# THE EFFECTS OF 8-WEEK CORE STABILIZATION EXERCISES FOR FUNCTIONAL STATE IN HIGH-LEVEL ATHLETES

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**Annotation**

*The purpose of this study was to compare clinical results for functional state in high - level athletes before and after 8 - week core stabilization exercise program.*

*After analyzing the publications of many foreign authors, it can be stated that the exercises of core stabilization applied in conjunction with regular training have a positive effect for abdominal and back muscle static strength endurance, posture, neuromuscular control.*

**Keywords:** core stability, posture, neuromuscular control, high - level athletes.

**Introduction**

Core stability and neuromuscular control is a key factor in everyone's daily activities and even more in sports rehabilitation, training, and performance [4]. Stability provided by the muscles of the trunk is also identified as critical for whole-body dynamic balance. The waist, hip, and thigh, along with their surrounding muscles, are considered as the core parts of the body [8;10]. Regarding this anatomical position, the center of gravity is located in this area and the movements and transmission of force from the upper extremity to the lower extremity and vice versa, as the integral chain of motion of the human body, mainly result from this region; therefore, its stability is extremely important [2]. To maintain whole-body stability while sustaining and/or generating external forces, athletes require both strength and endurance in these muscles. The body is able to maintain balance in the centre of gravity by receiving information from the visual, vestibular, somatosensory senses [9]. The importance of core stabilization exercises in reducing the chance of injury and maximizing the quality of athlete performances become increasingly popular over the past decade. It has been suggested that strengthening the core muscles may improve balance [6]. Studies have reported that core strength may be related to balance; however, other studies have stated that further research is needed to determine the correlation. There is still a lack of literature on the effects of including core stabilization exercise in regular athlete training [1;3].Proper and stable posture is an indicator of biomechanical efficiency, muscle balance, and neuromuscular coordination. It develops on the correct morphological and functional basis [2].

**The aim of the research:**

To evaluate and compare abdominal and back muscles static strength endurance, posture and neuromuscular control of high - level athletes whose performed and non - performed 8 weeks core stability exercise.

**Methodology**

*Subjects:* 30 man and woman high level athletes volunteered to participate in the study. The characteristics of the subjects are presented in Table 1. Athletes were randomly divided into two groups. Control (N1) subjects (n = 15) trained regularly in their sports. For the study group (N2) subjects (n = 15), with the regularly sport program was applied 8 - week core stabilization exercise program 3 times a week for 45 minutes.

Table 1

Characteristics of the subjects

| Research groups | N1 (n = 15) | N2 (n = 15) |
|---|---|---|
| Age (x ±SD) | 24 ±5,8 | 24 ±6,2 |
| Weight, *kg* (x ±SD) | 74 ±10,3 | 77 ±8,6 |
| Height, *cm* (x ±SD) | 177 ±7,3 | 179 ±6,7 |
| Sex, *m/f* | 6/9 | 8/6 |

*Organization of the study:* An empirical study was conducted to compare the effect of 8 - weeks core stabilization exercise for high - level athletes. All results was recorded twice, i.y. before and after the 8 - week core stabilization exercise program. Purpose of the research and its benefits for the participants were explained before the research. In order to maintain a balance between the researcher's desire for objective information and the safety of the participants, the researcher undertakes to assess the information provided. All experimental procedures were performed in accordance with the Declaration of Helsinki, and all participants read and signed an informed consent form. The investigator undertakes to strike a balance between ethical issues such as dignity, privacy and confidentiality at the end of the investigation.

