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The Effectiveness of Core Muscle Training on Skill and Balance for Snooker Players

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Abstract

Background: Snooker is a kind of cue sport in which skill plays an important role. To reach a professional level, snooker players must acquire many physical and mental skills. Strengthening the core muscles, which provide a foundation for a successful limb function in skill sports such as snooker, can be achieved by performing Pilates exercises.
Objectives: The purpose of this study was to investigate the effectiveness of core muscle training on skill and balance for snooker players.
Methods: In this study, 30 male snooker players were divided into Pilates (n = 15) and control groups (n = 15) by randomization. The Pilates group performed the mat Pilates exercises three sessions per week consisting of 30 minutes of Pilates training in addition to one hour of routine snooker training per session for six weeks. The control group performed one-hour routine snooker training three sessions per week at the same time period. To assess the players' skills, the line-up test was used to measure the break score, and the foul number test was used to calculate the foul number. Players' balance was evaluated by the stork balance test. All tests were performed pre and post 6 weeks of exercise for between and within- group comparisons.
Results: Line-up and stork test scores were significantly increased ($P < 0.05$) in the Pilates group compared with the control group. However, there was no significant difference in the foul numbers between groups after Six weeks of Pilates exercises.
Conclusions: Six weeks of mat Pilates exercises improves the snooker players' balance ability and break scores.

Keywords: Postural Control, Pilates Training, Snooker, Athletic Performance, Core Strength

1. Background

Cue sports, also known as billiards, are a variety of games that fall into three main categories: Carom billiards, pocket billiards or pool, and snooker. Snooker is played on a six-pocket pool table. The first world snooker championship was held in 1927 (1). Snooker is a skill sport, and in order to reach the professional level, snooker players must acquire skills such as decision-making, directional recognition, visual skills, and power control in addition to the following basic skills: Grip, bridge, stance, and cue alignment. Professional players also have mental skills such as motivation, commitment, focus, and confidence (2, 3). Athletes' abilities in any sport can be affected by neuromuscular factors, psychological factors, coaches, and environmental conditions (4). The effect size of each of these factors depends on athletic characteristics. The role of neuromuscular factors in cue sports has little been discussed. Zhou & Qu reported that upper limb joint coordination was higher in professional billiard players than in beginners (5). Cheng et al. found that shoulder and pelvic stability are important for an accurate pool shot (6). Successful limb function requires a stable base. The core muscles involved in the limbs have been shown to serve to generate, transmit, and control the forces during integrated kinetic chain activities (7).

Pilates is one of the exercises that emphasize strengthening the core muscles. The creator of these exercises, Joseph Pilates, based them on six principles: Breathing, centering, concentration, control, flow, and precision (8). Centering in the Pilates concept refers to the core and core muscles, which Joseph called Pilates' powerhouse. He believed that the body supplied its desired energy from here (9). These exercises can affect the core by maintaining the neutral position of the pelvis and correcting the curvature of the spine and posture, and improving the flexibility and strength of the muscles in this area. Also, Pilates exercises

increase the pressure in the abdominal-pelvic cavity to increase the stability of its walls (9).

Many physical and psychological benefits have been reported for Pilates exercises, including improving posture, strength, flexibility, and balance (10-12). A good balance is one of the important elements required for a normal active daily life (ADL) with individual independence. The effects of balance training on athletes are seen in increases in lower extremity muscle strength, jumping performance, running speed, agility, etc. Studies also showed that athletes improved skills such as rifle shot accuracy, archery accuracy, ice hockey top skating speed, and simulated luge starting speed balance (13, 14).

In cue sports like snooker, we understand that balance plays an important role in requiring a standing stance and shot accuracy. However, to our knowledge, it has not yet been evaluated. Although cue sports are practiced professionally around the world today, there has been limited research on it. Therefore, the importance of finding methods and exercises to improve the performance of these players is highlighted here.

2. Objectives

In this study, we aimed to investigate the effects of core muscle training on the ability and balance of snooker players. We hypothesize that training the core muscles by performing Pilates exercises improves the players' balance ability and can affect the players' performance by improving their score and reducing the number of fouls.

