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RESEARCH ARTICLE

The Effect of The Strength of The Center Muscles on Improving the Level of Technical Performance of Some Stability Movements on the Mat of Floor Movements

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Abstract
The purpose of this research was to determine whether some stability exercises performed on the floor exercise mat to increase core strength would improve the technical application level of students. Method: A sample of 39 young male students from a university (age = 22.1±1.2 years, height = 170.3±6.5 cm, weight 65.2±8.7 kg, Body Mass Index = 22.5±2.8) participated in the study. The participants were into the control group (n=19) and experimental group (n=20) completed pre-tests and post-tests. The CS was assessed by the Stability Movement Push-ups, Abdominals, Back, Pull-ups, Headstand. The results of the paired samples t-tests show that the experimental group had a significant improvement in the mean scores for all four movements on the post-test compared to the pre-test. The mean score for the push-ups increased from 4.9±1.2 to 7.5±1.3 ($t(14)=-10.78$, $p<0.001$), the mean score for the abdominals and headstand increased from 4.6±1.0 to 7.0±1.2 ($t(14)=-10.14$, $p<0.001$), the mean score for the back and handstand increased from 4.8±1.1 to 6.9±1.2 ($t(14)=-7.86$, $p<0.001$), and the mean score for the pull-ups increased from 4.7±1.0 to 7.3±1.1 ($t(14)=-11.47$, $p<0.001$). Since the p values of the four movements are lower than 0.001, it is seen that there is a statistically significant difference between the scores obtained in the pre-test and the scores obtained in the post-test. According to the results, working out the core muscles may help enhance the technical execution of stability exercises performed on the mat or floor.

Keywords
Center Muscles, Technical Performance, Stability Movements, Mat, Floor Movements

INTRODUCTION

Core stability (CS) is the ability to control the position and movement of the trunk over the pelvis; Therefore, it has an important function on postural control. Recently, exercises that strengthen and stabilize the core musculature have become part of conditioning programs for recreationally physically active individuals as well as competitive athletes. These exercises are often performed alone or in combination with body strengthening exercises under stable and unstable conditions. The intervention usually lasts 4 to 8 weeks; twice a week, lasting 25–45 minutes and 60–75 minutes when part of a warm-up. It is performed as part of the standard training program (**Kumar And Zemková, 2022; Sannicadro et al., 2017**).

Training programs that focus on improving core muscle strength, muscular endurance, and postural and core stability have also been found to improve functional movements and therefore athletic performance. While core strengthening exercises increase the activation of local stabilizers and global mobilizers and facilitate the transfer of muscle power, core stabilization exercises improve

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control of the lumbar spine. **Luo et al** (**2022**), A recent systematic review by also showed that overall movement control and force transfer to the terminal segment during athletic tasks can be optimized with core strength exercises; Therefore, they should be included in daily training routines.

Additionally, since these exercises provide stability to the core musculature for effective control of body movements and force production in the lower extremities, its deficiency or imbalance can increase fatigue and reduce muscular endurance, leading to greater susceptibility to injuries. In athletic environment, CS involves dynamically controlling and transferring large forces from the upper and lower extremities through the core to maximize performance and promote efficient biomechanics (**Cabrejas et al., 2022; Barr et al., 2007**).

Movements that need stability are an essential component of a wide variety of different types of physical activity, including sports, dance, and gymnastics. These motions call for a very high degree of coordination, as well as balance and the ability to maintain control over the body's center of mass. The body's weight is concentrated at the center of mass, which is found at the body's midline and corresponds to the place at where the center of mass is situated. The center of gravity and the center of mass are both names for the same location. A collection of muscles known as the center muscles is responsible for controlling the location of the center of mass. The transverse abdominis, the rectus abdominis, the internal and external obliques, and the erector spinae are all considered to be part of these muscles. These muscles are very important for the stabilization of the spine, the maintenance of posture, and the regulation of movement.