*Research methods:* According to McGill (1999) for the evaluation of trunk muscle static strength endurance two tests were chosen: abdominal muscle static strength endurance test and back muscle static strength endurance test. Abdominal muscle are evaluated when subject is lying on the back with the knee joints bent at 90 degrees and the hip joints at 45 degrees, with the arms relaxed and placed at the sides. During the test, the subject performs a bend, lifting the head, shoulders, approaching the knees with their hands. The upper part of the knee pads is touched with the fingertips. Efforts are made to maintain this situation for as long as possible.The test time is recorded with a stopwatch. The time is stopped when: the subject's fingertips lose contact with the patella, the shoulders reach the ground, the subject refuses to continue the examination, or severe pain occurs. Back muscle are evaluated when the subject is lying on pelvis. Straightening of the torso: the sternum is lifted from the couch through the hand, the arms are kept close to the torso. The subject maintains this position for as long as possible. The test time is recorded with a stopwatch and stopped when: the subject touches the ground in the chest, refuses to continue the test, or aggravates pain.

Selected to assess changes in tendencies to thoracic kyphosis and lumbar lordosis. Body posture was assessed using the DIERS 3D diagnostic system witch is one of the most modern spinal and posture diagnostic methods. The method allows photogrammetric video registration of the back surface using a raster stereography process. Based on the obtained data, a precise three-dimensional model of the back surface was created. The essence of the device is analysis of the back form. Taking anatomical and biomechanical assumptions of the model into account, it was possible to calculate permanent anatomic points, spine curvatures and parameters of spatial trunk forms. Parameters were analyzed in the sagittal plane. According to the recommendations the thoracic kyphosis must be 40 degrees, lumbar lordosis 30 degrees to be normal. Neuromuscular control was evaluated using HUBER® 360 Multiaxis Motorized Platform. Before testing on a special support is placed on the platform of the device to ensure the correct position of the feet. At the beginning of the test, the subject stood on the platform while holding arms along the body, feet shoulder-width apart, and legs slightly bent over the knee joints. During the movement of the platform, the subject needed to maintain balance and body masses at a point (center) on the screen of the center device without removing the feet from the platform. Natural and active pelvic movements reflected the maximum amplitude of movement of the body mass center, which was assessed during this test.

The research data were processed employing Microsoft Excel 2020 software for mathematical statistical analysis and all statistical analysis was performed using SPSS 22.0 software. The Wilcoxon criterion was used to compare the results of two interdependent samples. Results are presented as mean and standard deviation (x ± sn). The difference between distributions at $p<0.05$ was considered statistically significant.

**Analysis of results**

*Abdominal and back muscle strength endurance*

According to the recommendations of S. McGill (1999), the endurance ratio of abdominal and back muscles must be ≤1.0 for the results to be normal. The results of the study group N1 are presented in Figure 1. After the analysis of the data, it was found that in the group of subjects N1, when trained regularly in their sports there no significant ($p < 0.05$) change.

*Note: * - significant difference between results (p < 0.05).*

Increase abdominal muscle strength endurance (from 159 ± 7,7 s., to 160 ±7,5 s. *p=0,7*), back muscle strength endurance (from 150 ± 12,2 s., to 151 ± 11.9 s. *p=0,7*). Abdominal and back muscle endurance ratio before training - 1,06, after training also 1,06.

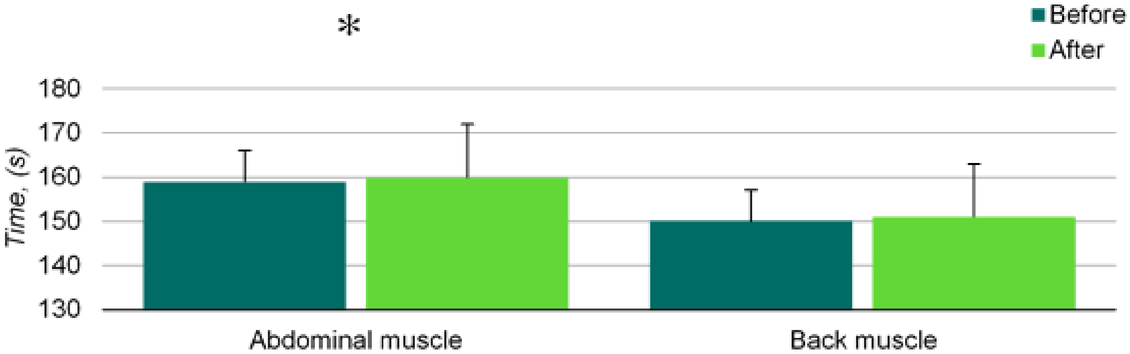


Fig. 1. Results of abdominal and back muscle strength endurance (N1)

