EFFECTS OF CORE STRENGTHENING AND PILATES EXERCISES ON POSTURE, BODY AWARENESS AND FATIGUE AMONG FEMALE ATHLETES

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Background : The representation of women in high-performance sport has increased in recent decades. Good postural balance is a prerequisite for improving the control of voluntary movements in sports and, consequently, for enhancing athletic performance. Athletes have higher levels of body awareness than nonathletic population.

Objective: To determine the effects of Core Strengthening and Pilates Exercises on Posture, Body Awareness, and Fatigue among Female Athletes.

Methods The study was a randomized clinical trial design which was conducted at Pakistan Sports Board, Lahore through non-probability convenience sampling technique on 44 female athletes who were allocated using Random sampling using computerized generated numbers into groups A and B. There

were 22 participants in each group. Subjects were enrolled according to inclusion and exclusion criteria. Group A received core strengthening exercises with warm-up exercises while Group B received Pilates along with warm-up protocol. The treatment session was around 60 min for each patient with three sessions per week on alternate days for 6 weeks. Assessment of the patient's posture, range, body awareness, and fatigue with a New York posture rating chart, body awareness scale, and modified fatigue impact scale was done. Data was analyzed by SPSS version 29.

Results The mean age of participants in group A was 20.54+2.04 and in group B was 21±2.44. There was significant difference in mean value of NPRYC score, BAQ score, MFIS score between core strengthening exercise group and Pilates exercise group at the end of 6 week of treatment (NPRYC P<.000)

Conclusion

This study concluded that Core strengthening exercises were more effective in improving MFIS score, body awareness and NPRYC score in female athlete individuals.

KEYWORDS: Awareness, core stability, fatigue, Pilates-Based Exercises

Introduction

In high-performance sports, women are now more prevalent than they were a few decades ago. In fact, with 49% of all participants being female—up from 45% in Rio 2016 and 38% in Sydney 2000—the Tokyo 2020 Olympic Games were the first to attain nearly equal medal prospects for men's and women's events (1). Women's sport is getting more and more popular due to factors such as the establishment of competitive female squads, the endorsement of the same financial expectations, and the growing participation of women at all levels are all helping to normalize and advance equal opportunity in sports.(2)

Maintaining proper postural balance lowers the chance of sports injuries(3) and the detrimental effects they can have on an athlete's physical and professional status. To improve the control of voluntary movements in sports and, ultimately, to improve athletic performance, one must have good postural balance(4). Large samples of athletes with varying ages, sexes, performance levels, and shoe preferences have not had enough research done on postural balance. However, in men, the capacity to sustain unipedal balance grows during adolescence and gets better in the latter stages of maturity(5). While postural stability in girls attained adult levels by the age of 10, in boys it improved further between the ages of 9 and 16 (6).

The higher postural stability in females is attributed by various authors to the following: lower body weight Villarón-Casales (7), earlier physical maturation, greater diligence and attention when performing postural tasks , structural characteristics (a lower center of gravity in teenage girls because of a slightly broader pelvis and narrower shoulders)(8), and a greater trainability of the posture the control system(8). A more talented athlete should have more postural stability because motor and postural abilities are interdependent (9). In fact, studies by certain writers have demonstrated that COP fluctuations are greater in shooters (10), football players (11), and rhythmic gymnasts performing at an expert or international level than in their less proficient peers. There is a positive correlation between postural stability and athletic performance, according to a recent systematic review of this topic (12).

According to the findings, certain sports-specific circumstances can alter typical postural techniques for preserving a vertical posture, which lowers postural stability in the benchmark test. For example, wearing high-heeled, rigid athletic shoes on a daily basis can assist stabilize the ankles; maintain body balance

on a sliding surface, and boost movement speed in sports like speed skating or skiing. Under typical test conditions without shoes, one might anticipate that prolonged use (several hours per day) of such footwear will reduce postural stability (13).

