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The Effect of the 8-Week Core Stability Training Program on the Dynamic Balance of Squash Players

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ABSTRACT

Dynamic balance is an important component in the performance of squash athletes because the sport demands high levels of directional change, posture control, and stability. This study aims to analyze the effect of the 8-week core stability training program on the dynamic balance of BKMF FIKK UNM squash players. This study uses a quantitative design with a one group pretest-posttest design approach. The research sample amounted to 19 athletes who were determined using the total sampling technique. Dynamic balance measurements are performed using the Y Balance Test. The results showed that the average score of the Y Balance Test increased from 90.68 ± 1.04 in the pretest to 95.79 ± 1.16 in the posttest with an average difference of 5.11. The normality test showed normal distribution data with a pretest significance value of 0.08 and a posttest value of 0.20. The results of the paired sample t-test showed a t-value of 63.95 with a significance of 0.00 ($p < 0.05$) and an effect size value of 4.67 which was included in the category of very large effects. These findings suggest that core stability training programs are effective in improving the dynamic balance of squash athletes. The results of this study make a practical contribution to the development of a core stability-based physical training program to improve movement performance and support injury prevention in athletes. Further research is recommended using experimental designs with control groups as well as adding other exercise performance variables to reinforce the generalization of the findings.

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B. Acquisition of data;
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INTRODUCTION

Squash is a sport played with a racket that is characterized by high intensity, multidirectional movements, rapid changes in direction, and complex motor coordination (Murray & Hughes, 2016; Palgunadhi et al., 2025). Squash athletes are required to have optimal physical abilities, especially balance, agility, strength, and body stability to support technical performance during matches (Jones et al., 2018; Salem & others, 2025; Schoeman et al., 2014). Balance, especially dynamic balance, is an important component in squash because athletes must be able to maintain body stability when performing lunges, body rotations, and quick position changes in a limited playing space (Schoeman et al., 2014). The ability to maintain dynamic balance allows athletes to

effectively maintain body posture control, thereby improving movement efficiency and shot quality (Ricotti, 2011; Solanki & Gill, 2021).

Dynamic balance is an individual's ability to maintain body stability while performing movements that involve changes in position and shifts in the center of gravity (Bouisset & Do, 2008; Muladi & Kushartanti, 2018). Body balance is influenced by the integration of sensory systems involving the visual, vestibular, and proprioceptive systems that work synergistically in controlling body posture (Peterka, 2018). Dynamic balance plays an important role in supporting athletic performance because it is related to an athlete's ability to maintain body stability during activities that require rapid changes in direction. A decline in dynamic balance ability can cause movement coordination disorders and increase the risk of lower extremity injuries (Zemková & Zapletalová, 2022).

An important factor in maintaining dynamic balance is core stability (Barrio et al., 2022). Core stability is the ability of the neuromuscular system to maintain trunk stability during movement (Granata & England, 2006). Core muscles function as the center of energy transfer between the upper and lower extremities and play a role in maintaining spinal and pelvic stability during sports activities (Kibler et al., 2006). Good trunk stability allows athletes to maintain an optimal center of gravity, thereby increasing movement efficiency. In addition, core stability training is known to improve neuromuscular coordination and proprioceptive function, which play a role in maintaining body balance during dynamic activities (Borghuis et al., 2008; Gulrandhe & Kovela, 2023).

A previous study has shown that core stability training has a positive effect on improving balance and physical performance in athletes. Among other things, it shows that core stability training programs can improve postural stability and functional performance in athletes (Hibbs et al., 2008; Zemková & Zapletalová, 2022). Other findings confirm that trunk stabilization exercises effectively improve athletes' dynamic balance and movement coordination and contribute to improved postural control and balance ability in young athletes (Imai et al., 2014; Samson, 2005). Additionally, other studies have shown that improved trunk stability is associated with improved dynamic balance as measured by the Y Balance Test (Kang et al., 2015).

Although various studies have examined the effect of core stability training on dynamic balance, most studies have been conducted on general sports such as soccer, basketball, or non-specific athletic populations. Studies that specifically examine the effect of core stability training on dynamic balance in squash athletes are still limited. In fact, squash has different movement characteristics compared to other sports, especially in terms of the intensity of lateral movement, body rotation, and rapid changes of direction in a narrow playing space. In addition, studies examining the effect of core stability training on student squash athletes are still relatively rare, so further research is needed to strengthen the empirical evidence regarding the effectiveness of such training in the squash athlete population.

