https://doi.org/10.54141/psbd.1383460

PAMUKKALE JOURNAL OF SPORT SCIENCES
ISSN: 1309-0356
dergipark.org.tr/en/pub/psbd

Pamukkale J Sport Sci, 15(1), 73-87, 2024 Research Article

The Effect of Pilates Exercises on Mobility and Dynamic Balance in Former Athletes and Sedentary Individuals

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Keywords
Balance,
Mobility,
Pilates,
Workout

Article History
Received 30 October 2023
Revised 30 December 2023
Accepted 31 January 2024
Available Online 14 March 2024

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ABSTRACT

Workout programmes have proven physiological benefits, and it is widely accepted that they can yield more positive health outcomes when parameters such as balance and mobility are at play. This study intends to examine the effects of a 12-week mat pilates workout program on mobility and dynamic balance parameters in the former athlete group (FAG) and the sedentary group (SG). The study was designed in an experimental design with pre-test and post-test in two groups. The study group consisted of 30 female participants, SG (n=15) and FAG (n = 15). Dynamic balance values were measured using the Star Excursion Balance Test, and lower extremity mobility was measured using the Sit and Reach Test. Both groups conducted mat pilates exercises twice a week for 12 weeks. At the end of the 12-week mat pilates workout programme, a significant difference of increase was obtained in the mobility values of the FAG (p<0,002) and the SG (p<0,001). The Y Balance Test identified a significant difference of increase with pre-test and post-test in anterior (p = 0.04), postero-lateral (p = 0.03), posteromedial (p = 0.04) directions balance in the FAG. In the difference between groups, SG showed a significant increase in posterolateral (p = 0.001) and posteromedial (p = 0.002) directions balance than FAG at post-test. At the end of the 12-week mat pilates workout programme, it was revealed out that the FAG scored better in post-test in dynamic balance than the SG although it scored lower in the dynamic balance pre-test than the SG.

Citation: Uzlaşır, S., Parlakyıldız, S. and Çimke T. (2024). The Effect of Pilates Exercises on Mobility and Dynamic Balance in Former Athletes and Sedentary Individuals. *Pamukkale Journal of Sport Sciences,* 15(1), 73-87. https://doi.org/10.54141/psbd.1383460

INTRODUCTION

Workout programmes have known health outcomes for individuals. The developer of the Pilates technique, Joseph Pilates, struggled with asthma and rheumatic disorders since his childhood, and his first intention was to strengthen his own body (Latey, 2001). Pilates argues that his method can be used for mental and physical development irrespective of age, gender and physical capacity, and it can also serve as a valuable tool for every individual (Pilates & Miller, 2001). Pilates exercises follow the basic principles of strength-building of popular fitness programmes such as yoga and Tai Chi. Core stability or core strength building has recently become a well-known fitness trend in the world of sports medicine. It can be suggested that workout programmes can yield more positive health outputs when they include parameters such as mobility and balance.

Core stabilization is known to improve athletic performance, prevent injuries, and relieve pain (Akuthota et al., 2008). Pilates includes low and medium-intensity mental-physical exercises oriented at core stability, muscle strength, breathing, and posture. Lange et al., (2000) report that pilates exercises offer benefits in physiological (resistance, force, muscle strength), psychological (mood, motivation, concentration) and motor functions. The outcomes of workout programmes for core or segmental stability are considered low (Wirth et al., 2017). Lower abdomen and inguinal injuries are considered among the most common reasons for both pain and lost playtime in sports. Studies in the literature demonstrate important results on core exercise programmes about performance improvement (Willardson, 2007) and reducing the risk of injury (e.g. back and lower extremity injury; Trajkovic & Bogataj, 2020). Strengthening the core muscles is considered essential to maximize force build-up, minimize loads on joints and for an efficient biomechanical function in all kinds of activities from running to throwing (Kibler et al., 2006).