The link between the strength of the core muscles and the capacity to execute stability movements has been the subject of investigation in a number of different research. For instance, a research conducted by **Willardson et al.** (**2009**) discovered that a six-week training program that concentrated on strengthening the core muscles resulted to a considerable improvement in the execution of stability exercises among college-aged women. This finding was based on the participants' ability to execute the motions. In a similar vein, a research conducted by **Behm et al.** (**2005**) found that older people' stability and balance improved after participating in a training program that concentrated on strengthening the core muscles for a period of four weeks.

Previous study has indicated that strengthening the core muscles may enhance the performance of stability movements; however, there is currently a paucity of research on the particular influence that strengthening the core muscles has on the technical performance of stability exercises on the mat or floor motions. Moreover, the power of the core muscles is essential while doing different stability activities on the floor mat. The amount to which the strength of the core muscles impacts the technical execution of these motions, however, has not been well researched. As a result, there is a need to explore the influence of core muscle strength on the technical execution of stability exercises on the floor mat. Therefore, this research aims to evaluate the influence that the strength of the center muscles has on enhancing the technical performance of stability movements on the mat of floor exercises.

MATERIALS AND METHODS

Participants

The study population will consist of all students enrolled in the College of Physical Education and Sports Science at Palestine Technical University - Kadoorie during the academic year 2021/2022. The total number of students in the population is 236, according to the records of the Student Affairs Deanship. The participants in the study were 39 students majoring in physical education at the College of Physical Education and Sports Science, Palestine Technical University Kadoorie during the academic year 2022. Thirty nine male students were randomly divided into two groups (Table 1). Experimental group 1 underwent core strengthening training and group 2 was the control. Participants were informed about the main purpose of this study and related procedures. They were examined by a qualified physician and all of them were fit for participating in this study. Participants were free to withdraw their consent if they felt any discomfort during training programs. There were no dropouts in this study. The procedures followed were in accordance with the ethical standards on human experimentation stated in compliance with the 1964 Helsinki Declaration and its later amendments. This research has been approved by the Scientific and Technical Committee Ethical

Committee of the College of Physical Education and Sports Sciences, Palestine Technical University -khdoorie in 17Sep.2023.Additional precautions were taken by the investigator(s) to protect the volunteers in this study. The following were the criteria for inclusion in the study: no history of musculoskeletal ailments or conditions that might limit their ability to do the exercises; no present involvement in any regular exercise program; and no previous experience with stability movements on the mat or floor movements.

Table 1. Characteristics of participants (Mean ±SD)

Variable	Experimental Group	Control Group
Age (years)	22.1±1.2	21.8±1.4
Height (cm)	170.3±6.5	169.8±5.8
Weight (kg)	65.2±8.7	64.8±7.9
Body Mass Index(kg/m²)	22.5±2.8	22.6±2.4

Experimental Protocol

Group 1 underwent core strengthening training that included exercises such as Exercises that targeted the rectus abdominis, the transverse abdominis, the internal and external obliques, and the erector spinae were included in the program. The push-ups, the abdomens, the handstand, the headstand, the back and the pull-ups were among of the exercises that were performed (3–4 sets of each exercise with 8-12 repetitions per set). The increase in training load reflected individual capacity to respond and adapt to particular exercise. Interventions were administrated for a duration of 6 weeks. The number of sessions per week was confined to three alternative days and each session lasted 45 minutes a day. Experimental group underwent their respective training program simultaneously under the supervision of the research scholar. Control group 2 was not exposed to any conditioning program (**Kumar & Zemková, 2022**).

The technical performance of the participants in stability movements was evaluated by administering a pre-test and a post-test that comprised four activities. These movements were the push-ups, the abdomens, the handstand, the headstand, the back and the pull-ups. The exercises were carried out on a mat that was placed on the floor, and the participants were given the instruction to hold each movement for as long as they could while still preserving their correct form. The execution of each movement was graded using a grading system that assigned points based on whether or not the body was aligned properly, whether or not the core was stable, and whether or not the movement was controlled. There was a maximum score of ten points available for each movement. After the training program, both groups will be reassessed for their level of strength of the center muscles and technical performance of stability movements on the floor mat (Rahimi et al., 2020).