This study is based on the importance of developing specific physical training methods to improve the performance of squash athletes. Dynamic balance is an important component in supporting technical performance and preventing injuries in squash athletes. Therefore,

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this study is expected to contribute scientifically to the development of effective and evidence-based physical training programs. In addition, this study is also expected to provide practical contributions to coaches and athletes in developing more targeted and specific training programs in accordance with the characteristics of squash. Based on this background, the purpose of this study is to determine the effect of an 8-week core stability training program on the dynamic balance of squash athletes.

METHODS

Study Design

This study used a quantitative approach with a pre-experimental one group pretest–posttest design. This design was chosen because it aimed to determine the effect of the core stability training program on the dynamic balance of squash athletes by comparing their conditions before and after the treatment was given. In this design, all research subjects received core stability training intervention for a certain period, then were re-measured to see the changes that occurred.

Population and Sample

The population in this study was all squash athletes who were members of the BKMF Squash FIKK UNM. The sampling technique used was total sampling, whereby the entire population was used as the research sample. The research sample consisted of 19 squash athletes who actively participated in the routine training program. The total sampling technique was chosen because the population size was relatively small and all members met the inclusion criteria for the study, namely active athletes, no injuries during the study period, and willingness to participate in the training program for eight weeks.

Core Stability Training Program

The core stability training program is conducted over 8 weeks with a frequency of twice a week. Each training session lasts approximately 30–40 minutes, consisting of a warm-up, core exercises, and a cool-down. The intensity of the training is gradually increased by adding contraction duration, repetitions, and more complex exercise variations.

Table 1.
Core Stability Training Program

Week	Types of Exercise	Set	Duration/ Repetitions	Progression Description
1–2	Front Plank, Side Plank, Glute Bridge, Bird Dog	3	15–20 seconds / 10–12 repetitions	Core stability adaptation, lateral stability focus, coordination and postural control.
3–4	Front Plank, Side Plank Hip Abduction, Single Leg Bridge, Bird Dog Hold	3	20–30 seconds / 10 repetitions	Core muscle endurance, dynamic and unilateral lateral stability, neuromuscular control.
5–6	Plank Shoulder Tap, Side Plank Rotation, Single Leg Romanian Deadlift, Dead Bug	3	12 repetitions	Core stability and trunk rotation, limb coordination control.
7–8	Plank Leg Lift, Side Plank Reach Through, Single Leg Bridge Hold, Dynamic Bird Dog	3	30–35 seconds / 12–15 repetitions	Dynamic stability, rotational stability and coordination, pelvic stability and movement control.

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Y Balance Test (YBT)

The measurement instrument used in this study was the Y Balance Test (YBT) to measure athletes' dynamic balance (Greenberg et al., 2019). The Y Balance Test is an extension of the Star Excursion Balance Test, which has been proven to have high validity and reliability in measuring dynamic postural control and lower extremity stability. Measurements were taken in three directions of movement, namely anterior, posteromedial, and posterolateral, then the results were normalized based on the length of the athlete's limbs to obtain a composite score. In conducting the test, the athlete stood on one foot as a support, while the other foot reached as far as possible in the three directions. The reach distance was then measured using the Y Balance Test kit or manual measurement using a tape measure.

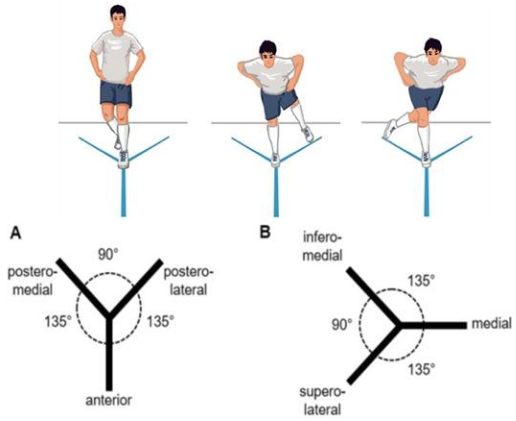

Figure 1.
Y Balance Test (Guo et al., 2021; Schwiertz et al., 2020)

The dynamic balance value is calculated based on the maximum reach distance in each direction and normalized by the athlete's leg length using the formula:

$$\text{Composite Score} = \frac{(\text{Anterior} + \text{Posteromedial} + \text{Posterolateral})}{3 \times \text{Leg Length}} \times 100$$

Previous studies have shown that the Y Balance Test has excellent reliability with an intraclass correlation coefficient (ICC) ranging from 0.85 to 0.93, making it suitable for use as a measure of dynamic balance in sports research (Shaffer et al., 2013).