The results of the study group N2 are presented in Figure 2. After the analysis of the data, it was found that in the group of subjects N2, when core stabilization exercise was applied with trained regularly in their sports there was significant ($p < 0.05$) change. Increase abdominal muscle strength endurance (from 162 ± 6,7 s., to 170 ±9,3 s., *p=0,00027)*, back muscle strength endurance (from 151 ± 11,4 s., to 163 ± 7,2 s.,*p=0,00046)*. Abdominal and back muscle endurance ratio before training - 1,07, after training 1,04.

*Note: * - significant difference between results (p < 0.05).*

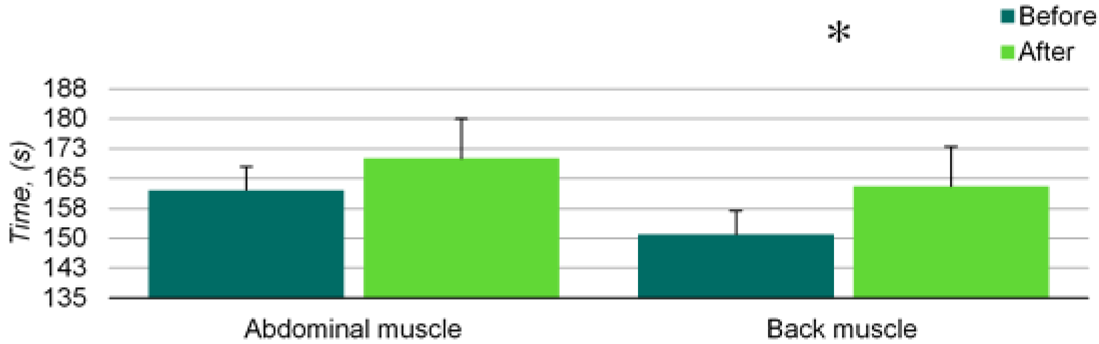


Fig. 2. Results of abdominal and back muscle strength endurance (N2)

Comparing the alteration of abdominal and back muscle strength endurance between the groups (Figure 3), it was found that the alteration after 8 - week of muscle strength endurance was significantly ($p < 0.05$) higher in the N2 subjects compared to the N1 subjects. Abdominal muscle strength endurance after 8 - week in group N1 is 1 ± 3 s. group N2 8 ± 4 s. Back muscle strength endurance in group N1 1 ± 3 s., in group N2 12 ± 3 s.

