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Effect of Pilates Exercise for Football Players on Hamstring Flexibility Using Kinovea Software - A Quasi-Experimental Study

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Abstract. Hamstring injuries are common in sports activities like explosive moves, sprinting and kicking with football players experiencing them at a rate of 16–23% of all injuries. Incorporating Pilates training into flexibility regimens showed promise for enhancing hamstring flexibility among football players, surpassing the effectiveness of stretching alone. This study aimed to examine the impact of hamstring flexibility using Kinovea software after Pilates training. This quasi-experimental study invites 34 male football players aged between 18 and 25, of whom 30 met the inclusion criteria. The players were engaged (n = 30) in Pilates exercises; the pre- and post-test values were assessed using Kinovea software video analysis by an AKE and SRT test.The results demonstrated significant improvements in players hamstring flexibility and muscle performance in both groups. Pilates exercises showed a statistically significant increase (p value) in mean scores for the SRT (33.75+4.76) and the AKE test (46.83+5.40). Pilates exercises are effective in increasing hamstring muscle flexibility among football players. In addition, this study shows the feasibility of flexibility assessment using Kinovea software, which shows the advancement in assessment methods in the sporting population.

Keywords*: Football, Hamstring Flexibility, healthy lifestyle, Kinovea Software, Pilates.*

INTRODUCTION

Football also referred to as soccer in North America, holds the title of the most universally embraced sport worldwide, with an estimated 200 million participants [1]. The rising number of players is leading to a higher risk of injuries, resulting in significant medical expenses and missed playing opportunities [2]. Therefore, it is essential to implement injury prevention measures. Recognizing this necessity, the FIFA's governing body has acknowledged the importance of actively engaging in the advancement and sponsorship of football-related research [3]. Hamstring injuries make up 16–23% of all injuries sustained by football players, causing disruptions in running mechanics [4]. These injuries can significantly impair performance and may progress to more severe complications such as muscle imbalances and reduced flexibility, particularly tightness, posing significant challenges for players [5]. Insufficient flexibility presents a barrier to optimal performance and increases susceptibility to muscular injuries [6]. The force generated during kicking relies heavily on muscle flexibility, yet the extending potential of tendons, ligaments, and capsules is constrained by their role in articular stabilization [7].

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Previous research indicates that static stretching has been associated with decreased knee extension and jump performance [8]. As a result, dynamic stretching is preferred as it offers superior enhancements in performance, yet there is presently insufficient robust scientific evidence to support their efficacy in facilitating player regeneration [9,10]. Pilates exercise has been found to increase muscular elasticity combined with increased power and flow, improving both flexibility and strength by engaging in activities that involve dynamic movements such as swinging, twisting, jumping, and kicking [11].

Kinovea Motion Analysis Software is a free, open-source tool developed for video-based analysis, making it valuable for medical professionals, athletes, and coaches. Primarily used in the playing area, Kinovea allows detailed evaluation of movements with biomechanical patterns. Utilizing the Kinovea Computer Program (KCP), investigators can measure distance, speed, and line extension within specific videos that are captured [17]. The analysis data can be exported to Excel for further examination. Captured videos were evaluated using the stable version of Kinovea v0.8.15 software. This function supports accurate motion analysis. and is useful in optimizing rehabilitation strategies [18]. It is a 2D motion analysis software for movement alalysis that operates under the General Public License version 2 (GPLv2). Created in 2009 by a global non-profit collaboration of scientists, athletes, coaches and developers, Kinovea allows for the verification of distances, angles, coordinates and parameters. Spatiotemporal With precision and detail in video clips frame by frame to validate the readings recorded.

The Sit and Reach Test (SRT) is an assessment for flexibility. particularly targeting the hamstring and lowback muscles [19] It has found application in various fitness assessments. Includes specific tests for sports such as football, gymnastics and track and field [20]. Keep your knees straight and lean forward to touch your toes. This test is a quantitative measure of hamstring and lumbar flexibility [21]. Accuracy in form and technique is essential to achieving accurate results. Additionally, differences in testing methods, such as equipment selection or technique, measure may influence the results [22]. In summary, SRT has proven to assess hamstring flexibility in a wide range of groups [21]. The reliability, validity, and availability of normative data allow it to be used in Research and real-world situations are possible. This assessment will help prevent injury. Increase efficiency and monitor the effectiveness of flexible interventions [23].