Compared to non-athletes, athletes show higher levels of bodily awareness (14). Because physical feelings are a vital source of information for adapting and reaching peak performance, athletes focus more of their attention on body signals (15). Expert runners, for instance, coordinate their breathing and stride length to run as quickly and efficiently as possible (16). Exercise appears to stimulate similar brain areas involved in processing interoceptive awareness, according to previous research (17). This is probably because exercise increases afferent signaling. Interoception accuracy, according to Willson and Kerr, may also help an athlete improve through attentively tuning in to their own bodies and recognizing, as well as refining, internal feelings and sensations. (18).

According to research, top performers function better than other athletes in demanding environments; in order to perform at their best, athletes must suppress elite traits like psychological resilience, motivation to succeed, bodily power and stamina, emotional stability, and functioning of the body (19) Gielen et al. (2022) discovered that when exercising, forcing one's attention to the body increased feelings of exhaustion compared to focusing it somewhere else. It has also been demonstrated that focusing on external attention focus leads to a large reduction in symptoms, but only in those that are pertinent to the work at hand (20). Nonetheless, increased post-exercise discomfort is linked to diverting attention away from unpleasant physiological cues such pain and exhaustion when engaging in an activity (21).

Athletes' body awareness may also be significantly influenced by the technical and tactical demands of their sport as well as the advantages it offers them in terms of improved physical and mental toughness and overall health. The findings unequivocally showed that, although impacted by a variety of factors, athletes' levels of body awareness across various disciplines are identical (14).

The idea that heartbeat perception varies depending on cardiac output, volume of stroke, body mass index, alignment, and the degree of exercise-induced circulatory activity are all aspects to consider. is also supported by a number of research (22). Fatigue affects athletes in both their everyday lives and competitive sports. The diminished muscle's capacity to produce force during a contraction that progressively occurs following the start of extended physical exercise is known as fatigue. Reduced

strength, agility, balance, and an increased chance of injury are just a few of the negative effects of fatigue, all of which contribute to a decline in sports performance. Muscular weariness can arise due to a number of reasons, including peripheral, cellular, psychological, and central nervous system-related variables (23).

Exercises focusing on core stability have frequently been linked to increased athletic performance and/or a lower risk of injury. Although these exercises appear to be effective in reducing the risk of injury, there is not enough information to determine how they affect functional movements and performance in a given activity. By minimizing postural displacement following unanticipated shocks, the core, which includes the lumbo-pelvic-hip area, keeps the vertebral column balance within its physiological bounds. To do this, the central nervous system must be instantly activated in order to stimulate the best possible muscle recruitment for both stability and mobility(24) .

Numerous research have examined the effects of Pilates methods on motor abilities like strength, agility, flexibility, and endurance as well as coordination. The foundation of Pilates exercises is the idea of trunk stability, or "core stability." Pilates exercises enhance mobility, efficiency, and muscular control while strengthening the deep core muscles (25). Body awareness is defined as "the sensory awareness that comes from the human body's state of health, procedures (which includes discomfort and sentiment), and acts (including motion) and functions as a dynamic endeavor which involves an individual's assessment and influence by opinions, convictions, and interactions in their cultural and social context" (26).

The present research project aims to determine the manner in which Pilates exercises along with core strengthening influence female athletes' posture, body awareness, and fatigue. Both of these treatments have been shown to have effects on many illnesses and can be customized to meet an athlete's unique body requirements.

MATERIAL AND METHODS

This randomized clinical trial was conducted after the Ethical approval from ethical committee of Riphah International University Lahore with the trial registry at clinical trial.org NCT06196268. After informed written consent, a total of 44 patients were enrolled in this study and then divided into two groups with 22 patients in each group. Sample size was calculated using Epitool software. Non probability sampling technique was used to collect data from Pakistan Sports Board Lahore

Following inclusion Criteria was used: (27).

- Female amateur athletes,
- Ages 18–26.
- BMI <29 kg/m2;
- Athletes not performing core strengthening for at least 4 weeks; • Females without previous records of injuries that might impact the study;
- Period of playing: a minimum of six months to 1 year;

Following Exclusion criteria was used:

- The person's surgical history, any medical or mental diseases, and stressful events that occurred during the last three months.
- Any neurological or vascular conditions.
- Individuals following a different fitness regimen, which may have an impact on the outcomes
- Individuals who are unable to take part in any regular fitness regimen (28).