*Note: # - significant difference between groups (p < 0.05).*

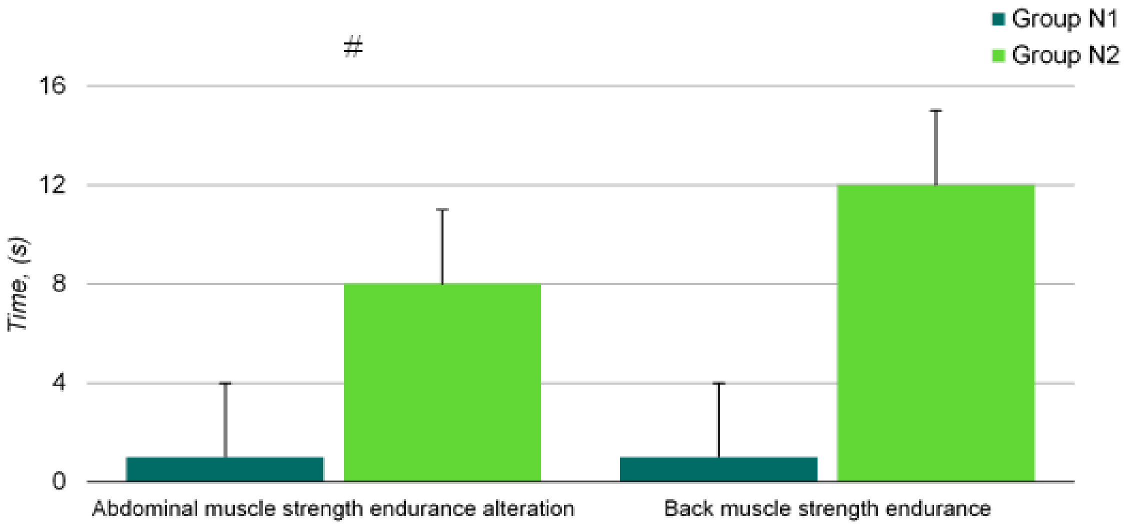


Fig. 3. Abdominal and back muscle strength endurance alteration

*Thoracic kyphosis and lumbar lordosis measurement results*

Valued high - level athletes thoracic kyphosis and lumbar lordosis measurement results according to the recommendations the thoracic kyphosis must be 40 degrees, lumbar lordosis 30 degrees to be normal. The results of the study group N1 are presented in Figure 4. After the analysis of the data, it was found that in the group of subjects N1, when trained regularly in their sports there no significant ($p < 0.05$) change. Thoracic kyphosis variation (from 43,2 ±°9,1 to 44,1 ±°8,6. *p=0,7*), lumbar lordosis variation (from 40,4 ±°5,9, to 40,9 ±°4,9, *p=0,8*).

*Note: * - significant difference between results (p < 0.05).*

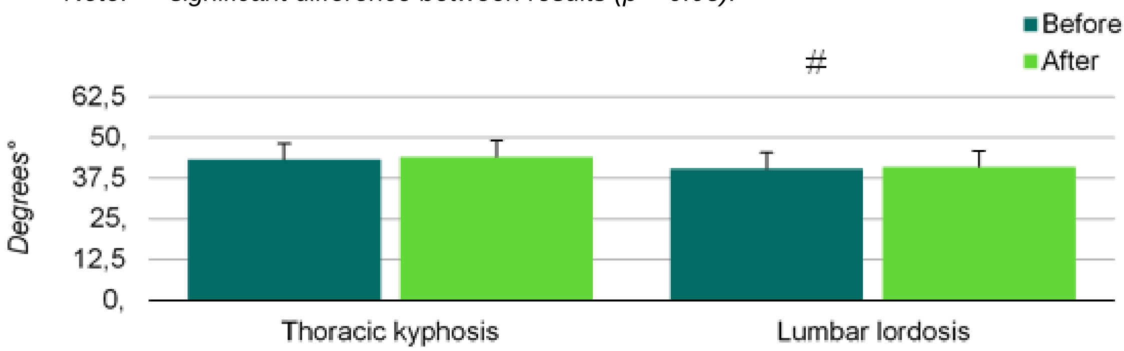


Fig. 4 Thoracic kyphosis and lumbar lordosis N1

The results of the study group N2 are presented in Figure 5. After the analysis of the data, it was found that in the group of subjects N2, when core stabilization exercise was applied with trained regularly in their sports there was significant ($p < 0.05$) change in thoracic kyphosis variation (from 46,1 ±°9,2, to 42,2 ±°6,6. *p=0,05),* but no significant in lumbar lordosis variation (from 40,3 ±°6,2, to 39,8 ±°2,8. *p=0,2*).