3. Methods

3.1. Participants

This experimental study was conducted at cue-ball club, Lahijan, Iran. It was approved by the Ethics Committee of Tabriz University of Medical Sciences (IR.TBZMED.REC.1399.230) and generally followed the CONSORT guidelines and checklist to provide a detailed report on the conduct of the study. In particular, the sample size of the current study was calculated with 32 players with a power of 0.80. Players who met the inclusion and exclusion criteria participated in this study. The inclusion criteria for the study were: The group age between 18 - 40 years, being intermediate and advanced snooker players with a break score > 30. Players excluded from the study were those with musculoskeletal problems or medical conditions that would interfere with their exercise activities and who had done Pilates training in the past few years. Sampling and data collection took place between September 2020 and March 2021. The entire course of the training program was explained to the players, and a written declaration of consent was obtained from all participants. Two players were unwilling to cooperate, so 30 participants were divided into the Pilates (n = 15) and control (n = 15) groups by simple randomization (each participant was randomly assigned a code that was assigned to one of the groups via online randomization). The study period comprised six weeks of training. In this study, to assess the players' skills, we evaluated the scores achieved and the number of fouls committed by the players. For this purpose, we have designed two game scenarios on the table, including the line-up test and the error count test. To assess balance as an important musculoskeletal factor in snooker player performance, we used the stork balance test.

3.2. Line-up Test

The line-up test was used to record break scores. As shown in Figure 1, the balls were arranged in a specific pattern in a row on the table. Players pocket a red ball first and then a colored ball of their choice. Any colored ball that fell into the pocket was returned to its place on the table. After all the red balls have successfully dropped into the pockets, the remaining colored balls will be hit based on the ascending scores. If the players failed to sink a ball, the game was over, and the break score was recorded. This test was repeated three times at 30 to 60-second intervals, and the best score from three trials was recorded as the major break score.

3.3. Foul Number Test

To evaluate the number of fouls, the foul count test was used such that the cue ball was placed along the gang as shown in Figure 2, then the players were asked to hit the jack (black ball in the picture) and pot it. Any time a player failed to sink the target ball with the cue ball, it was counted as a foul. In this test, four cue balls were used, and the test was repeated three times with 30-60 seconds rest between tests, and the minimum number of fouls in the three attempts was recorded as the player's foul score.

3.4. Stork Balance Test

The player's static balance was evaluated by the stork balance test. This test is an inexpensive and simple standard test with high reliability (0.87) and an interrater of ICC = 0.76 (15). The test was conducted with players standing barefoot on one leg on a flat surface with hands on hips. Then they put their free foot next to the knee of the supporting leg. After that, they lift their heels off the ground and balance on their toes. The time was recorded with a stopwatch. In each of the following situations, the timer stopped when: (a) the hands came off the hips; (b) the supporting leg moved in any direction; (c) the free foot came off the knee of the supporting leg; and (d) the heel bucked touches the ground. This test was repeated three times for

Figure 1. Line-up test

each player and three times for each leg, with a 30 - 60 second rest between each repetition. The best time between the three repetitions was recorded as a result of the stork balance test.

3.5. Practice Program

All of the above tests were performed once before the exercises and repeated at the end of the last session of the sixth week of exercises. The exercise program was as follows: The Pilates group performed the Pilates exercises three sessions per week consisting of 30 minutes of Pilates training plus 1 hour of routine snooker training per session. At this point, the control group only completed a one-hour routine snooker training course with three sessions per week. For matched groups, the control group was asked to engage in 30 minutes of gentle aerobic activity, such as slow walking, prior to their routine snooker practice. Details of the designed program are given in Table 1 and Box 1. After six weeks of practice, all dexterity and balance assessment tests were repeated, and results were recorded for between- and within-group comparisons.

3.6. Statistical Analysis

For data analysis, we used IBM SPSS Statistics 23. First, the normality of the data parameters was confirmed by the Shapiro-Wilk test, and the equality of variances was assessed by the Levene test. Normal variables mean the difference between group pre- and post-tests assessed by independent-sample *t*-test, and Mann-Whitney U-test was used for abnormal distribution of variables. We also analyzed data by paired *t*-test for normal and Wilcoxon's test for abnormal variables to assess within-group differences. If the result was significant, the effect size (Cohen's d) was calculated. The analyzes were performed with a significance level of 0.05.