The Active Knee Extension (AKE) test is a widely used clinical assessment for hamstring (ROM) [24]. The examiner then passively extends the knee until the participant submits. Signaling that discomfort or stretching threshold has been reached, ROM measurements are performed using a goniometer placed over specific landmarks on the body. Includes the lateral epicondyle, lateral malleolus and the greater trochanter [25].

Joseph Pilates named his method "Control" which reflected his belief that Engaging the mind to control the muscles [12]. The training focuses on improving core strength, posture, and overall flexibility. At the same time, combining breathing with movement [13]. as it claims to maintain a balance of strength, flexibility and improve movement efficiency [14] Therefore, the purpose of this study was to evaluate the effect of Pilates training on hamstring flexibility using the Kinovea software.

CLINICAL DESCRIPTION

Participants

Thirty male football players aged between 18 and 25 were accepted to enroll in the study. All participants were playing from the regional level to the state level in football games. The participants underwent a baseline assessment for hamstring flexibility using (AKE) test with a knee angle less than 120 degrees in kinovea video analysis. Those with acute knee injuries or recent surgeries who did not meet the baseline criteria were excluded. In total, 30 participants met the study inclusion criteria [28]. SR box, smart phone camera, computer system, kinovea motion analysis software were the advanced technological tools used in this study.

Procedure

Participants were fully explained about the study's goals, procedures, possible risks and Willingly agreed to take part by signing a consent form. The research was conducted at SPS Sports Academy in Chennai, involving 30 participants adhering strictly to predefined exclusion and inclusion criteria. Prior to commencing the procedures, written consent was collected from each individual. Subsequently, participants assigned to do Pilates Exercise (Table-1). Over a four-week period, all participants underwent five weekly sessions, with adequate recovery periods

incorporated. Participants will be instructed to abstain from engaging in weight training activities throughout the experimental phase. Pre-test assessments will include measurements using kinovea video analysis software for the AKE test and SRT test [27]. Each participant will engage in training sessions to the best of their abilities and capacities during each session. Post-test evaluations will be conducted upon the completion of the fourth week. The gathered data will subsequently undergo statistical analysis utilizing the predetermined analytical approach.

Treatment Protocol

TABLE-1. pilates exercise protocol

Exercises	Week-1	Week-2	Week-3	Week-4
Leg circles	2x20	2x20	2x20	2x20
Leg up and down	2x20	2x20	2x20	2x20
Scissors	2x10	2x10	2x10	2x10
Side kick	2x10	2x10	2x10	2x10
Pilates-push up	2x10	2x10	2x10	2x10
Dynamic hamstring stretches	1x10	1x10	1x10	1x10

Outcome

Sit and Reach Test (SRT)

This test has good construct validity as it effectively discriminates between individuals with different levels of flexibility and shows high test-retest reliability [21]. Participants undergo the SRT both prior to and following the training period. With legs kept straight, the individual leans forward, sliding their fingers along the table's surface to reach as far as they can. Since the 'SR' table usually extends 15 cm beyond the toes, reaching 10 cm past the toes results in a score of 25 cm, with the best three scores recorded for evaluation [22]. The SRT trials were recorded, and videos were transferred to system, a marker was placed on the tip of the finger at the starting position, utilizing Kinovea's "Marker", the coordinates of the marker's end position were recorded after the participant reached forward to their maximum distance and held the position for 5 seconds. The horizontal distance between the start and end coordinates is measured using "Line" tool [17].

Active knee extension (AKE)Test

The AKE test is an accurate and reliable way to measure hamstring flexibility. Its widespread use in clinical practice and sports is supported by strong evidence of accuracy and stability [23]. Participants performed tests before and after a training session. AKE was the procedure used to assess hamstring flexibility, the athlete lies on their back with hip and knees in a neutral position. This allows accurate measurement [24]. Stabilization of the trunk and pelvis is essential, achieved through natural weight distribution and proper positioning. To accurately obtain the range of motion, a marker is placed with a specific alignment. axis positioned at the lateral epicondyle pointing at the greater trochanter [25]. Record the entire movement from the side using a phone camera to capture the hip and knee angles, and ensure the video is calibrated for analyzing the extension angle [26].

STATISTICAL ANALYSIS & RESULTS

The data was analyzed using SPSS, both the demographic variables and outcome measures were assessed for normality, with Shapiro-Wilk test confirming a normal distribution. Consequently, within-group data for AKE and SRT tests were obtained using a paired t-test, The Statistical values are given in tables below.

