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HOW PILATES EXERCISES AFFECT SPORTS PERFORMANCE? A SYSTEMATIC REVIEW

SYSTEMATIC REVIEW

ABSTRACT

Purpose: This systematic review aims to describe and summarise the effects of Pilates exercises (PE) on athletic performance in athletes.

Methods: The published literature was reviewed in the electronic databases of PubMed, Web of Science, and SCOPUS between 01.01.2010 and 01.01.2022. The articles were determined according to the PICO criteria (population, application, comparison, and results) using the keywords "pilates training", "pilates exercises", and "pilates and athlete performance" in the title and abstract sections. The titles and abstracts of articles were screened for relevance to the main research topic of this study.

Results: A total of 151 articles were identified from the database search. Twelve articles were included in the systematic review. The results showed that the studies carried out PE practice between four weeks and 14 weeks. Also, it was found that, PE helps to improve postural stability, static and dynamic balance, agility, muscle strength, flexibility, core strength, muscular endurance, general sprint performance, VO2 max level, coordination, and technical skills in athletes.

Conclusion: Coaches and sports performance specialists can help athletes improve their physical performance and core strength levels by including PE in their training programmes.

Keywords: Athletes, Athletic Performance, Exercise, Exercise Movement Techniques, Movement

PİLATES EGZERSİZLERİ SPOR PERFORMANSINI NASIL ETKİLER? SİSTEMATİK DERLEME

SİSTEMATİK DERLEME

ÖZ

Amaç: Bu sistematik derlemenin amacı, pilates egzersizlerinin sporcularda atletik performans gelişimi üzerindeki etkisini incelemektir.

Yöntem: Mevcut araştırmada, Pubmed, Web of Science (WOS) ve Scopus gibi veri tabanlarında başlık ve özet kısımları içerisinde "pilates antrenmanı", "pilates egzersizleri" ve "pilates ve sporcu performansı" anahtar kelimeleri kullanılarak 01.01.2010 ile 01.01.2022 tarihleri arasında yayımlanan bilimsel hakemli dergilerdeki makalelerin bir listesi çıkarılmıştır. Makaleler PICO kriterlerine (popülasyon, uygulama, karşılaştırma ve sonuçlar) göre belirlenmiştir.

Sonuçlar: Veri tabanlarında yapılan tarama sonucunda yüz elli bir (151) makaleye ulaşılmıştır. Ulaşılan makalelerin başlıkları ve özetleri daha sonra bu çalışmanın ana araştırma konusuyla ilgisi açısından taranmış ve sonuç olarak dahil edilecek makale sayısı on ikiye (12) indirilmiştir. Araştırma bulgularına incelendiğinde, çalışmalarda pilates egzersiz uygulamaları dört hafta ile on dört hafta arasında gerçekleştirilmiştir. Aynı zamanda araştırmalarda pilates antrenmanının sporcularda postürel stabilite, statik ve dinamik denge, çeviklik, kas gücü, esneklik, core kuvveti, kas dayanıklılığı, genel sprint performansı, VO2 max seviyesi, koordinasyon ve teknik beceriyi geliştirmeye yardımcı olduğu görülmüştür.

Tartışma: Bu sistematik derlemenin sonuçlarına göre antrenörler ve fizyoterapistler, pilates egzersizlerini antrenman programlarına dahil ederek sporcuların fiziksel performanslarını ve core kuvvet seviyelerini geliştirmelerine yardımcı olabilirler.

Anahtar Kelimeler: Atletik Performans, Egzersiz, Egzersiz Hareket Teknikleri, Hareket, Sporcu

INTRODUCTION

Pilates activates the musculoskeletal system by using versatile movements in different starting positions, which helps improve strength, endurance, flexibility, and neuromuscular coordination (1). Movements, starting from the center and focusing on the whole body, help the body improve its physical and mental performance by providing strength, posture, balance, and coordination with more breath control (2,3). However, Pilates exercise (PE) is based on six core principles: control, flow, concentration, precision, breathing, and centering (4). Exercises consist of a group of functional moves destined to be performed using only body weight and then with the help of equipment (5,6). Owsley explained that PE can be performed on a mat or with various apparatuses, including a trapeze table, cadillac, wunda chair, reformer, barrel, and the spinal corrector.