Pilates seems to have a positive impact on muscle strength and resilience also by making positive changes in the body mass index in addition to various physical developments such as improved flexibility, bone density, and dynamic balance (Caldwell et al., 2009; Jago et al., 2006; Johnson et al., 2007). Mobility gradually decreases after 17 years of age in both men and women. Mobility workouts can prevent and reduce the risk of injury in sedentary individuals (Otto et al., 2004) and athletes (Bertolla et al., 2007). A significant increase in mobility is reported in sedentary individuals (Segal et al., 2004) and athletes (English & Howe, 2007) who engage in pilates workouts. Pilates exercises are also considered influential on balance as well as flexibility. Strengthening core muscles and improving spinal stabilization are considered important in avoiding situations such as loss of balance and falls and reducing the associated risk of injury (Lange et al., 2000; Von Sperling de Souza & Vieira, 2006). Regular pilates exercises seem important for improving balance in sedentary individuals and athletes (Johnson et al., 2007). Clinical pilates practices implemented for rehabilitation target the local stabilizer muscles in the lumbar pelvic area and intend to improve posture and movement control through neuromuscular control techniques that are believed to improve lumbar spinal stability (Suárez-Iglesias et al., 2019). Therefore, it can be suggested that pilates core exercises on dynamic balance and mobility in sedentary individuals and former athletes. Based on this, we hypothesize that pilates exercises impact mobility and balance. This study aims to examine the differences in impacts on mobility and dynamic balance in sedentary individuals and former athletes at the end of a 12-week pilates workout programme.

METHODS

Participants

Demographic information was collected from former athletes (FAG) and sedentary (SG) groups on the first day. General evaluation parameters were inquired thereafter. Only females were included in the study to eliminate physiological differences. First, general background information was collected from all female participants in the study. Information collected for participant history includes:

- Demographics (age, height, weight, education)
- Sports branch, years in active sports, if any
- Systemic disorders such as hypertension, diabetes etc., if any
- Neurological disorders, if any,
- Surgical history, if any,

The study included females between the ages of 18 and 25, who had no lower extremity injuries, no chronic diseases, no symptomatic musculoskeletal or head injuries, and no known balance disorders. The inclusion criteria were that females in the SG group had never participated in active sports, while women in the FOG group had been experts in any sport for at least four years. The FAG consists of active athletes in volleyball (4), basketball (4), taekwondo (4), and football (3), and the SG consists of individuals without a history as an athlete.

The study's power analysis was performed with G-Power (latest ver. 3.1.9.3: Heinrich-Heine-Universität Düsseldorf, Germany). The study covered 20 female participants in total, 10 with an athlete history and 10 sedentary, with 0.65 effect size, 5% type 1 error and 0.85

power (Park et al., 2016). A total of 30 students who were enrolled in Nevşehir Hacı Bektaş Veli University and took elective Pilates classes voluntarily took part in the study. The purpose of the study was explained to the participants. This study was reviewed and approved of by Nevşehir Hacı Bektaş Veli University Non-Invasive Clinical Studies Publication Ethics Board (No: 2300022766, 19.04.2023).

Data Collection

In the study, test batteries were applied following a five-minute jogging and two-minute m. gastrocnemius muscle stretching exercise as a warm-up programme on day two. Lower extremity mobility was calculated based on the mean of three different measurements with the Sit and Reach (SR), one of the most commonly used linear flexibility measures, which measured the distance from the feet adjacent to the toes (Castro-Piñero et al., 2010; Holt et al., 1999). As a linear test, SR distinguishes as an easy method as it requires minimum skills, equipment, and cost compared to angular tests (Castro-Piñero et al., 2010; López-Miñarro & Rodríguez-García, 2010). The Star Excursion Balance Test (SEBT) was modified and arranged for dynamic balance values in Y form, and anterior, antero-medial and postero-lateral measurements were taken on day three. The Y Balance Test (YBT) measurements were repeated three times, and the mean values were calculated. The means were divided by the leg length, and the values were normalized (Burcal et al., 2019). YBT was performed with the dominant lower extremity. The dominant lower extremity of the participants was identified based on the foot they used to kick the ball (Van Melick et al., 2017).

YBT is a low cost, clinical dynamic balance measure used in sports requiring balance on a single leg (Neves et al., 2017). YBT evaluates limb symmetry through a reaching task by a single lower extremity in three different directions (anterior, postero-medial and postero-lateral; Greenberg et al., 2019). YBT is considered an important tool in clinical practice, especially in sports. The dynamic stability tested by YBT has extensor and abductor strength depending on the stiffness of the lower extremities and lumbopelvic stability (Ambegaonkar et al., 2014). Dynamic balance and flexibility values were measured twice as pre-test and post-test. Both groups were made to do mat pilates exercises two days a week for 12 weeks. The mat pilates exercises implemented for 12 weeks are provided in the following table.