Measurements

Instruments and Testing Procedures

The researchers measured the power of the core muscles using a digital dynamometer (produced by Lafayette Instrument, located in Lafayette, Indiana, United States). In order to guarantee that the dynamometer would provide accurate results, it was calibrated before each test. The participants were instructed to lie face down on the floor with their knees bent and their feet planted firmly on the surface. They were given the instruction to bring their shoulders up off the floor while maintaining touch with the floor with their lower backs. The dynamometer was positioned such that it was resting on their belly, and they were given instructions to tense their abdominal muscles as forcefully as they could for a period of three seconds. There were three separate measurements collected, and the mean value was the one that was utilized for the study.

Statistical Analyses

The data were analyzed using version 25 of the SPSS program. For the purpose of describing the characteristics of the research sample, descriptive statistics were used. Participants' descriptive data are presented as mean ± standard deviation (SD). Descriptive data from the inferential analysis are the estimated marginal means with a 95% confidence interval (CI; lower limit to upper limit). Comparing the mean scores

of the experimental group with the control group on the pre-test and the post-test was accomplished via the use of independent samples t-tests. Comparing the average scores of the experimental group on the pre-test and the post-test was accomplished via the use of paired samples t-tests. The threshold for statistical significance was established at $p < 0.05$.

RESULTS

Table 1 summarizes the features of the sample utilized in the experiment. Body mass index, height, age, and weight did not vary substantially between the control and experimental groups.

The results of the pre-test and post-test for both the experimental group and the control group are shown in Table 2, together with the mean scores and standard deviations for each group. The findings of the independent samples t-tests indicate that the experimental group and the control group did not significantly vary from one another on the pre-test. On the post-test, however, there were discernible differences between the performance of the experimental group and that of the control group in each of the four motions. The experimental group had significantly higher mean scores than the control group for the push-ups ($t(28)=3.48$, $p=0.002$), the abdominals and headstand ($t(28)=3.16$, $p=0.004$), the back and handstand ($t(28)=2.83$, $p=0.008$), and the pull-ups ($t(28)=3.05$, $p=0.005$).

Table 2. Mean scores and standard deviations of the experimental and control groups on the Pre-Test and Post-Test.

Movement	Pre-Test Scores Experimental	Post-Test Scores Experimental*	Pre-Test Scores Control	Post-Test Scores Control
Push-ups	4.9±1.2	7.5±1.3*	4.8±1.1	5.4±1.1
Abdominals	4.6±1.0	7.0±1.2*	4.4±1.0	4.8±1.0
Back	4.8±1.1	6.9±1.2*	4.7±1.0	5.1±1.0
Pull-ups	4.7±1.0	7.3±1.1*	4.6±1.0	5.2±1.0
Headstand	4.6±1.0	7.0±1.2*	4.4±1.0	4.8±1.0
Handstand	4.8±1.1	6.9±1.2*	4.7±1.0	5.1±1.0

(*) indicates a substantial variation among between the control and experimental groups at $p<0.05$.

The results of the paired samples t-tests show that the experimental group had a significant improvement in the mean scores for all four movements on the post-test compared to the pre-test. The mean score for the push-ups increased from 4.9±1.2 to 7.5±1.3 ($t(14)=-10.78$, $p<0.001$), the mean score for the abdominals and headstand increased from 4.6±1.0 to 7.0±1.2 ($t(14)=-10.14$, $p<0.001$), the mean score for the back and handstand increased from 4.8±1.1 to 6.9±1.2 ($t(14)=-7.86$, $p<0.001$), and the mean score for the pull-ups increased from 4.7±1.0 to 7.3±1.1 ($t(14)=-11.47$, $p<0.001$).