Data analysis

Data analysis was performed in stages using SPSS statistical software. The analysis began with descriptive statistics to determine the mean, standard deviation, minimum, and maximum values of the dynamic balance measurements. Next, a prerequisite analysis test was performed, namely a normality test using the Shapiro-Wilk test to ensure that the data distribution was normal. After the data met the normality assumption, hypothesis testing was performed using the Paired Sample T-Test to determine the difference in dynamic balance values before and after the core stability training program. In addition, this study also calculated the effect size using Cohen's d to determine the magnitude of the effect of core stability training on improving the dynamic balance of squash athletes. The results of the data analysis were then interpreted to answer the research objectives that had been formulated.

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RESULTS AND DISCUSSION

Result

Sample Characteristics of Squash Athletes

Table 2.
Data summary of squash player gender distribution

Gender	N	Percentage (%)
Male	13	68,42
Female	6	31,58
Total	**19**	**100**

Table 3.
Data Summary Descriptive Statistics Physical Characteristics of Squash Athletes

Variables	Mean	SD	Minimum	Maximum
Age (years)	20,58	1,43	18	23
Height (cm)	171,84	5,21	163	180
Weight (kg)	64,21	5,28	55	72
Leg Length (cm)	89,16	3,40	83	95
Training Experience (years)	3,47	1,07	2	5

Based on the table above, there are 13 male athletes (68.42%) and 6 female athletes (31.58%) out of a total of 19 athletes (100%). The average age of the athletes is 20.58 years with a standard deviation of 1.43, a minimum age of 18 years, and a maximum age of 23 years. The athletes' height has an average of 171.84 cm with a standard deviation of 5.21, a minimum value of 163 cm and a maximum of 180 cm. The athletes' weight has an average of 64.21 kg with a standard deviation of 5.28, a minimum value of 55 kg and a maximum of 72 kg. The athletes' leg length had an average of 89.16 cm with a standard deviation of 3.40, a minimum value of 83 cm and a maximum value of 95 cm. The athletes' training experience had an average of 3.47 years with a standard deviation of 1.07, a minimum value of 2 years and a maximum value of 5 years.

Analysis of Research Results on the Effect of Core Stability Training on the Dynamic Balance of Squash Athletes

Table 4.
Summary of Descriptive Statistical Analysis Data, Assumption Tests, and Hypothesis Testing

Data group	Descriptive Statistics of Y Balance Test Scores				Shapiro-Wilk		Paired Sample T-Test			Effect Size
	Mean	SD	Min	Max	Statistics	Sig.	Mean Difference	t	Sig. (2-tailed)	Cohen's d
Pretest	90,68	1,04	88,63	91,94	0,91	0,08	5,11	63,95	0,00	4,67
Posttest	95,79	1,16	93,33	97,54	0,93	0,20				

Based on Table 4, the results of descriptive statistical analysis show that the Y Balance Test score in the pretest condition had an average value of 90.68 with a standard deviation of 1.04. The minimum value obtained by athletes in the pretest was 88.63 and the maximum value was 91.94. Meanwhile, after being given treatment in the form of a core stability training program for 8 weeks, the Y Balance Test score in the posttest condition showed an increase with an average value of 95.79 and a standard deviation of

1.16. The minimum value in the posttest was recorded at 93.33 and the maximum value was 97.54. These data show an increase in the average value of 5.11 points from the pretest to the posttest. Then, based on the results of the normality assumption test using Shapiro-Wilk, a statistical value of 0.91 with a significance value of 0.08 was obtained for the pretest data, while for the posttest data, a statistical value of 0.93 with a significance value of 0.20 was obtained. The significance value in both data groups was greater than 0.05, so it can be concluded that the pretest and posttest data were normally distributed. With the assumption of normality fulfilled, the hypothesis testing analysis could be continued using a parametric test, namely the paired sample t-test.

The results of hypothesis testing using a paired sample t-test showed a mean difference of 5.11, indicating a difference in the mean dynamic balance scores before and after the core stability training program. The t-value obtained was 63.95 with a significance value (Sig. 2-tailed) of 0.00. This significance value is smaller than the predetermined significance level (α = 0.05), indicating that there is a significant difference between the Y Balance Test scores before and after the core stability training program. In addition, the effect size calculation shows a value of 4.67, which is classified as a very large effect. This effect size value indicates that the core stability training program contributes significantly to improving the dynamic balance of squash athletes. Thus, the overall data analysis results show that the 8-week core stability training program is effective in improving the dynamic balance of squash athletes.