Table 1
Mat Pilates Workout Programme

Exercise	Repetition
Hundred	5+5(10 breathes) x10
Roll Up	5-8
Leg Circles	6-8
Rolling like a Ball	6-8
Single Leg Stretch	6-12
Double Leg Stretch	6-12
Single Straight Leg Stretch	6-12
Double Straight Leg Lower Lift	6-12
Criss Cross	6-12
Spine Stretch Forward	5-8
Corkscrew	4-8
Saw	6-8
Shoulder Bridge Prep	5-8
Front and Back/Up and Down/Circles	10-12
Inner Thigh Lift & Circles	8-15
Beats on Belly	10-15
Teaser	3-5
Teaser One Leg	3-5
Swimming Prep	6-10
Push Up	3-5

Data Analysis

Data collected from the study group was analysed using SPSS 22.0 (IBM Corp.; Armonk, NY, USA). Descriptive statistical methods were used for data analysis. Mean ± standard deviation was used for the representation of numeric data, and ratio (%) was used for the expression of categorical data. For SG and FAG mobility and balance and mobility data, the Repeated-measures analysis of variance with one fixed factor was used. Bonferroni correction was performed for statistically significant results in multiple comparisons. Variables were presented as mean ± standard error. Effect sizes were evaluated using partial eta-squared (ηp2). Effect sizes were measured <0.01 small, 0.01-0.06 medium, and >0.14 large (Richardson, 2011). Statistical significance was set for $p < 0.05$.

RESULTS

The study consisted of 30 participants in total, 15 in the SG (age: 19.4±0.4 years, height: 1.70±0.2 cm, weight: 63.2±3.21 kg) and 15 in the FAG (age: 20±0.5 years, height: 1.66±0.1 cm, weight: 59.52±3.39 kg).

Table 2
Demographics

Measures Gender (M/F)	FAG (n = 15) 0/15 Mean ±SE	SG (n = 15) 0/15 Mean ±SE	p
Age (years)	20.00±0.50	19.40±0.43	0.453
Height (m)	1.66±0.01	1.70±0.02	0.085
Body weight (kg)	59.52±3.39	63.21±3.21	0.155
Dominant side (Right/left)	15/0	15/0	

Note. FAG: Former Athlete Group, SG: Sedentary Group, SE: Standard error, m: meter, kg: kilogram

A significant increase was recorded in the intra-group flexibility values in SG ($p<0.001$, $\eta_p^2 = 0.57$) and FAG ($p<0.002$, $\eta_p^2 = 0.31$) after the 12-week mat pilates workout programme. No inter-group difference was observed (Table 3).

Table 3
Flexibility Results (Interaction Factor 1, p<0,001)

Flexibility	Mean±SE			
	Pre-test	**Post-test**	**p value**	**Partial Eta Squared (η_p^2)**
FAG (cm), (n=15),	20.35±1.76*	23.07±1.69*	**0.02**	**0.31**
SG (cm), (n=15)	18.04±1.70	22.53±1.64	**0.01**	**0.57**
P value	0.35	0.82	---	-------------
Partial Eta Squared (η_p^2)	0.003	0.002	---	-------------

Note. FAG: Former Athlete Group, SG: Sedentary Group, Cm: Centimeter, η_p^2: Partial eta squared, SE: Standard error *Time difference ($p < 0.05$).

The star excursion balance test obtained a significant difference of increase in the FAG with inter-group ($p = 0.002$, $\eta_p^2 = 0.29$) and pre-test post-test ($p = 0.04$, $\eta_p^2 = 0.26$) in anterior balance, inter-group ($p<0.001$, $\eta_p^2 = 0.42$) and pre-test post-test ($p = 0.03$, $\eta_p^2 = 0.16$) in postero-lateral balance, inter-group ($p = 0.002$, $\eta_p^2 = 0.29$) and pre-test post-test ($p = 0.04$, $\eta_p^2 = 0.26$) in postero-medial balance (Table 4, 5, 6).

Table 4
Dynamic Balance Results Anterior (Interaction Factor 1, p<0,03)

Dynamic Balance Results (Anterior Right)	Mean±SE			
	Pre-test	**Post-test**	**p value**	**Partial Eta Squared (η_p^2)**
FAG (cm)*, (n=15),	55.92±2.32†*	64.07±2.88*	**0.04**	**0.26**
SG (cm)*, (n=15)	66.80±2.24†	70.66±2.78	0.136	0.08
P value	**0.002**	0.111	---	-------------
Partial Eta Squared (η_p^2)	**0.29**	0.09	---	-------------

Note. FAG: Former Athlete Group, SG: Sedentary Group, Cm: Centimeter, η_p^2: Partial eta squared, SH: Standard error *Time difference ($p < 0.05$). † Inter-group difference ($p < 0.05$).