*Note: * - significant difference between results (p < 0.05).*

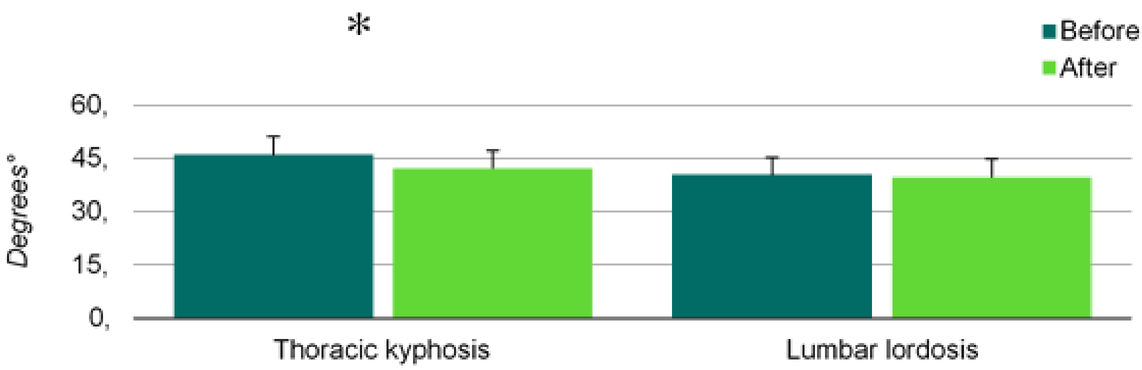


Fig. 5 Thoracic kyphosis and lumbar lordosis N2

Comparing the alteration changes in thoracic kyphosis and lumbar lordosis between the groups (Figure 6), it was found that the alteration changes in thoracic kyphosis was significantly ($p < 0.05$) higher in the N2 respondents compared to the N1 respondents (alteration N1 0,9 ± 2 , N2 9,3 ± 3), but no significant deferences between groups in lumbar lordosis alteration measurements (alteration in both groups N1 0,5 ± 3, N2 0,5 ± 3)($p > 0,05$).

*Note: # - significant difference between groups (p < 0.05).*

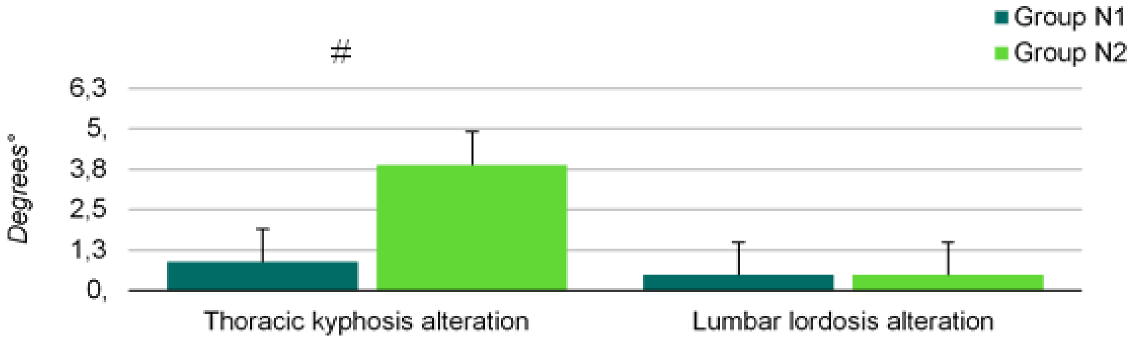


Fig. 6 Thoracic kyphosis and lumbar lordosis alteration

*Neuromuscular control measurement results*

Table 2 presents data on the alteration of neuromuscular control. Stability tests show fluctuations in the center of gravity, which indicates the ability to maintain a stable body position. The higher velocity, area, and length of the center of gravity of the body, shows the more difficult it is for the subject to maintain a stable body position. After evaluating the results of the study before and after the 8 - weeks of core stabilization training program, it was found that in both study groups better neuromuscular control results with open eyes standing on both legs. When evaluating the results between the groups, it was found that Group N2 shows significant ($p < 0,05$) better results that group N1 ( Table 2 see “alteration”). Group N1 shows better stability on right leg, meanwhile group N2 on left leg. After the results we can guess that in the first group more athletes dominate the right leg, in the second group - on the left. In group N1 significant increase ($p < 0,05$) only stability with open eyes length this means less fluctuation forward/backward. We found that in group N2 significant improve ($p < 0,05$) all neuromuscular control results except stability on left leg area ($p > 0,05$).