Discussion

The results of the study showed that the core stability training program had a positive effect on improving the dynamic balance of squash athletes. After participating in the training program, athletes demonstrated improved ability to maintain body stability when reaching in various directions. This condition indicates that core stability training can improve body posture control, movement coordination, and stability during sports activities that require rapid changes in direction. In squash, the ability to maintain balance when lunging, rotating the body, and shifting positions is an important factor in supporting technical performance and movement efficiency (Murray & Hughes, 2016). Good body stability allows athletes to maintain optimal body position when striking, resulting in more effective and efficient movements (Elphinston, 2008; Zemková & Zapletalová, 2022). Additionally, good dynamic balance also contributes to an athlete's ability to respond quickly to changes in the direction of the ball, thereby improving overall game performance quality (Falces-Prieto et al., 2022; Kozinc & Šarabon, 2021).

Theoretically, core stability is the ability of the neuromuscular system to maintain spinal and pelvic stability during movement (Muladi & Kushartanti, 2018). Core muscles function as a center for energy transfer between the upper and lower extremities, thus playing an important role in coordinating sports movements (Silfies et al., 2015). Core muscles include the abdominal muscles, lower back muscles, diaphragm muscles, and pelvic muscles, which work synergistically to maintain trunk stability. Optimal trunk stability allows the body to maintain its center of gravity efficiently during dynamic

activities. The theory of body segment stability also explains that trunk stabilizer muscles play a role in controlling intervertebral movement, thereby maintaining the integrity of the spinal structure during sports activities (Roth, 2019). Additionally, trunk stability also plays a role in enhancing the ability to transfer force from the lower extremities to the upper extremities during explosive movements, thereby supporting the effectiveness of athletic movements (Tomčić et al., 2021).

In the concept of postural control, body balance is the result of sensory information integration involving the visual, vestibular, and proprioceptive systems (Bronstein, 2019). The proprioceptive system plays a role in providing information about the position of the body in relation to the environment, enabling individuals to maintain dynamic balance. Core stability exercises are known to increase proprioceptor sensitivity through stimulation of muscle and joint receptors that play a role in body movement control (Hlaing et al., 2021). Improved proprioceptive function allows athletes to adjust their posture more quickly and accurately when faced with changes in movement direction. In addition, motor control theory explains that the improvement in neuromuscular coordination resulting from core stability exercises can increase movement efficiency and reduce unnecessary muscle activity, making movements more economical and stable (Bagherian et al., 2019). This is in accordance with previous studies showing that core stability training can improve dynamic balance in athletes through increased neuromuscular control of the trunk (Hlaing et al., 2021; Saki et al., 2023). Other studies have also found that core stability training has a positive impact on improving balance and postural stability in competitive athletes (Haugen et al., 2016). In addition, it significantly improves the functional performance and postural stability of athletes involved in sports that require multidirectional movements (Bagherian et al., 2019). These findings indicate that core stability training plays a crucial role in enhancing athletes' ability to maintain body balance during sports activities.

The results of this study showed that core stability exercises can be an important component of physical training programs for squash players. These training programs can help improve athletes' postural stability during complex movements that require a high level of balance. In addition, core stability training also has the potential to be used as an injury prevention strategy because it can improve postural control and lower extremity joint stability. Thus, the application of core stability training in athletes' training programs can provide dual benefits, namely improving athletic performance and reducing the risk of injury. Overall, the results of this study reinforce the concept that trunk stability is an important foundation in supporting athletes' movement performance. Core stability exercises have been proven effective in improving dynamic balance through increased postural stability, neuromuscular control, and movement efficiency. These findings contribute scientifically to the development of physical training methods, particularly in the sport of squash, and reinforce empirical evidence regarding the importance of trunk stabilization exercises in improving athletes' performance.

CONCLUSION

An 8-week core stability training program has been proven to have a positive effect on improving the dynamic balance of BKMF FIKK UNM squash players. The results of the study show that training focused on strengthening and stabilizing the core muscles can improve postural control, neuromuscular coordination, and the ability to maintain body stability when performing dynamic movements, which are the main requirements in squash. This improvement in dynamic balance indicates that core stability is an important component in supporting athletes' movement performance and has the potential to reduce the risk of injury due to postural imbalance. Therefore, the core stability training program can be recommended as part of the routine physical training of squash athletes to improve performance quality and physical readiness in competitions.

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