Football players in the Pilates group demonstrated significant improvements, as evidenced by the (SRT), with scores increasing from a pre-test Mean = 27.51 (Standard Deviation = 4.25) to a post-test mean = 33.75 (SD = 4.76).

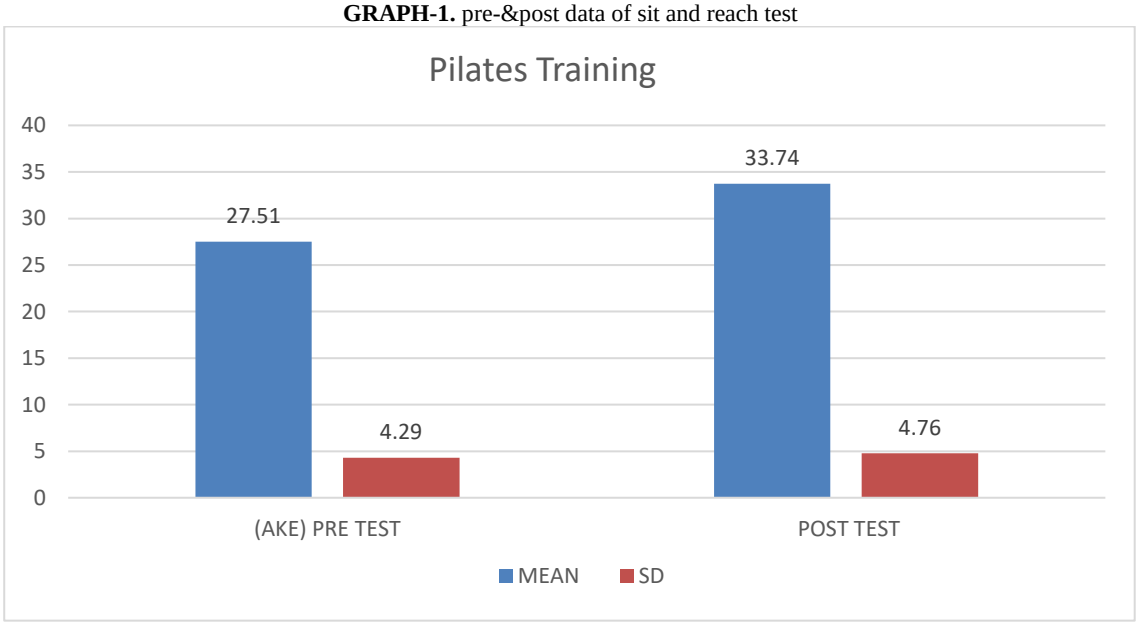
The statistical analysis showed t (29) = 9.2428, $p < 0.001$. Similarly, in the (AKE) group showed notable gains in hamstring flexibility, with pre-test score averaging 35.70 (SD = 6.50) and post-test scores averaging 46.83 (SD = 5.40), resulting in t (29) = 7.9471, $p < 0.001$.

The findings indicated a statistically significant increase in hamstring flexibility, this is evidenced by increased scores on both the SRT and AKE tests after the post-intervention. Especially the mean scores on the SRT and AKE tests showed a significant increase from the pretest to posttest assessments, with p values less than 0.05 indicating statistical significance. And these findings suggest that Pilates exercises significantly improve hamstring flexibility in soccer players. It is a possible alternative to the traditional one. Static expansion method the use of Kinovea software for video analysis has proven effective in measuring and evaluating flexibility improvements. It demonstrates the software's benefits in sports performance and recovery contexts.