Randomization:

The randomization was conducted using lottery Method. Participants were randomly assigned to treatment group in a 1:1 ratio.

Data Collection Procedure:

This was randomized clinical trial. The methodology and the objective of the study was clarified and communicated to all the patients before their informed consent obtained. Screening was done as per inclusion criteria by using convenient sampling technique. Baseline assessment was done, and patients were randomly allocated to the two groups by lottery method. A 6-weeks treatment protocol was given to the patients, thrice a week on alternate days.

In addition to the warm-up routine (lumbar stretches), patients in Group A performed core strengthening exercises. The Core Stability Exercise (CSE) program included abdominal hollowing, Side Bridge, supine extension bridge, straight leg rise from prone, alternate arm and leg raise from quadruped, and prone bridge.For seven to eight seconds, each exercise required maintaining an isometric contraction. There was a 3-second break in between each of the ten repetitions of the exercises. The whole treatment time was sixty minutes, which included the regular exercises as well as a ten-minute warm-up and a five-minute cool-down. There was a 10- minute break in between each exercise. For six weeks, the entire intervention program was implemented.(29).

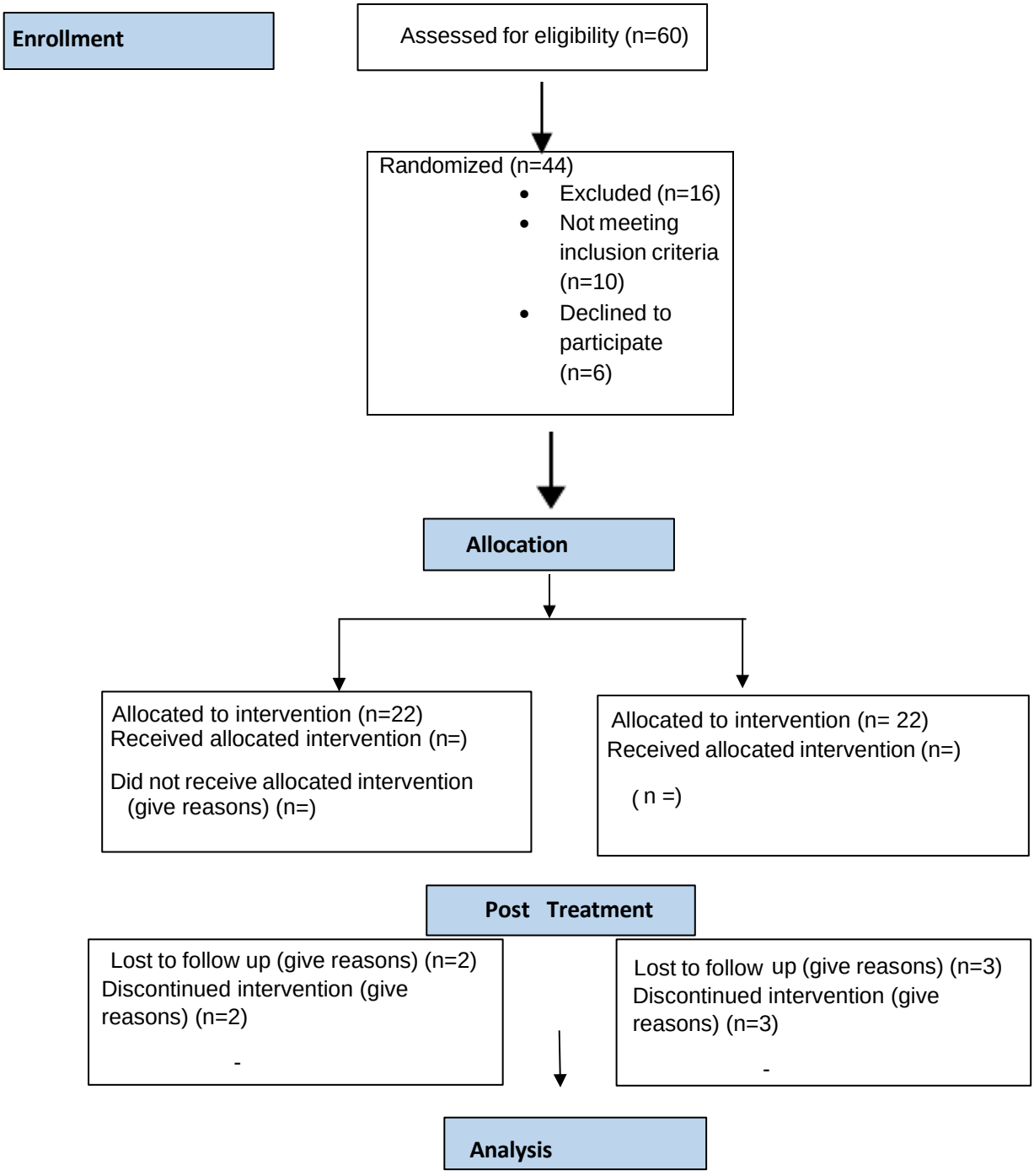
Pilates exercises as well as warm-up exercises were given to patients in Group B. Pilates is a type of exercise that uses regulated movements to improve body awareness, strength, and flexibility and Participants in this treatment received Pilates instruction. The entire 60-minute treatment session consisted of standard exercises with a 10-minute warm-up and a 5-minute cool-down. There was a 10-minute break in between each exercise.(25).The baseline values of all the dependent variable were recorded on day one and end of the 6th week (post treatment), New York posture rating chart, Body awareness questionnaire and Modified fatigue impact scale.

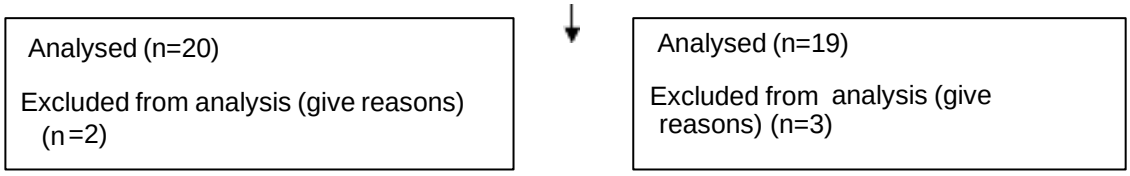
Ethical Consideration:

- Ethical approval was obtained from the Ethical committee of Riphah International University, Lahore.
- Informed consent was taken from the participants and confidentiality was assured to the patients.

- All the information was provided to the patient that what will be potential benefits of the treatment and without any harm.

CONSORT FLOW CHART




Analysed (n=20)
Excluded from analysis (give reasons) (n=2)
Analysed (n=19)
Excluded from analysis (give reasons) (n=3)

DATA ANALYSIS PROCEDURE

Data analysis was conducted using SPSS version 25. The normality of the data was assessed through the Shapiro-Wilk sign test. Parametric or nonparametric tests were applied based on the distribution of the data. If the p-value exceeded 0.05, indicating a normal distribution, parametric tests were employed. Conversely, when the p-value was less than 0.05, non-parametric tests were utilized.

Descriptive Statistics: Frequency tables, pie charts, and bar charts, were employed to present a summary of group measurements measured over time.

Inferential Statistics: For the analysis of two groups, Independent t-Test or Mann–Whitney U Test was applied based on the nature of the data

RESULTS

The total sample size of this study was 44 divided into 2 equal groups. Group A had mean±standard deviation of age 20.07±2.17, while group B had 19.76±2.08 (Table 4.1, 4.2). The data's normality was accesss using the Shapiro-Wilk test. For the NYPRC score at baseline, the Shapiro-Wilk test's P value was.086.