Pilates benefits pain control, body posture, flexibility, muscular strength, endurance, body composition, functional autonomy, static balance, motor skills, and specific sports activity components (1). Nevertheless, PE increases muscle strength, endurance, and flexibility and improves balance (8). PE can be an essential tool for improving dynamic balance and precise movement control for physiotherapists and exercise coaches (1). Besides positive contributions to athletes, PE has been reported to reduce pain and improve functional movements in people with low back pain (9,10,11). In addition, PE improves scoliosis by maintaining body balance and strengthening weak muscles that cause postural disorders (12). Furthermore, PE positively affects mood, quality of life, and psychological illnesses including anxiety and depression (13).

Athletes, coaches, and physiotherapists aim to

achieve sporting success by improving athletic performance (14). While muscle strength improves athletic skills such as jumping, sprinting, and changing direction, increasing athletic performance reduces the risk of athletic injury (15). The neuromuscular system's abilities, such as maximal power production, sprinting, jumping, and throwing, are important for achieving maximum performance (16). PE is generally observed to be increasingly included in athletic training programs aimed at improving performance and preventing injuries (2). There is no previous systematic review study investigating the effect of Pilates on sports performance. However, the literature lacks a systematic review of the influence of PE on sports performance. A systematic review of the effects of PE on sports performance could help to identify the lack of management of such effects, thereby optimizing athlete performance. This systematic review aimed to identify the influence of PE on sports performance.

METHOD

This study was a systematic review of articles published in various scientific and peer-reviewed publications. This study proposes a systematic review of peer-reviewed literature on the effects of PE on athletic performance. In this respect, a keyword search for "Pilates training", "Pilates exercises", and "Pilates and athlete performance" was performed in databases such as Web of Science (WOS), PubMed, and Scopus to extract a list of journal articles published between 01.01.2010 and 01.01.2022. Following the database search, the reference lists of the extracted articles were reviewed.

Data collected from databases were blended and standardized in such a way as to create a new

Table 1. PICO Criteria

	Criteria
Population	Athletes
Application	Pilates exercise application for athletes
Comparison	Control group The experimental group (mat pilates, reformer/Cadillac pilates, swiss ball)
Outcome	Physical and physiological responses (posture, static and dynamic balance, agility, muscle strength, flexibility, chorea strength, muscular endurance, running performance, coordination, technical skill, VO2max)

