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A PRELIMINARY COMPARATIVE STUDY ON THE EFFECTS OF PILATES TRAINING ON PHYSICAL FITNESS OF YOUNG FEMALE VOLLEYBALL PLAYERS

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ABSTRACT

Introduction*: Volleyball is one of the world's most popular sports and because of its enormous popularity many studies have been conducted in an attempt to understand the better method training required to develop fitness performance by a volleyball player. Among which, Pilates exercises have also offered new effective methods for increasing strength and enhancing flexibility. However, many studies have looked at the benefits of Pilates-based exercises only for low back pain and improvement of a person's quality of life. Therefore, the purpose of this preliminary causal-comparative study was to examine the effects of Pilates training on some physical fitness components in young female volleyball players.*

Materials and methods*: 56 female players (13-18 years) were recruited and assigned to two groups: a Pilates group (n = 28) performing a Pilates training program since at least two years by the team physiotherapist in addition to volleyball team training, and a standard volleyball training group (n = 28) that has never practiced Pilates before. All participants were tested on the sit and reach and vertical jump (height and power by squat jump and countermovement jump). Comparison by one-way ANOVA revealed no significant differences between the groups (p > 0.05) both for the sit and reach and vertical jump tests.*

Results*: Pilates training and standard volleyball training groups did not differ significantly at baseline in anthropometric characteristics (p > 0.05). Statistical analysis of the data revealed no significant differences between the groups for the sit and reach test squat jump test and countermovement jump test.*

Conclusion*: our data suggest that Pilates exercises program could be not sufficient to cause significant improvement in hamstring flexibility and lower limb explosive strength. Future research with rigorous experimental design is needed to assess Pilates effectiveness.*

Keywords*: flexibility, explosive strength, mat-work, volleyballers,causal-comparative study.*

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Introduction

Volleyball is one of the world's most popular sports and because of its enormous popularity many studies have been conducted in an attempt to understand the better program training required to develop fitness performance by a volleyball player [14, 26]. Actually, the development of muscle strength and specific technical skills are particularly important for young[17] and especially to female athletes[27], as priority factors to achieve success[9, 24, 28, 31].

The ability to jump plays an effective and important role in volleyball, it has to be said that is an important factor for successful volleyball performance[26, 39]. Also developing flexibility is important because it increases joint ROM and could reduce injury risk[39, 4]. Coaches and physical educators employ advanced exercises in order to improve and enhance physical and technical skills in their trainees. Among which, Pilates exercises have also offered new effective methods for increasing strength and enhancing flexibility.

Pilates is an exercise system started in Germany nearly hundred years ago[2]. Pilates training is a popular form of exercise, which mandates specific movement patterns, unique positions and equipment, specialized instructors, and purports benefits of positive changes in body composition/appearance, flexibility, muscle function, and posture[34]. The Pilates exercises can be carried in two different ways. Exercises done on a mat on the floor are called "mat work" [8]. Among the apparatus used in Pilates are trapeze tables, Cadillac, wunda chair, reformer, barrel, spine corrector[35]. Pilates method incorporates six key principles namely centering, concentration, control, precision, breath and flow[29]. These techniques are recommended as modern exercise methods, both for general exercises and for volleyball training in particular, to strengthen weak muscles[1]. The increasing popularity of Pilates as an exercise method has caught the attention of researchers who are interested in the potential health benefits[5, 12, 23, 32, 33, 41, 42].

Many a number of studies have looked at the benefits of Pilates-based exercises for low back pain, maintenance of functional capacity, and improvement of a person's quality of life[22, 30, 32, 33, 34, 37, 38, 40], only a few studies have evaluated the effectiveness of Pilates training on the physical fitness of athletes[3, 13, 21] and volleyballers in a specific way[14, 25]. Several previous studies demonstrated that Pilates training promotes improvements in the physical fitness of young athletes[3, 14, 21, 25], the study by da Cruz et al. is not in line with this literature[13].

Moreover, all these studies showed differences in manipulation of training variables (i.e., intensity and volume in particular), Pilates training methods (mat exercises vs. apparatus), and some studies with athletes did not use a control group[14, 21]. Unfortunately, the scientific understanding of this issue remains unclear and for this reason we designed a preliminary study to compare the effects of Pilates training on physical fitness of the volleyball players. We compared performance of two young female players groups (one practicing Pilates and the other not) on hamstring flexibility and explosive leg strength.

Materials and methods

Research design

In this research, a causal-comparative study design also known as ex post facto was used in order to collect the data from sit and reach, squat jump and countermovement jump tests to measure hamstring flexibility and explosive leg strength, respectively. These continuous data, representing the outcome variables, were used to compare the groups[11]. The results of the comparative analysis were defined by statistically significant differences between the two groups (Pilates training group and standard volley training group).