This p value was greater than selected alpha 0.05 that reveal data of this variable was normal distributed, therefore parametric test was applied (Table 4.3). Paired sample t test was utilized to identify significant differences within the group subjects over time, whereas the independent t- test was employed to ascertain significant differences between two groups. The p value of Shapiro wilk test for BAQ at Baseline was .076. This p value was greater than selected alpha 0.05 that reveal data of this variable was normal distributed, therefore parametric test was applied (Table 4.3). Paired sample t test was utilized to identify significant differences within the group subjects over time, whereas the independent t-test was employed to ascertain significant differences between two distinct groups. P value of Shapiro wilk test for MFIS score at Baseline was .445. This p value was greater than selected alpha 0.05 that reveal data of this variable was normal distributed, therefore parametric test was applied (Table 4.3). Paired sample t test was utilized to identify significant differences within the group subjects over time, whereas the independent t-test was employed to ascertain significant differences between two groups.

After a 6-week treatment, an independent sample t test reveals a significant difference in the mean BAQ score between group A and B individuals (P=0.000) (Table 4.8). After the

completion of the six-week treatment, the independent sample t test reveals a significant difference (P=0.000) in the mean value of the MFIS score between group A and B subjects (Table 4.9). The MFIS score, body awareness, and NPRYC score of female athletes who participated in the core strengthening activities group showed a significant improvement.

Descriptive statistics
Demographic characteristics

Table: Age of participants in group A

Age of Groups	Mean±SD	Minimum	Maximum
A	20.54±2.04	18	25
B	21±2.44	18	26

The above Table showed the descriptive statistics of age of participants in group A. Group A had mean and standard deviation of age 20.54±2.04. The maximum age was 25 and minimum age was 18. The above Table 4.3 showed the descriptive statistics of age of participants in group B. Group B had mean and standard deviation of age 21±2.44. The maximum age was 26 and minimum age was 18

Table : Comparison of NYPRC total score with in group A and Group B subjects

NYPRC Total Score: Paired Sample T test				
Groups	Variable	N	Mean±SD	P value
Group A	NYPRC score at Baseline	20	47.90±3.91	.000
	NYPRC score at 6th week	20	56.15±4.10	
Group B	NYPRC score at Baseline	19	48.78±4.04	.000
	NYPRC score at 6th week	19	53.26±4.22	

The above table showed the comparison of mean value of NYPRC score within group A and B subjects. The mean and standard deviation of NYPRC score at baseline was 47.90±3.91, at post treatment 6th week was 56.15±4.10 after treatment with core strengthening exercises. Paired

sample t test p value was .000 for NYPRC score that was less than selected alpha 0.05 reveal that there was significant different in value of NYPRC score due to effect of core strengthening exercises with in group A subjects.

In group B, the mean and standard deviation of NYPRC score at baseline was 48.78±4.04, at post treatment 6^{th} week was 53.26±4.22 after the treatment with pilates exercise. Paired sample t test p value was .000 for NYPRC score that was less than selected alpha 0.05 reveal that there was significant different in value of NYPRC score due to effect of pilates exercise within group B subjects.

Table : Comparison of BAQ Total within Group A and Group B subjects

BAQ Total Score: Paired Sample T test				
Groups	Variable	N	Mean±SD	P value
Group A	BAQ score at Baseline	20	90.30±3.82	.000
	BAQ score at 6th week	20	101.6±4.22	
Group B	BAQ score at Baseline	19	90.94±4.51	.000
	BAQ score at 6th week	19	95.52±4.55	

The above table showed the comparison of mean value of BAQ score within group A and B subjects. The mean and standard deviation of BAQ score at baseline was 90.30±3.82, at post treatment 6th week was 101.6±4.22 after treatment with core strengthening exercises. Paired sample t test p value was .000 for BAQ score that was less than selected alpha 0.05 reveal that there was significant different in value of BAQ score due to effect of core strengthening exercises with in group A subjects.

In group B, the mean and standard deviation of BAQ score at baseline was 90.94±4.51, at post treatment 6th week was 95.52±4.55 after the treatment with pilates exercise. Paired sample t test p value was .000 for BAQ score that was less than selected alpha 0.05 reveal that there was significant different in value of BAQ score due to effect of pilates exercise within group B subjects.