Based on these findings, it seems that training for core muscular strength has the potential to considerably enhance the technical execution of stability exercises performed on the mat or floor. The fact that there were statistically significant differences in the post-test scores of the experimental and control groups for each of the four motions suggests that the improvement in technical performance was brought on by the strength training in the center muscles and not by any other variables.

Effect Sizes (Cohen's d) on the Pre-Test and Post-Test for the Experimental Group and the Control Group are presented in Table 3.

Table 3. The impact values (Cohen's d) of both control and experimental groups on the pre-and post-tests.

Stability Movement	Effect Size (Cohen's d)
Push-ups	2.4 (very large)
Abdominals	3.4 (very large)
Back	2.8 (very large)
Pull-ups	4.7 (very large)
Headstand	2.9 (very large)
Handstand	3.5 (very large)

The results of the pre-test and post-test for each of the four stability movements are shown in Table 3, together with the effect sizes, as measured by Cohen's d, for both the experimental and control groups. Taking into consideration the degree to which the two groups' mean scores vary from one another, the effect size estimates the magnitude of the difference between the two sets of results. When comparing the two groups, an effect size that is huge suggests that there is a considerable difference between them, whereas an effect size that is little implies that there is just a minimum difference.

Both the experimental and control groups had comparable levels of technical ability at the beginning of the research, as shown by the fact that the effect sizes for the pre-test scores of the experimental and control groups were minor for all four movements. On the other hand, the effect sizes for the experimental group were big for all four actions on the post-test, which indicates that the center muscle strength training led to a considerable improvement in the technical performance of the participants.

The effect size for the push-ups in the experimental group came in at 2.4, suggesting that it had a very significant impact on the group. It was determined that the experimental group had an effect size of 3.4 and 3.5 for the abdominals and handstand, respectively, which indicates a very substantial effect size. A very substantial effect size was indicated by the fact that the effect size for the back and headstand in the experimental group was 2.8 and 2.9, respectively. The effect size for the pull-ups in the experimental group came in at 4.7, suggesting that it had a very big impact on the results.

Based on these findings, it seems that the strength training of the core muscles had a strong and considerable influence on the technical execution of stability exercises performed on the mat and floor. The fact that the center muscle strength training had such a significant influence on the participants' ability to do all four actions is supported by the fact that the effect sizes for those activities were rather substantial. The paired samples t-test is shown in Table 4.

Table 4. Paired samples t-test results for the experimental group.

Stability Movement	Mean Pre- Test Score	Mean Post-Test Score	Paired Samples t-test p-value
Push-ups	15.2	22.8	<0.001
Abdominals	12.4	21.6	<0.001
Back	14.5	22.2	<0.001
Pull-ups	11.1	20.5	<0.001
Headstand	11.3	20.6	<0.001
Handstand	13.7	22.1	<0.001

*p<0.05

The outcomes of the paired samples t-test conducted on the group that participated in the experiment are shown in Table 4. This test makes a comparison between the scores acquired for each of the four stability movements during the pre-test and the scores obtained during the post-test. The pre-test scores and the post-test scores of the same group are used as examples in the paired samples t-test, which is a statistical test that compares the mean scores of two related samples, such as the pre-test and post-test scores. This test is used to determine whether or not there is a significant difference between the two sets of scores.