Participants

Fifty-six female subjects between 13 and 18 years of age volunteered to participate in this study. All of the subjects were recruited by Under 16 Women's Volleyball teams in provincial level competitions that perform a regular physical training averagely of 3 sessions ·wk-1. An a priori power analysis[15] with an assumed type I error of 0.05 and a type II error rate of 0.20 (80% statistical power) was calculated for measures of physical fitness and revealed that at least 27 participants per group would be sufficient to observe medium fixed effect (i.e., one-way ANOVA). Participants were assigned to two groups: a Pilates group (n = 28; mean age, 15.1 ± 1.6 years; body mass, 58.0 ± 4.7 kg; and height, 166.7 ± 5.3 cm) performing a Pilates training program since at least two years in addition to training for the volleyball team, or a standard volleyball training group (n = 28; mean age, 15.9 ± 1.8 years; body mass, 55.1 ± 5.9 kg; and height, 164.4 ± 6.1 cm) that has never practiced Pilates before. The inclusion and exclusion criteria for participation were: (a) had practiced volleyball for at least 2 years; (b) had no previous injury that could interfere with the study; and (c) was not currently using nutritional supplements. All volunteers were accepted for participation. All participants and their parents received a complete explanation in advance about the purpose of the experiment, its contents, and safety issues based on the Declaration of Helsinki, and provided their informed consent. Pilates group participants reported being trained by a physiotherapist with certification in Modern Pilates mat exercises. This study was conducted in May 2018.

Testing procedures

All testing procedures were performed at a school sports facility. Measurements were made from 3:00 to 5:00 pm, prior to the volleyball training. Before testing, the subjects abstained from physical exercise for 1 day, drank no caffeine-containing beverages for 4 hours, and ate no food for 2 hours. Verbal encouragement ensured maximal effort throughout all tests. Prior to data collection all subjects participated in one introductory session during which time proper form and technique on each physical fitness test were reviewed and practiced. During this session research assistants demonstrated proper testing procedures and participants practiced each test. The same researchers tested the participants. Each subject performed the tests on 2 separate days with a 24-hr interval between visits for the following procedures: (a) sit-and-reach test; (b) vertical jump. During the evaluation the training load (technical and tactical training) expected of the athletes was reduced.

Sit and reach test: This test measures the flexibility of the lower body. The sit and reach box (Cartwright Fitness, Chester, UK) was braced against a wall and subjects sat with their legs fully extended (medial sides of their feet 20 cm apart, no shoes) and bottoms of the feet against the box. While exhaling, subjects slowly bent forward toward the top of the box with 1 hand over the other. The technician ensured that the knees stayed in full extension and that movement was conducted slowly and smoothly. Subjects performed 4 trials, each held for 1-2 seconds, and the farthest reach was recorded in centimeters[20]. A standardized warm-up procedure consisting of 5 min of jogging at a comfortable speed was performed before test. The test-retest reliability reported a high reliability for this test (ICC = 0.95).

Vertical jump: To assess the explosive strength of the lower limbs and the ability to use a stretch-shortening cycle with leg muscles[7] the Vertical jump was performed through 1) the Squat jump and 2) countermovement jump tests, and the data for variables of height (cm) and power (W) were provided using an App installed on an iPhone 6s (Apple Inc., USA), named "My Jump" and validated by Gallardo-Fuentes et al.[18]. This app was designed for analysing vertical jumps to allow the calculation of the time (in ms) between two frames selected by the user and subsequently to calculate the height of the jump using the equation described in the literature: $h = t^2 \times 1.22625$, with h being the jump height in metres and t being the flight time of the jump in seconds[6]. The participants completed a standard 10-min warm-up composed of jogging, lower body dynamic stretches and vertical jumps

Next, the *squat jump test* was performed from a starting position in which the participants' knees were at a 90-degree knee angle for 3 seconds, without allowing any counter movement. The participants' hands were kept on their hips, thus avoiding any arm swing. The subjects were required to jump as high as possible, without performing a countermovement (pre-stretch), and to land at the same point of take-off. They were also required to rebound with straight legs when landing to avoid knee bending and alteration of measurements.

The countermovement jump test: The test started with a fast-downward movement to approximately a 90° knee flexion immediately followed by a quick upward vertical movement, as high as possible for the subject, all in one sequence. The test was performed with hands on hips. The jump tests were performed in the following order: squat jump and countermovement jump. The rest interval between tests was 2 min. