force assessment at baseline (T0) and at 4 weeks follow-up (T1).

Variable	T0	T1	*p*
Maximal Flexion (N)	4.63 ± 1.33	6.46 ± 2.32	0.000713*
135° of Abduction (N)	4.79 ± 1.39	5.76 ± 1.61	0.000684*
ABER (N)	5.45 ± 1.81	6.48 ± 1.82	0.000378*

T0 and T1 values are reported in mean value ± standard deviation; ABER: 90° abduction and 90° external rotation. *: $p < .05$. N: Newton.

Although left trunk rotation speed increased significantly from 256.19 ± 86.83 to 316.81 ± 41.65 (p=0.00522), right speed rotation did not show any significant difference, modifying from 262.95 ± 91.73 to 295.61 ± 55.95 (p=0.233) (Table 3).

Table 3. Trunk rotation ROM and speed assessment at baseline (T0) and after 4 weeks of follow-up (T1).

Variable	T0	T1	*p*
Left ROM (°)	108.25 ± 13.14	117 ± 9.87	0.00403*
Right ROM (°)	105.06 ± 11.54	117.39 ± 12.99	0.00750*
Left S. (rad/s)	256.19 ± 86.83	316.81 ± 41.65	0.00522*
Right S. (rad/s)	262.95 ± 91.73	295.61 ± 55.95	0.233

T0 and T1 values are reported in mean value ± standard deviation; ROM, range of motion; *$p < .05$. S: Speed.

The countermovement jump test did not show any significant difference either in explosive force or in height. The explosive force of the jump decreased from 58.31 ± 10.16 to 57.35 ± 10.16 (p=0.478), whereas the height of the jump increased from 33.57 ± 7.44 to 34.48 ± 6.57 (p=0.281) (Table 4).

Table 4. Counter Movement Jump (CMJ) assessment at baseline (T0) and after 4 weeks of follow-up (T1).

Variable	T0	T1	*p*
Explosive Force (W*kg)	58.31 ± 10.16	57.35 ± 10.16	0.478
Height (cm)	33.57 ± 7.44	34.48 ± 6.57	0.281

T0 and T1 values are reported in mean value ± standard deviation.

DISCUSSION

The most important finding of this study was that a core stability home-based exercise program seems to significantly improve shoulder strength in non-professional beach volleyball athletes. These results showed that increasing stabilization at the proximal level of a kinetic chain (e.g., core) also enhances the distal extremities (e.g., shoulder) performance and strength. This theoretically would increase athletes' performance and decrease the rate of shoulder injuries. That is particularly true as the greatest improvement is in the ABER position (p=0.000378), which is the one used to spike.

A direct correlation between core with both lower back pain and lower extremities has been well documented in the literature[1-3].

Reed et al[11] showed that patients performing core stability-specific training improved in strength assessments and athletic performance. Also, Silfies et al[7] underlined that there is a correlation between core stability, athletic performance, and injury. Furthermore, previous studies[4-6] have shown a correlation between core stability and shoulder performance through activation of core muscles during upper extremity movements

Although core stabilization exercises are frequently added in shoulder rehabilitation programs[12], there is still little evidence regarding the direct effect of core stability on shoulder muscle strength.

Our study evaluated whether there is a direct relationship between core stability and shoulder performance in overhead athletes. Shoulder stability and function are essential for increasing performance and reducing the incidence of shoulder pathology.

Although some studies have assessed the topic of overhead athletes, nothing has been carried out that has focused on beach volleyball players. Radwan et al[13] showed that greater shoulder dysfunction is correlated with greater core balance and stability deficiency. A recent systematic review by Cope et al[14] suggests that a greater lumbopelvic control is related to improved athletic performance and decreased prevalence of injuries in overhead athletes. Wilk et al[15] emphasized the importance of focusing on the shoulder rehabilitation process not only on the upper extremity segment but also on the stabilization of the entire kinetic chain. Endo and Sakamoto[16] showed that poorer lumbopelvic control may be associated with a greater risk of shoulder pain development. Surprisingly, Söğüt[17] found a negative correlation between lumbopelvic stability and overhead performance. This might have been due to the small sample size used.

Furthermore, our study showed the influence of a core-based training program on trunk rotation speed and ROM. Surprisingly, although left and right trunk rotation ROM and left rotation speed increased significantly, right speed rotation did not show any significant difference.

Most athletes were right-handed, and the dominant side trunk rotation speed of beach volleyball athletes is normally already well trained in order to perform the spike effectively, getting closer to the athlete rotation speed plateau. This might explain our results.

Different tests have been described to assess the athlete's vertical jump height and explosive lower-body power: the countermovement jump, the squat jump (SJ), and the drop jump (DJ)[18-22]. Electromyostimulation and training with Plyometric and whole-body vibration exercises have been shown to improve CMJ[23-26].

Our study tried without succeeding in demonstrating an association between a core-based training program and a better CMJ. The protocol should be integrated with more exercises focusing on the lower extremities to lead to better explosive force and jump height. However, this is the first study evaluating the CMJ with an oscilloscope.

Limitations

Several limitations of this study exist. A small sample size of healthy beach volleyball athletes was evaluated for a very short follow-up, and there was no control group. There was no supervision of the athletes during the 4 weeks, and this might have influenced the results.

As the athletes were assessed after a training program composed of both static and dynamic exercises, our results did not show which has a greater impact on shoulder strength. As the assessment was done after 4 weeks, it was difficult to define the optimal time frame for improvements to be observed.

This is the first study evaluating the influence of a core stability home base program on shoulder function in beach volleyball athletes. The protocol given to the athletes was simple and easy to perform, as no specific instruments were needed. This has demonstrated its efficacy in improving shoulder function, and therefore, physical therapists might use it with patients.

Although there seems to be a relationship between core training and shoulder function, our results should be taken with caution due to the small sample size and short follow-up. Higher-quality research with a larger sample size and a control group is needed to further support our results in improving shoulder strength. Further studies should also analyze whether core stabilization exercises are effective both in decreasing shoulder injuries and in improving the efficacy of shoulder rehabilitation after surgery.

CONCLUSIONS

This study demonstrates the efficacy of a core stability home-based exercise program in improving shoulder strength without succeeding in outlining the same results for all trunk rotation assessments and CMJ.

Overhead athletes and physical therapists may use the results of our study to implement the exercise training program with the aim of improving shoulder strength.

Conflict of Interest:

The authors declare no conflicts of interest.

Ethics Approval:

The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of Unicamillus University for studies involving humans (E00711-2022).

Informed Consent:

Informed consent was obtained from all subjects involved in the study.

Authors' Contributions:

Conceptualization, E.S., and G.D.G.; Methodology, E.G.d.S.; Investigation, E.R., C.G., P.B.; Writing–original draft preparation, E.G.d.S..; Writing–review and editing, F.F., C.T.

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