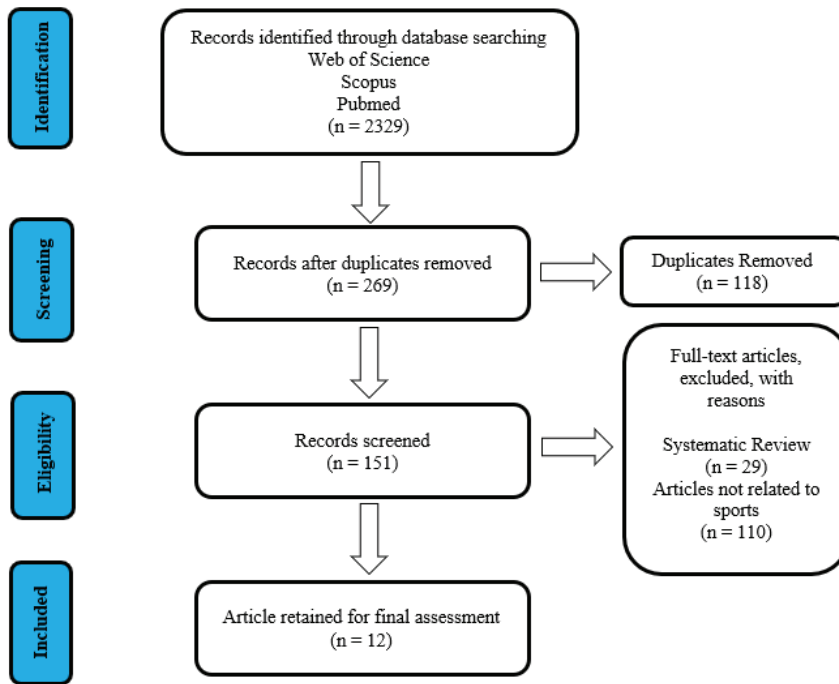


Figure 1. PRISMA flow diagram

dataset relevant to the purposes of the present study. The databases were limited to peer-reviewed journals published in English only. A systematic literature review was conducted following PRISMA recommendations (17). The search in databases using the keywords yielded a result of hundred and fifty-one (151) journal articles. The titles and abstracts of the retrieved articles were then screened in terms of relevance to the research topic of the present study, namely, the athletic performance of athletes. As a result, the number of articles included was reduced to 12 (12). Articles were included according to the PICO criteria (18).

FINDINGS

This part of the study is devoted to presenting an overview of relevant findings about the impact of PE on athletic performance.

Training Practices

Recent research has shown that various interventions can be used to improve athletic performance. Pilates practices incorporated in training programs include: i) Mat Pilates (19, 20, 21, 22, 23, 24, 25, 26, 27), ii) Reformer (or Cadillac) Pilates (23, 28),

(iii) Swiss ball exercises (20), and (iv) Plyometric training (19).

Physical and Physiological Performance Evaluation

PE has been reported to improve athletic performance in various sports. Pal et al. showed that PE improves balance and core strength in Karate athletes. Similarly, Kamatchi et al. reported that PE efficiently increased the core strength of cricket players. On the other hand, Park et al. demonstrated that PE increases muscle mass, body, and shoulder strength, and the hamstring-to-quadriceps strength ratio in baseball players. Preeti et al. reported significant improvements in lower-extremity dynamic balance, agility, strength, and coordination regarding performance increase in badminton athletes due to the incorporation of PE in training programs. The findings of Montesano and Mazzeo indicate that PE helps improve flexibility, muscular endurance, and serving and shooting skills in volleyball players. Furthermore, surveys by Ahearn et al. and Amorim et al. suggest that incorporating PE in training programs improves strength, flexibility, and postural stability in dancers. While PE helps in-

Table 2. Physical and Physiological Responses to Pilates Exercise Intervention

Reference	Sample	Treatment Group	Duration of Intervention (weeks/frequency)	Type of Pilates	Certificated Instructor	Outcome Measure	Results
Pal et al., 2021	Karate Athletes (M=120)	PG=40 (21.10±1.48) PTG=40 (21.00±1.77) CG=40 (21.10±1.87)	Eight weeks 3 days/60 min	Mat Pilates	NA	Star Excursion Balance Test Trunk Flexor Test Trunk Extensor Test Lateral Musculature Test	Physiometrics and PT improved karate athletes' balance and core strength. However, plyometric training positively affected core strength and dynamic balance more than the pilates group.
Park et al., 2020	Baseball Athletes (N=8)	PG=8	Eight weeks 3 days/ 50 min	Reformer/Cadillac Pilates	NA	BIA Isokinetic Testing	PT increased muscle mass, hamstring/quadriceps ratio, and trunk and shoulder strength.
Kamatchi et al., 2020	Cricketer Athletes (M=50)	PG=15 SBG=15	Six weeks 4 days/ 30 min	Mat Pilates	NA	Double Leg Lowering Test Sphygmomanometer	It has been observed that PEs are more effective in improving core muscle strength than Swiss ball exercises.
Presti et al., 2019	Badminton Athletes (M=20)	PG=10 CG=10	Five weeks 2 days/25 min	Mat Pilates	NA	10 m Shuttle Run Test Vertical Jump Test Star Excursion Balance Test Hand and Eye Coordination Test	PEs have improved lower-body strength, agility, dynamic balance and coordination skills.
Greco et al., 2019 ^a	Volleyball Athletes (FM=56)	PG=28 (15.1±1.6) VTG=28 (15.9±1.8)	The experimental group (n=28) has been utilizing the team physiotherapist's PT program in addition to the volleyball team's training for at least two years.	NA	NA	Sit and Reach Test Vertical Jump Test Countermovement Jump Test	It has been observed that PT does not improve hamstring flexibility and lower extremity explosive strength.
Greco et al., 2019 ^b	Volleyball Athletes (FM=20)	PG=10 (15.3±0.7) VTG=10 (14.9±0.7)	Eight weeks	3 days/30 min	Mat Pilates	NA	Sit and Reach Test Vertical Jump Test
Finatto et al., 2018	Runner Athletes (N=32)	PG= 16 (18.42±0.51) CG=16 (18.44±0.52)	Twelve weeks	21 hours weekly	Mat Pilates	NA	BIA Electromyographic Variables
Ahearn et al., 2018	Dancer Athletes (FM=20)	PG=20	Fourteen weeks	7 days Reformer: 50 min Mat:45 min	Mat/Reformer Pilates	YES	Aligna Posture Assessment Double Leg Power Test Upper Abdominal Muscle Test Modified Thomas Test Hamstring Flexibility Test
Montesano and Miazzeo, 2018	Volleyball Athletes (M=20)	PG=10 CG=10	Eight weeks	NA	Mat Pilates	NA	Service and Smash Accuracy
Park et al., 2016	Archer Athletes (N=20)	PG=10 (17.30±1.06) CG=10 (17.00±0.67)	Twelve weeks	3 days/60 min	Mat Pilates	NA	Static and Dynamic Balance Test
Chimavan et al., 2015	Football Athletes (FM/M=50)	PG=15 CG=15	Four weeks	5 days/30 min	Mat Pilates	NA	Goniometer Test Sit and Reach Test
Amorim et al., 2011	Dancer Athletes (FM=12) (M=5)	PG=7 (15.7±0.8) CG=8 (11.0±2.7)	Eleven weeks	2 days/60 min	Mat Pilates	NA	Muscular Strength Measurement Flexibility Measurement