Table 2

Neuromuscular control results after 8 - week core stabilization exercise program

| Measurement | N1 | | | N2 | | |
|---|---|---|---|---|---|---|
| | Before | After | Alteration | Before | After | Alteration |
| ***Stability with open eyes*** | | | | | | |
| Length *(mm) (x±SD)* | 569,68 ± 100 | 532,43 ± 115* | 37,25 ± 12 | 606,91 ± 90 | 449,57 ± 85* | 157,34 ± 20 # |
| Area *(mm2) (x±SD)* | 280,00 ± 166 | 230,27 ± 109* | 49,73 ± 10 | 239,00 ± 134 | 180,27 ± 94* | 58,73 ± 15 |
| Speed *(mm/s) (x±SD)* | 11,40 ± 2 | 10,77 ± 1,7 | 0,63 ± 0,3 | 12,13 ± 1,8 | 10,13 ± 1,3* | 2 ± 0,5 # |
| ***Stability with close eyes*** | | | | | | |
| Length *(mm) (x±SD)* | 900,13 ± 237 | 880,14 ± 230 | 19,99 ± 35 | 1002,26 ± 202 | 829,22 ± 130* | 173,04 ± 45 # |
| Area *(mm2) (x±SD)* | 403,03 ± 182 | 398,44 ± 170 | 4,59 ± 15 | 314,35 ± 205 | 248,34 ± 178* | 66,01 ± 24 # |
| Speed *(mm/s) (x±SD)* | 18,00 ± 4 | 17,91 ± 3 | 0,09 ± 0,6 | 20,04 ± 4 | 17,89 ± 3* | 2,15 ± 1 # |

| Stability on right leg | | | | | | |
|---|---|---|---|---|---|---|
| Length *(mm) (x±SD)* | 1743,98 ± 152 | 1645,00 ± 145 | 98,98 ± 93 | 1759,44 ± 336 | 1498,32 ± 213* | 261,12 ± 99 # |
| Area *(mm2) (x±SD)* | 677,51 ± 371 | 600,23 ± 299 | 77,28 ± 78 | 1144,74 ± 580 | 988,32 ± 399* | 156,42 ± 89 # |
| **Stability on left leg** | | | | | | |
| Length *(mm) (x±SD)* | 1926,55 ± 410 | 1893,15 ± 357 | 33,4 ± 34 | 1813,31 ± 396 | 1456,36 ± 341* | 356,95 ± 101 # |
| Area *(mm2) (x±SD)* | 1032,24 ± 431 | 998,19 ± 411 | 34,05 ± 37 | 588,23 ± 133 | 520,23 ± 289 | 68,00 ± 55 # |

*Note: * - significant difference between results before and after 8 week core stabilization exercise ($p < 0.05$).*
*# - significant difference between groups ($p < 0.05$).*

**Discussion**

Functional, dynamic and integrated postural stability is a prerequisite for optimal movement and performance whether during activities of daily living in high - level athletes environment or in the recovery of neurology or orthopaedic patients [2]. Core stability is a broad construct that includes neuromuscular control, strength, power, and endurance [3]. The primary purpose of this study was to determine the effect of an 8 - week core stability program on abdominal and back muscle static strength endurance, posture and neuromuscular control of high - level athletes.

Torbatineshad et al. (2019) study results showed that the 6 - week exercises of core stabilization had a significant effect on the results of all the muscular endurance tests of the core body part of the subjects.The results of this study were consistent with the results of studies by Kokinda et al. (2019). In this study, stabilization exercises were applied for 8 - weeks. The researchers found that there was a significant increase in core muscle strength endurance in athletes after the intervention. Our study support these researchers hypothesis that after core stabilization exercise program significant increases abdominal and back muscle strength endurance.