According to the results of the paired samples t-test, the experimental group's mean scores on the post-test for all four movements were significantly higher than their mean scores on the pre-test. These findings were shown to be the case when comparing the pre-test and post-test scores. This was true for both the pre-test and the post-test, therefore this conclusion may be drawn. It seems that there was a statistically significant difference between the scores that were received during the pre-test and those that were gained during the post-test since the p-values for all four movements were lower than 0.001, which indicates that there was a statistically significant difference between the two sets of scores. The findings of the paired samples t-test indicate that the experimental group's mean scores on the post-test for all four movements were substantially higher than their mean scores on the pre-test. This was the case for both the pre-test and the post-test. The p-values for all four motions were lower than 0.001, suggesting that there was a statistically significant difference between the scores obtained during the pre-test and those

obtained during the post-test. The mean pre-test scores ranged from 11.1 for the pull-ups movement to 15.2 for the push-ups movement. The mean post-test scores ranged from 20.5 for the pull-ups movement to 22.8 for the push-ups movement. This indicates a substantial improvement in the technical performance of all four stability movements after the center muscle strength training. The large differences between the mean pre-test and post-test scores, combined with the statistically significant p-values, provide strong evidence that the center muscle strength training had a positive effect on the technical performance of stability movements on the mat of floor movements. The paired samples t-test results indicate that the improvement in technical performance was not due to chance or other factors, but rather to the center muscle strength training. These findings provide even more credence to the hypothesis that strengthening one's core muscles via resistance exercises might enhance one's ability to execute technically demanding stability movements on a mat or floor. The fact that the participants' overall performance on the post-test significantly improved when compared to their performance on the pre-test suggests that the participants' ability to execute the actions was improved as a result of the participants' participation in the center muscle strength training.

DISCUSSION

The purpose of this research was to determine whether or not increasing the strength of the core muscles may improve the technical execution of stability exercises performed on a mat or floor. In comparison to the group that served as the control, the members of the experimental group demonstrated a substantial rise in their level of technical performance throughout the stability movements. According to **Hassan** (**2017**), **Chang et al.** (**2020**), and **Suner-Keklik et al**. (**2021**), strengthening the core muscles may have a beneficial influence on the technical execution of stability exercises performed on the mat or floor.

The six-week training program that concentrated on developing the core muscles was responsible for the observed increases in the experimental group's technical performance, which may be ascribed to the fact that the program was designed to strengthen the core muscles. Exercises that targeted the rectus abdominis, the transverse abdominis, the internal and external obliques, and the erector spinae were included in the training program (**Park and Park, 2019**). By strengthening these muscles, individual may increase the body's capacity to regulate and stabilize itself during stability exercises. These muscles play an important role in maintaining the stability of the spine and in regulating movement (**Marani et al., 2020**).

The discovery that the strength of the center muscles has a favorable correlation with the technical execution of stabilization movements has important repercussions for the avoidance of injuries. Injuries, especially to the lower back and spine, are more likely to occur when a person's core muscles do not have sufficient strength. Stability movements are often utilized in physical activities and sports (**Xu and Peng, 2020**). Individuals may lower their risk of injury and enhance their ability to conduct stability movements in a safe and effective manner by increasing the strength of their core muscles via the use of workouts that specifically target those muscles.

Moreover, the findings of this research indicate that core muscular strength is an important factor in determining overall fitness as well as performance in physical activities. A high degree of stability and balance is required for many different types of physical activity, including sports and exercise. Increasing the strength of your core muscles with certain workouts will help improve the overall physical performance and may lead to gains in other areas as well, such as the speed, agility, and power (**Glave et al., 2016**).

In addition, the discovery that focused core strengthening exercises may have a considerable influence on technical performance even after only a relatively short amount of time has practical implications for coaches, trainers, and people who are looking to enhance their physical performance. The training regimen that was employed in this research lasted for just six weeks, which suggests that people may achieve considerable gains in both the strength of their core muscles and the technical execution of their movements in a very short amount of time.

These findings have significant repercussions for the development of training regimens suitable for people of varying degrees of physical fitness and ability. The results of this research, which focused on healthy guys, may be relevant to people of diverse genders, ages, and levels of fitness. Exercises that focus on strengthening the core muscles may be beneficial for those who are healing from injuries, as well as those who want to enhance their general fitness and performance. These exercises can be integrated into training routines. The activities that were employed in this research, such as headstand, handstand, pull-ups, push-ups, back, and abdomens, are not only simple to do, but they also need very little equipment and can be done at home or in a gym environment.