PG: Pilates Group, CG: Control Group, SBG: Swiss Ball Group, PLG: Plyometric Group, VTG: Volleyball Training Group Min: Minute, NA: Not Available, BIA: Body Impedance Analysis, N: Sample, F: Female, M: Male.

crease hamstring flexibility in football players (26), it has also been reported to be efficient in facilitating static and dynamic balance in archers (25). According to the conclusions of Finatto et al. PE helps increase the Vo2 max level and sprint performance in sprinters. PE is not efficient in improving hamstring flexibility or lower limb explosive strength in volleyball players (29). However, while PE did not positively affect explosive strength, flexibility was improved (21).

DISCUSSION

This study proposes a systematic review of peer-reviewed literature on the impact of PE on athletic performance. In today's world, in sports competitions at the national or international level or in Olympic games, trainers and coaches must apply scientific methods and approaches to maximize athletic performance. Kordi argued that trainers and coaches need to utilize the best exercise methods to help athletes reach optimal performance levels. Providing support to this argument, Amtmann et al. demonstrate that workout programs involving adequate strength and conditioning contribute to higher athletic performance levels. The literature offers further evidence to support these arguments. For instance, Preeti et al. reported significant increases in lower extremity dynamic balance, strength, coordination, and agility in badminton athletes' physical performance due to the incorporation of a five-week Pilates workout in training programs. Similarly, Park et al. argued that a twelve-week Pilates workout improved the static and dynamic balance in archers. Several studies have found that PE improves balance performance in baseball athletes (32). PE can significantly improve abdominal endurance, hamstring flexibility, and upper-body muscular endurance in active middle-aged men and women. However, it did not significantly improve posture or balance (33). PE was performed slowly and with control. This helps to improve balance by allowing focus on body alignment and preventing loss of balance.

Similarly, Park et al. demonstrated that PE increases muscle mass, body, and shoulder strength, and the hamstring-to-quadriceps strength ratio in baseball players. Similar results have shown that PE positively affects trunk strength in baseball ath-