Lower extremity injuries is common in professional sports. The hip and pelvic floor musculature serves as the base of support for the core. According to Hodges [5] synergistic activation patterns exist in pelvic and trunk controlling musculature. The hip musculature, with its large cross-sectional area, is involved with stabilization of the trunk as well as force and power generation during lower extremity movements in sports activities. Weak hip muscles and resulting alteration of hip/ trunk position are a common finding associated with knee injury in high - level athletes [10].

Core stability creates several advantages for interaction of proximal and distal segments in generating and controlling forces to maximise athletic function. The larger, bulkier muscles in the central core create a rigid cylinder and a large moment of inertia against body perturbation while still allowing a stable base for distal mobility [4]. Bagherian (2019) conducted a study to determine the benefits of core stabilization for dynamic stability in young athletes. They was found that an 8-week core stability training program enhances functional movement patterns and dynamic postural control in college athletes. The benefits are more pronounced in college athletes with poor movement quality. The results of our study confirm the results presented by Bagherian and co - authors (2019) that the core stabilisation exercise improves neuromuscular control. In Bagherian study athletes shows better results after core stabilization exercise during Modified Star Excursion Balance Test. We chose to evaluate using the HUBER® 360 Multiaxis Motorized Platform during the study and found that athletes undergoing core stabilization exercises demonstrated better stability both when opening and closing their eyes. Meanwhile, athletes who trained usually improved their stability results only with their eyes open. The importance of the neuromuscular system, as it pertains to the core, has been clarified through research specifically addressing muscle activation patterns during sports activities. It has been demonstrated that, in response to rapid arm movements, muscle activation patterns begin in the lower extremity and proceed upwards through the trunk and to the arm. This pattern of force development from the ground through the core to the extremity has been shown in tennis, baseball, and kicking activities [5;8]. The study found that athletes in group were training regularly shows better stability on right leg, meanwhile group with included core stabilization exercise on left leg. Whereas in the study we do not classify athletes according to sports, according to other research data we can say that in the first group more athletes have the right leg as dominant, in the second group the left. For example Ozmen (2016) finds in the study that football players who perform a Star Excursion Balance Test on a resilient leg show better results. Cook (2020) described the concept of alternating patterns of joint stability and mobility throughout the body that serves to enable functional activities and that loss of stability at one joint requires provision of stability at the adjoining segments. Researchers have demonstrated a similar analysis in pitching as there is a consistent pattern of muscle activation that begins with the contra-lateral external oblique and proceeds to the arm. The importance of core stability is further evidenced by findings that suggest the trunk and peri-scapular muscles are responsible for nearly 85% of the muscle activation required to decelerate the forward moving arm during throwing. These findings provide a basis for further research to evaluate the specific role of core stability in performance, injury, and rehabilitation [1;4]. Based on these associations, most rehabilitation and conditioning programmes for the knee now emphasise core stabilisation and hip strengthening [2;3]. Recent studies have shown that core stabilization exercise significant reduce possibility of injury for professional tennis players [9]. Many researchers point to the desirability of using postural reeducation exercises to improve balance through biofeedback on balance platforms [2]. Many researchers indicates a number of dependencies between body posture and postural stability parameters. Direct proportional correlations have shown that with the increase in posture stability, the values of postural variables also increased, which means that worse postural stability correlates with worse posture. Inverse proportional dependencies can be explained by the strategy of the hip joint, which causes the torso to tilt forward with the flexion of the hip joint [ 2;7;10]. After our study results evaluating it was found that core stabilization exercise significant increase thoracic kyphosis but have no significant results on lumbar lordosis. There may be several reasons for this, according to other researchers [2;5;9]: too short an intervention time and the specifics of the sport involved. An analysis of the study data and scientific literature suggests that core stabilization exercise can be integrated into a training program for high - level athletes to reduce injury probability and increase functional state.

**Conclusions**

High - level athletes shows significant better results on the abdominal and back muscle static strength endurance, posture and neuromuscular control after 8 — week core stabilization exercise program compare with non - performing group athletes.

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