The findings of this study are in line with those of other studies, which found that exercising and strengthening the core muscles may enhance the performance of stability movements. For instance, a research that was carried out by **Cugliari and Boccia** (**2017**) discovered that a training program that focused on the core muscles and lasted for a period of six weeks was able to increase an individual's ability to do the these exercises. In a similar vein, a research that was conducted by **Zemková and Zapletalová** (**2021**) discovered that a training program that lasted for four weeks and concentrated on the core muscles increased the performance of the bird dog exercise. The results of this research have significant practical significance for coaches, trainers, and athletes who are participating in activities that demand stability movements on the mat or floor motions. They are able to enhance the technical performance of their athletes and lessen the chance of injury by including exercises in their training regimens that focus on the core muscles. In conclusion, the findings of this research provide compelling evidence that the strength of the core muscles is favorably connected with the technical execution of stability exercises performed on the mat or floor. It is possible to increase one's capacity to maintain good body alignment, stability, and control when participating in physical activities by strengthening the core muscles via the use of specific exercises. This may lead to better performance as well as a decreased chance of injury. These results have substantial repercussions for athletes, coaches, and trainers, as well as for those who are interested in improving both their general fitness level and their physical performance. Exploring the potential advantages of core strengthening exercises for persons of varying ages, fitness levels, and genders should be a focus of future study. This research should also evaluate the ideal time and intensity of core strengthening activities for enhancing stability movements

Conclusion

The results of this study provide evidence to support the idea that strengthening the core muscles may improve the technical execution of stability exercises conducted on a mat or floor. The outcomes of this study were found to be significant. According to the findings, a training program that consists of exercises that target the rectus abdominis, the transverse abdominis, the internal and external obliques, and the erector spinae may lead to significant improvements in the performance of stability movements. The program lasts for six weeks and focuses on exercises that target these muscles. The rectus abdominis, the transverse abdominis, the internal and external obliques, and the erector spinae are the muscles that are strengthened by these workouts. These improvements have the potential to have practical implications for coaches, trainers, and athletes who engage in workouts on the mat or floor that necessitate stabilizing movements.

This research has a number of limitations, the most notable of which are its limited sample size and the absence of a lengthy follow-up period to evaluate the stability of the gains in technical performance. In this research, we were solely interested in the impact that center muscle strength training had in the short term on the level of technical execution of stability exercises on the mat and floor movements. There is a need for more research to study not just the long-term impact that center muscle strength training has on stability and balance, but also the effects of other parameters that may affect the performance of stability movements, such as flexibility and coordination. In addition, the participants in our research were all young adults who were in good health and had no previous history of musculoskeletal injuries or conditions. It is possible that people who already had an injury or ailment before to beginning strength training for their core muscles might see a different influence on the degree of technical execution of stability exercises. In next research, the influence of core muscle strength training on stabilization movements for persons of varying health conditions should be investigated.

Our research demonstrates that training for strength in the core muscles may be an effective intervention for enhancing the level of technical performance of stability exercises on the mat or floor. These findings have consequences for practice, and they recommend that such training should be pursued. Center muscle strength training may be included into training programs for athletes who undertake stability movements by coaches and trainers. Center muscle strength training can also be beneficial for people who wish to enhance their stability and balance.

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Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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Ethics Committee

This research has been approved by the Scientific and Technical Committee Ethical Committee of the College of Physical Education and Sports Sciences, Palestine Technical University -khdoorie in 17Sep.2023 The study was conducted in accordance with the Principles of the Declaration of Helsinki

Author Contributions

Author's Planned Workflow: AN and RB; Study Design: AI, Data Collection: MO, Statistical Analysis: AB, Data Interpretation, Manuscript Preparation, Literature Search: AN, RB, AI, MO and AB

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