Figure 2. Foul number test

Table 1. Exercise Programs in the Pilates and Control Group

Groups	Exercises Duration: 3 Sessions Per Week for Six Weeks			
Pilates	5 min warm-up	20 - 25 min Pilates exercises	5 min cooldown	1-hour routine snooker training
Control	5 min warm-up	20 - 25 min slow walking	5 min cooldown	1-hour routine snooker training

4. Results

4.1. Participation

According to Table 2, the mean age, height, weight, and body mass index of the players showed no statistically significant difference between the two groups. These results also demonstrated the homogeneity of the players in the study.

4.2. Inter-group Comparison

As shown in Table 3, the independent-samples *t*-test was used to assess the mean differences between groups on the stork balance and placement tests. The results showed that there was a significant difference in stork test scores between the Pilates and control group after exercise on the right and left foot, while this difference between the two groups before six weeks of the exercise was not statistically significant. Also, the results of comparing the break scores of the two groups in the post-line-up test showed a significant difference between the control and the Pilates group after the Pilates training. However, in the pre-test, there was no significant difference between them. The intergroup analysis to assess the foul score by the Mann-Whitney U test showed that after six weeks of Pilates exercise, there was no significant change in the Pilates group compared to the control group. Assessment of variables

Box 1. Pilates Exercises in the Pilates Group [a] (16)

Pilates Exercises Program
Warm-up
Breathing, relaxing, pelvic curl, cat stretching, rolling arms
Exercises week 1st and 2nd
Hundred (10 reps, 3 sets)
Single leg circle (10 reps, 3 sets)
Single leg stretch (10 reps, 3 sets)
Rolling like a ball (10 reps, 3 sets)
Full roll up (5rep, 3 sets)
Exercises week 3rd and 4th
Single straight leg stretch (10 reps, 3 sets)
Crisscross (10 reps, 3 sets)
Saw (10 reps, 3 sets)
Squat with arms rolling (10 reps, 3 sets)
Exercises week 5th and 6th
Crock screw (10 reps, 3 sets)
Single leg bridge (10 reps, 3 sets)
Push up (10 reps, 3 sets)
Standing on one leg with arms rolling (10 reps, 3 sets)
Cool down
Cat stretching, slow walking, relaxing

[a] 45 - 60 s rests between sets.

Table 2. Mean Difference in Weight, Age, Height, and BMI of Players

Variables	P	Mean ± SE
Age	0.87	-0.26 ± 1.66
Weight	0.55	-1.80 ± 2.98
Height	0.14	-0.34 ± 0.23
BMI	0.68	-0.29 ± 0.69

Abbreviation: BMI, body mass index.

with significant differences showed a large effect of Pilates exercises on balance and break scores (Table 4).

4.3. Intra-group Comparison

The results of the Pilates group before and after six weeks of training showed: (a) there was a statistically significant improvement in the balance of both legs after six weeks of Pilates training ($P < 0.05$); (b) the break scores before and after line-up tests had a significant difference ($P < 0.001$); and (c) there was no significant difference between the number of fouls before and after Pilates training ($P = 0.80$). Analysis of the results of the control group showed the following: (a) there was no statistical change in the balance of both legs in pre- and post-stork balance tests ($P > 0.05$); (b) there was no significant difference in the number of fouls before and after six weeks ($P = 0.26$); and (c) a significant difference was found in rest score before and after six weeks of training ($P = 0.001$).

Table 3. Inter-group Comparison of the Stork Balance Test, the Line-up Test, and the Foul Number Test

Variables and Time	Mean Difference	P
Right leg stork balance test score		
Pre	0.09	0.98
Post	9.47	0.01
Left leg stork balance test score		
Pre	2.63	0.40
Post	7.28	0.02
Line-up test break score		
Pre	1.53	0.70
Post	12.00	0.00
Foul number test score		
Pre	0.36	0.50
Post	0.05	0.32

5. Discussion

This study aimed to investigate the effect of six weeks of core muscle training by performing Pilates exercises on the skill and balance of snooker players.