Table : Comparison of MFIS Total within Group A and Group B subjects

MFIS Total Score: Paired Sample T test				
Groups	Variable	N	Mean±SD	P value
Group A	MFIS score at Baseline	20	34.05±3.74	.000
	MFIS score at 6th week	20	24.60±4.12	
Group B	MFIS score at Baseline	19	34.94±3.47	.000
	MFIS score at 6th week	19	29.36±3.60	

The above table showed the comparison of mean value of MFIS score within group A and B subjects. The mean and standard deviation of MFIS score at baseline was 34.05±3.74, at post treatment 6th week was 24.60±4.12 after treatment with core strengthening exercises. Paired sample t test p value was .000 for MFIS score that was less than selected alpha 0.05 reveal that there was significant different in value of MFIS score due to effect of core strengthening exercises with in group A subjects.

In group B, the mean and standard deviation of MFIS score at baseline was 34.94±3.47, at post treatment 6th week was 29.36±3.60 after the treatment with pilates exercise. Paired sample t test p value was .000 for MFIS score that was less than selected alpha 0.05 reveal that there was significant different in value of MFIS score due to effect of pilates exercise within group B subjects.

Table : Comparison of NPRYC Total score between two groups

	Treatment group of patients	N	Mean±SD	Mean Difference	P value
NPRYC score at Baseline	Core strengthening Exercises	20	47.90±3.91	-.889	.490
	Pilates exercise	19	48.78±4.04		
NPRYC score at 6th week	Core strengthening Exercises	20	56.15±4.10	2.886	.037
	Pilates exercise	19	53.26±4.22		

The above table showed the comparison of mean value of NYPRC score between Core strengthening Exercises and pilates exercise group. The mean value of NYPRC score at baseline was 47.90±3.91 that was significantly improved to 56.15±4.10 at end of 6th weeks of treatment due to effect of between Core strengthening Exercises while mean value of NYPRC score at baseline was 48.78±4.04 that improved to 53.26±4.22 at the end of 6 week of pilates exercise group. Independent t test p value of NYPRC score was .490 at baseline that greater than selected alpha shows that there was no significant difference between two groups in term of NYPRC score. P value was .037 at 6^{th} week of treatment that shows there was significant difference in mean value of NYPRC score between two groups. Improvement in NYPRC score was more observed in group A.

Table: Comparison of BAQ Total score between two groups

	Treatment group of patients	N	Mean±SD	Mean Difference	P value
BAQ score at Baseline	Core strengthening Exercises	20	90.30±3.82	-.647	.631
	Pilates exercise	19	90.94±4.51		
BAQ score at 6th week	Core strengthening Exercises	20	101.6±4.22	6.073	.000
	Pilates exercise	19	95.52±4.55		

The above table showed the comparison of mean value of BAQ score between Core strengthening Exercises and pilates exercise group. The mean value of BAQ score at baseline was 90.30±3.82 that was significantly improved to 101.6±4.22 at end of 6th weeks of treatment due to effect of between Core strengthening Exercises while mean value of BAQ score at baseline was 90.94±4.51 that improved to 95.52±4.55 at the end of 6 week of pilates exercise group. Independent t test p value of BAQ score was .631 at baseline that greater than selected alpha shows that there was no significant difference between two groups in term of BAQ score. P value was .000 at 6^{th} week of treatment that shows there was significant difference in mean value of BAQ score between two groups. Improvement in BAQ score was more observed in group A.

Table Comparison of MFIS Total score between two groups

	Treatment group of patients	N	Mean±SD	Mean Difference	P value
MFIS score at Baseline	Core strengthening Exercises	20	34.05±3.74	-.897	.444
	Pilates exercise	19	34.94±3.47		
MFIS score at 6th week	Core strengthening Exercises	20	24.60±4.12	-4.76	.000
	Pilates exercise	19	29.36±3.60		

The above table showed the comparison of mean value of MFIS score between Core strengthening Exercises and pilates exercise group. The mean value of MFIS score at baseline was 34.05±3.74 that was significantly improved to 24.60±4.12 at end of 6th weeks of treatment due to effect of between Core strengthening Exercises while mean value of MFIS score at baseline was 34.94±3.47 that improved to 29.36±3.60 at the end of 6 week of pilates exercise group. Independent t test p value of MFIS score was .444 at baseline that greater than selected alpha shows that there was no significant difference between two groups in term of MFIS score. P value was .000 at 6^{th} week of treatment that shows there was significant difference in mean value of MFIS score between two groups. Improvement in MFIS score was more observed in groupA.