Table 5
Dynamic Balance Results Posterolateral (Interaction Factor 1, p<0,014)

Dynamic Balance Results (Posterolateral Right)	Mean±SE			
	Pre-test	Post-test	p value	Partial Eta Squared (η_p^2)
FAG (cm), (n=15),	49.57±2.52*†	55.07±2.13*†	**0.03**	**0.16**
SG (cm), (n=15)	64.86±2.24†	68.20±2.06†	0.16	0.07
P value	**0.001**	**0.001**	---	-------------
Partial Eta Squared (η_p^2)	**0.41**	**0.42**	---	-------------

Note. FAG: Former Athlete Group, SG: Sedentary, Group Cm: Centimeter, η_p^2: Partial eta squared, SH: Standard error * Time difference (p < 0.05). † Inter-group difference (p < 0.05).

Table 6
Dynamic Balance Results (Interaction Factor 1, p<0,05)

Dynamic Balance Results (Posteromedial right)	Mean±SE			
	Pre-test	Post-test	p value	Partial Eta Squared (η_p^2)
FAG (cm)*, (n=15),	48.85±2.54*†	54.57±2.51*†	**0.04**	**0.26**
SG (cm)*, (n=15)	62.86±2.24†	66.26±2.42†	0.136	0.08
P value	**0.001**	**0.002**	---	-------------
Partial Eta Squared (η_p^2)	**0.36**	**0.29**	---	-------------

Note. FAG: Former Athlete Group, SG: Sedentary Group, Cm: Centimeter, η_p^2: Partial eta squared, SH: Standard error * Time difference (p < 0.05). † Inter-group difference (p < 0.05).

DISCUSSION

The study examined the balance and mobility values of 30 former athletes and sedentary individuals after doingathletes and sedentary individuals after doing pilates exercises for 12 weeks. It was found out that the FAG and SG had their mobility improved and the FAG had better dynamic balance results than the SG after the pilates workout programme.

Based on the guidelines of the American College of Sports Medicine (ACSM), the flexibility component of the study demonstrated significant improvement through the implementation of the Pilates exercise prescription (ACSM, 2013). More research has examined the impact of incorporating a particular extensibility program into physical education lessons on adolescents' hamstring extensibility (González-Gálvez et al., 2019). These studies, which lasted between five and eight weeks, used three to seven minutes per session, twice weekly, and demonstrated notable improvements following the experimental period (Mayorga-Vega et al., 2014; Sánchez Rivas et al., 2014). These outcomes are related to the current study's findings, which has the benefit that the Pilates method is a more comprehensive approach that enhances extensibility (González-Gálvez et al., 2019).

Although the exact mechanism is unknown, two theories are being considered. The Golgi tendon organ plays a crucial role in regulating muscle tension during stretching exercises. When tension decreases, as is the case in slow stretches associated with Pilates, the Golgi tendon organ inhibits alpha motor neurons, allowing the muscle fibers to lengthen and promoting flexibility and range of motion. This mechanism helps prevent excessive muscle contraction and potential injury during stretching activities. (McArdle & Katch, 2017). Second, the improvement in range of motion associated with stretching exercises, according to Shrier and Gossal, may be attributed to changes in viscoelastic properties (Shrier & Gossal, 2000). This could involve a reduction in the resistance of tissues to deformation or an increased tolerance to the stretching sensation. Kubo et al.'s findings on the effects of static stretching on tendon viscoelasticity align with this explanation (Kubo et al., 2002)

In the literature, studies on pilates exercises about balance rather focus on geriatric (Długosz-Boś et al., 2021), Parkinson's (Çoban et al., 2021), Multiple sclerosis (Arik et al., 2022) and similar neurological origin disorders. Balance is an essential component of all sports. The fact that pilates mainly focuses on core exercises based on the centring principle encourages more research to be done in this field. The literature includes a study of the impact of pilates on footballers' static and dynamic balance performance (Keziban et al., 2020) and a comparison of YBT performances of women who regularly do pilates workouts and sedentary women (Ateş & Öztürk, 2019). However, a comparison of former athletes and sedentary individuals is important for exhibiting the impact of pilates exercises in different populations.

Both groups had their mobility improved after pilates workouts that lasted for 12 weeks. Increased mobility with these exercises for this period of time can be considered normal. Performing the moves in a certain rhythm and harmony and controlling them with resistance at different angles play an important role in improving mobility. Available studies also demonstrate that Pilates can improve mobility (Hınçal, 2019; Karadenizli & Kambur, 2016). Considering the dynamic balance results of the study, there is a significant increase in all directions in the YBT and the pre-test post-test values of the FAG. Considering inter-group differences, a significant difference is present in postero-lateral and postero-medial values.