letes (32). Another study showed that a 12-week study was conducted to assess the effects of mat Pilates on running efficiency. Sixteen participants were randomly assigned to either the experimental group, which performed mat PE two days a week for 60 min, or the control group, which did not perform any exercise. At the end of the study, the experimental group showed significantly improved running efficiency compared to the control group (22). In addition, PE improves abdominal and back muscle strength in sedentary women (34). On the other hand, comparing the effects of Swiss ball exercises and Pilates workouts on athletic performance, Kamachi et al. indicated that PE appears more efficient in increasing core strength. Pilates involves more dynamic movements, such as single-leg stretches, double-leg stretches, and double straight-leg stretches, which may be more effective in improving core strength than Swiss ball exercises. Comparing the impact of PE and plyometric training on karate athletes' performance, plyometric training yields better results in improving balance and core strength (19). Eight weeks of PE significantly improved agility and functional mobility but did not significantly improve VO2 max in elderly women (35). A 5-week study was conducted to assess the effects of mat pilates on lower limb strength, dynamic balance, agility, and coordination in male athletes. Twenty male athletes were randomly assigned to either the experimental group, which performed mat PE two days a week for 60 min, or the control group, which did not perform any exercise. At the end of the study, the experimental group showed a significant difference from the control group in terms of lower limb strength, dynamic balance, agility, and coordination (2). The dynamic balance ability of the exercise group significantly improved after 12 weeks of mat PE, which was applied 3 days a week for 60 min each time (25). A study compared the effects of mat Pilates and Swiss ball exercises on core strength. The study included 30 randomly assigned participants to either the mat Pilates or Swiss ball group. Both groups exercised for 30 minutes, 4 days a week, for 6 weeks. At the end of the study, the mat Pilates group had significantly improved core strength compared with the Swiss ball group (20). Futsal athletes who performed mat PE for 25 minutes, 3 days a week for 4 weeks showed signif-

icant improvements in flexibility (36). PE strengthens the core muscles, which support the spine and pelvis. Strong core muscles help improve balance by providing a stable support base. Furthermore, good posture and balance depend on core muscles that support the spine and pelvis.

Regarding the relationship between PE and performance increase in dancers, Amorim et al. showed that PE yields improved muscular strength and flexibility. Similarly, Ahearn et al. reported that Pilates workouts helped improve dancers' posture, strength, and flexibility. PE also helps increase hamstring flexibility in football players (26). Another study showed that Pilates positively affected flexibility in futsal athletes (36) and sedentary individuals (33). According to Finatto et al., incorporating PE in sprinters' training programs can improve muscular strength, Vo2 max level, and overall sprint performance. In contrast to these findings, Gildenhuis et al. reported in a study on sedentary individuals that eight weeks of PE did not improve VO2 max capacity, and that an additional training model should be used in addition to PE for improvement. The results showed that PE had a positive effect on athlete performance. This effect can be observed in sedentary individuals with additional exercises that improve their motor characteristics.

PE does not improve 13-18 aged young female volleyball players' hamstring flexibility or lower extremity explosive strength (21). In another study of 14-16 aged young female volleyball players for eight weeks, PE enhanced flexibility but did not increase the explosive strength of female volleyball players (29). Although both studies were conducted on young female volleyball athletes, the age ranges of the two studies differ significantly. However, Considering the effects of relative age, biological maturation, and training experience on athlete performance, such a difference seems likely. In contrast to these findings obtained in lower extremity explosive strength, El-Sayed et al. stated that PE improved lower extremity explosive strength in young volleyball players. PE has been reported to improve muscular endurance, flexibility, serving, and shooting in volleyball players (24). PE can help improve the range of motion and flexibility in all major muscle groups. This can help athletes move more freely and efficiently, which can reduce their

risk of injury. Pilates is a great way for athletes to improve their lower and upper body strength, balance, and flexibility. This low-impact workout can be tailored to the needs of individual athletes. However, Pilates can help athletes improve their sports performance and reduce the risk of injuries.

This systematic review aimed to reveal the effects of PE on sports performance. According to the studies conducted in this context, PE positively improved posture, static and dynamic balance, agility, muscle strength, flexibility, core strength, muscular endurance, running performance, VO2 max, coordination, and technical skills in athletes. The effects of PE on sports performance revealed that coaches and experts can improve the physical performance characteristics of athletes by including PE in their training programs. Although studies have investigated its effect on physical performance, no study has investigated its effect on the technical development of athletes. Researchers' reflections on the impact of Pilates and technical skills will create different perspectives on sports performance.

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