DISCUSSION

The hips, pelvis, and lumbar complex make up the core of the human body, which also includes active and passive components that either facilitate or restrict movement of the body. The capacity to regulate bodily motions is referred to as core stability. In order to keep the spinal column from bending and to regain balance after experiencing severe postural sway, the lumbar complex, pelvic, and hip movements are all included in the complicated phenomena known as core stability. especially for basic tasks, core stability serves as the foundation for managing posture and movement, especially while lifting large objects. In particular, core stability offers a steady foundation for upper or lower extremity movement (30). Pilates targets the movements of the trunk, pelvis, and hips and is a useful technique for enhancing core stability. It can strengthen muscles and rectify bad posture while raising body awareness, which can enhance flexibility Consequently, pilates training strengthens the muscles in the trunk and pelvis and enhances posture control (25). This study examined how six weeks of pilates and core stability training affected the athletes' posture, body awareness, and level of exhaustion. Posttest results compared to pretest values revealed a substantial gain in posture, body awareness, and fatigue in the CST group, while the pilates group also demonstrated improvement. Furthermore, after six weeks, variations were seen in every parameter between the pilates group and the CST group ($P < 0.05$). These results are consistent with recent studies showing the positive impacts of pilates and core stability exercises on body awareness, posture, and tiredness. Another research demonstrated that after receiving 12 weeks of Pilates, young adults experienced a considerable improvement in their posture(31). According to a systematic study by Hornsby et al. (2020) pilates improves postural stability in kids and young adults while lowering muscle energy consumption and raising physical activity levels (32).

In a 2021 study, Zirek et al. investigated the effects of Reformer Pilates on young people's body awareness, activity level, aerobic capacity, and balance. Two participant groups were formed: an inactive group ($n = 87$) and a Reformer Pilates group ($n = 82$) that engaged in a range of exercises designed to increase muscle strength and flexibility. The subjects were assessed using the YMCA 3-Minute Step Test, the International Physical Activity Questionnaire Short Form (IPAQ-SF), the Body Awareness Questionnaire (BAQ), the Functional Reach Test (FRT), and the Single-Limb Stance Test (SLST). The

results of the BAQ, IPAQ-SF light level activity.(31)YMCA 3-Minute Steps Test, SLST with closed eyes, and lateral FRT showed that the Reformer .Pilates group had benefited from a statistically significant difference(30).

A study by Yu et al. (2012) looked at the effects of eight weeks of Pilates training on the strength and postural stability of lower extremity muscles. Twenty members of the core stability training (CST) group and twenty members of the control group were randomly assigned to each of the forty healthy individuals. The CST group underwent three weekly 60-minute Pilates training sessions during the course of the eight weeks. while the control group received no training. Lower extremity muscular strength was assessed using isokinetic equipment before and after training, and postural stability was measured using a balancing device. The CST group demonstrated significant posttest increases in both postural stability and lower limb muscle strength ($P < 0.05$), whereas there was no noticeable improvement in either of these measures in the control group. In the control group, no noticeable improvement was observed in either postural stability or lower limb muscle strength. However, after 8 weeks, significant differences ($P < 0.05$) in both lower limb muscle strength and postural stability were evident between the core stability training (CST) group and the control group. These findings showed that pilates core stability training improves postural stability, strengthens lower extremity muscles, and prevents musculoskeletal problems while also enhancing quality of life and motor performance skills (33). This study is in agreement with the present study by showing that pilates exercise and core strengthening exercises ultimately improve the motor performance skill and posture of individuals but core strengthening exercise were most effective in individuals. Comparative study mentioned above had used the Pilate exercise along with core stability exercise to improve balance and motor performance but present study used these treatments as comparison. This present study had targeted the femaleathletes.

CONCLUSION

This study concluded that both Core strengthening exercises and pilates group showed improvement in posture, body awareness and fatigue in female athletes. However, significant improvement was shown in Core strengthening exercises in improving MFIS score, body awareness and NPRYC score in female athlete individuals.

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