There is a difference in the pre-test values of the FAG and SG. This difference is in favor of the SG and to the detriment of the FAG. This difference may be attributed to the fact that the FAG covers different branches such as volleyball (4), basketball (4), taekwondo (4), and football (3). It can be said that they did not include misloading or balance education in their branch-specific field training. Because, dynamic balance performance is a whole-body reaction depending on many basic physiological factors including proprioception, sight, vestibular function, reaction time, coordination and muscular strength.

Dynamic posture covers voluntary movement levels based on support. A practice to be implemented on individuals with reduced core stability, muscle imbalance, and abnormal movement patterns is thought to be beneficial in preventing injuries (Ateş & Öztürk, 2019; Yaprak & Dellekoğlu, 2021). When 12-week pilates exercises were included in the training programme of former athletes, their dynamic values rapidly exceeded the values of sedentary individuals thanks to having a sports history. As can be understood here, it can be said that their training did not include balance exercises. In this respect, it is essential to use specific balance exercises in the training programmes for athletes. As can be seen in our study, the increased balance in athletes engaging in pilates exercises compared to the other group is proof of this. The impact of pilates on mobility and balance, especially in athletes, should be paid attention to. In many different sports, it is necessary to have the balancing skills to reach maximum competitiveness and prevent lower extremity injuries (Hrysomallis, 2007, 2011; Kiers et al., 2013). Balance controls visual, vestibular, and somatosensory information to generate motor movements that coordinate the central nervous system and the activation ignition of muscles (Roijezon et al., 2015; Shumway-Cook & Woollacott, 2007; Speers et al., 2002). A systematic compilation published in this field demonstrated that archers' static balance skills were correlated with their shooting accuracy, and ice hockey players' dynamic balance skills were correlated with their skating speed (Hrysomallis, 2011). It was reported that gymnasts had a similar dynamic balance to that of footballers (Bressel et al., 2007; Davlin, 2004). Additionally, it was demonstrated that footballers had a similar dynamic and static balance to swimmers and basketballers (Davlin, 2004; Matsuda et al., 2008; Thorpe & Ebersolei, 2008).

There are few evidence in studies for core muscles (Wirth et al., 2017). Lower abdomen and inguinal injuries are among the most common reasons for pain and loss of playtime in sports (Mulry et al., 2021). Several studies provided information about the importance of core training and testing to enhance performance (Willardson, 2007) and reduce the risk of injury (e.g., back and lower extremity injury; Leetun et. al., 2004; Willson et al., 2005) in various populations (Tabacchi et al., 2019; Trajković & Bogataj, 2020). Spinal stability depends on not only muscle strength but also suitable sensory input, which alerts the central nervous system about the interactions between the body and its surroundings, provides constant feedback, and allows for the improvement of movement (Hodges, 2003). Core stability is considered extremely important for an efficient biomechanical function to maximize force build-up and minimize loads on joints in all activities, from running to throwing (Kibler et al., 2006). In this sense, pilates exercises can have a significant impact on increasing the stability of core muscles.

This study evaluates mobility and dynamic balance between former athletes and sedentary individuals. For this reason, that further research is required to demonstrate the impact of pilates exercises on elite and professional athletes. The limitation of our study is that former athletes are from different sports. It can be suggested that it is necessary to do comparative studies with athletes from a single sport due to the fact that trainings are programmed differently in different sports.

CONCLUSION

It was found that former athletes and sedentary individuals had improved mobility when they engaged in pilates workouts, and former athletes had improved dynamic balance results compared to sedentary individuals when they engaged in core pilates exercises. Great balance and mobility are essential for all sports. Pilates should be used as an exercise component in training models. However, the importance of mobility and balance practices is ignored in training modeling. The results of our study support this situation. It is thought that the increase in the mobility and balance of former athletes who apply Pilates program will reflect positively on their sports branches. Former athletes, whose pre-test results were less than sedentary athletes, showed more post-test results after the Pilates program than sedentary individuals. Consequently, it is important to include Pilates program in the training programs regardless of the branch. Gained balance and mobility means reduced risk of injury. Pilates exercises are crucial to include in programs, especially for physiotherapists who specialize in preventive rehabilitation and athletic performance coaches who design training models.

Acknowledgements

Thanks to Beyza Çınar, Büşra Soner for their contributions in recruitment and data collection. Special thanks also to all participants.

Authors' contribution

All authors revised the manuscript and contributed to the interpretation of the results. All authors have read and approved the final version of the manuscript.

Declaration of conflict interest

Authors declare no conflict of interest.

Ethics Statement

This study was reviewed and approved of by Nevşehir Hacı Bektaş Veli University Non-Invasive Clinical Studies Publication Ethics Board (No: 2300022766, 19.04.2023).

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