5.1. Effects of Pilates on Balance

Our results showed a significant improvement in players' balance after Pilates exercises compared to the control group. These results are similar to a study by Park et al. who assessed both static and dynamic balance in archers. Twenty archers were divided into two groups of Pilates exercises and the control group. The intergroup comparison showed a significant improvement in the static and dynamic balance of the Pilates group after 12 weeks of Pilates training (17). A study by Panse et al. showed that basketball players' dynamic balance improved after four weeks of Pilates training (18). It appears that Pilates exercises play an important role in improving balance, possibly due to strengthening core muscles (19, 20). Kaji et al. showed that immediately after core stability exercises, the speed and range of excursion of the pressure center were reduced during quiet standing (21). A possible explanation is that these exercises can improve proprioception arising from afferent messages from sensory input collected from the skin, muscles, tendons, etc. Increasing sensory inputs can improve balance. For example, an increase in swing

Table 4. The Effect Size of Pilates Training on Variables with a Significant Difference

	Right Leg Stork Balance Test Score	Left Leg Stork Balance Test Score	Line-up Test Break Score
Cohen's d [a]	0.93	0.84	1.04

[a] Cohen's d effect size threshold (small effect = 0.20, medium effect = 0.50, large effect = 0.80 or higher).

complexity has been shown to occur after the application of plantar sensory vibrations (22). In addition, Anderson et al. found that people used the ankle control strategy as a cost-effective method instead of the hip control strategy to improve their balance due to better muscle coordination through core strengthening (23). Player skill was the other item evaluated in this study. In skill sports, good results are achieved when players get higher scores and make fewer mistakes in the game.

5.2. Effects of Pilates on Players' Scores

Our result showed that there was a significant difference in test scores between the two groups after Pilates training. Both groups had an increase in line-up test scores at six weeks, but this increase was greater in the Pilates group. Preeti et al. showed that balance, flexibility, lower-limb strength, and eye-hand coordination improved in prospective state-level badminton players after Pilates training (24). Gul's study evaluated tennis players' ability to reach the ball on time in parallel and cross strokes and faster recovery for the next shot. They found that these skills increased after eight weeks of Pilates practice (25). For cue athletes, it is important to keep the shoulders and torso stable in certain positions to ensure accurate cue alignment and movement (6). The stability of the core region provides this basis for the movement of the upper and lower extremities to support loads (26). The core muscles have the role of the fundamental axis in the biological chain of motion to provide a channel for transmission and integration of the upper and lower extremities (27). Greater core stability leads to greater strength in the upper and lower limbs (28). So it appears that the core exercises can reduce unnecessary upper body movement and energy loss during movements. This mechanism can lead to better performance in athletes (29).

5.3. Effects of Balance on the Number of Fouls

The results of the present study on the number of fouls showed no statistically significant difference between the two groups after six weeks of Pilates exercise. There is also no significant difference in the results between the groups. It appears that these results may be related to the choice of foul number test. This test is a very demanding test in snooker that requires a high level of skill from the players, while the line-up test was at an intermediate level in terms of difficulty. According to a study by Chung et al. advanced-level snooker players are required to have various skills, such as fine control of the power and spin imparted to the ball (30). Although many studies have shown that core-strengthening exercises can improve athlete performance, they can vary in advanced skill levels. Recent studies in accuracy sports like golf have shown that long durations of strengthening interventions or high-frequency training must produce significant differences in the results of advanced golfers (31, 32). It seems that six weeks of Pilates training is not enough to improve cue power control in such a tough test. In general, improving a skill depends on many factors that Pilates may not be able to influence in all aspects.

There are limited confirmed tests to assess the ability of snooker players. Further studies are needed to evaluate the reliability and validity of tests in cue sports. It appears that this study was the first to find the effect of core muscle training by performing Pilates exercises in cue athletes. Future studies of different methods of Pilates training are suggested to better understand the effectiveness of this method on the skills of cue athletes.

5.4. Conclusions

Six weeks of core muscle training through Pilates mat exercises can improve the snooker player's balance. Also, the break scores of players in the Pilates group increased more after Pilates exercises than in the control group, but our results showed that this type of exercise failed to reduce players' foul counts after six weeks of Pilates training.

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Footnotes

Authors' Contribution: Study concept and design: A. E. O., T. GH. and M. S.; analysis and interpretation of data: A. E. O., T. GH. and M. S.; drafting of the manuscript: M. S.; critical revision of the manuscript for important intellectual content A. E. O., T. GH. and AA. N.; statistical analysis: P. S. and M. S.

Conflict of Interests: It was not declared by the authors.

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Informed Consent: The entire course of the training program was explained to the players, and a written declaration of consent was obtained from all participants.

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