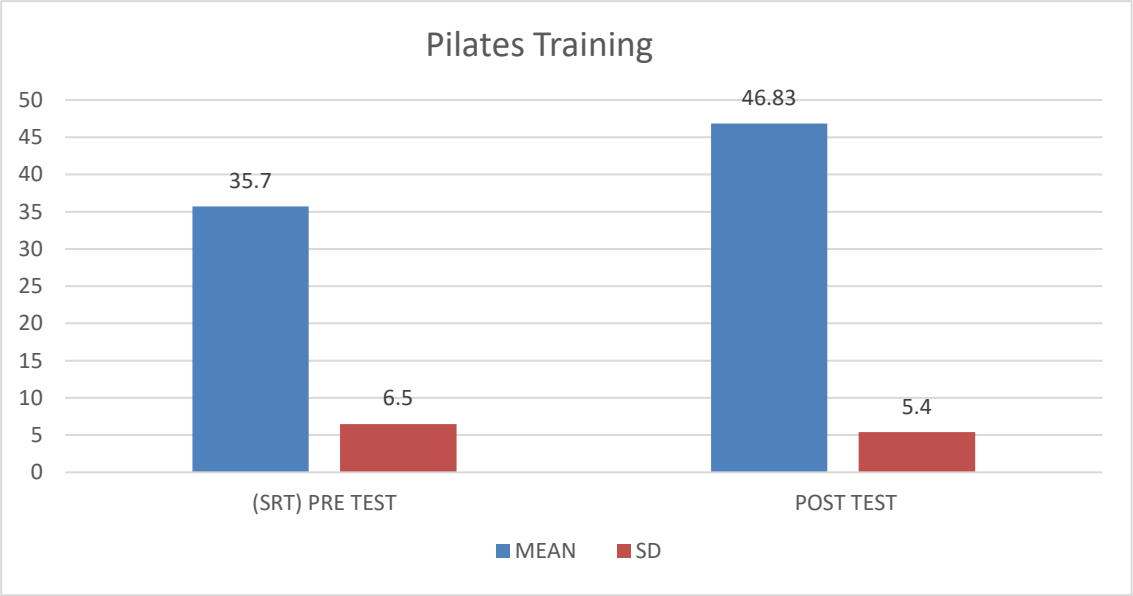
TABLE-2. pre and post test values for pilates group

Outcome	Test criteria	Mean	SD	T Value	P value
SRT Test	Pre-test	27.51	4.29	9.2428	<0.001
	Post-test	33.74	4.76		
AKE Test	Pre-test	35.70	6.50	9.2428	<0.001
	Post-test	46.83	5.40		

GRAPH-1. pre-&post data of sit and reach test



GRAPH-2. pre-&post data of active knee extention test



DISCUSSION

The results provide valuable perspectives on the efficacy of Pilates exercises in increasing hamstring muscle flexibility among football players. The discussion will focus on the implications of the results, potential mechanisms underlying the observed effects, comparison with previous literature, and limitations of the study.

Firstly, the results demonstrate that Pilates exercises led to significant improvements in hamstring flexibility, as indicated by kinovea video analysis software in the SRT and AKE tests.

Witvrouw et al., (2003) concluded that decreased muscle ROM is a risk factor for muscle injuries. This suggests that incorporating either of these exercise in the training regimen for players in football can effectively enhance hamstring flexibility, which is crucial for preventing injuries such as hamstring strains.

These findings align with previous research by Gopalakrishnan et al. (2015), who also reported the beneficial effects of Pilates training on hamstring flexibility among football players. The observed improvements in flexibility may be attributed to several factors. Pilates exercises involve dynamic movements that target the hamstring muscles, promoting elongation and relaxation of the muscle fibers. Additionally, this report strengthens the present study findings among football players that pilates exercises improve hamstring flexibility, that may also have positive effects on athletic performance, particularly in activities such as sprinting and jumping. This study adds value to the current body of literature concerning injury prevention and performance improvement among football players [15].

By identifying effective exercise interventions for increasing hamstring flexibility and muscle performance, coaches and sports medicine professionals can develop targeted training methods to reduce the incidence of hamstring strain and optimize athletic performance among football players [16].

The use of Kinovea software for video analysis adds a layer of precision to the study, allowing for accurate measurement of changes in hamstring mobility. The AKE and the SRT are well-established methods for assessing hamstring flexibility, and their combination with Kinovea software enhances the reliability of the results.

LIMITATIONS

Even though the results are good However Several limitations should be acknowledged. Small sample size may restrict to validate these results and increase their relevance to a wider range of football players. Future research should involve a more diverse population. Additionally, the duration of the study was limited to four weeks. This may not be sufficient to conclude the long-term effects of the intervention on flexibility and injury prevention long-term follow-

up are needed. In addition, the studies did not evaluate exercise patterns or variables. This may cause confusion, such as concurrent training activities or dietary habits. This means that female athletes or athletes of different skill levels are not applicable, future studies should include a diverse participant population to examine potential gender differences and differences in training response. This is because software performance may vary when used with diverse or clinical populations.

CONCLUSION

Pilates exercises have been shown to effectively increase hamstring flexibility in football players. Additionally, this study demonstrates the practicality of using the Kinovea software for assessment. flexibility This marks a significant advance in assessment techniques for athletes.The results advocate for the integration of Pilates into football training programs to improve flexibility and potentially lower the risk of hamstring strains. These findings underscore the benefits of modern assessment tools and innovative training methods in optimizing athletic performance and injury prevention.

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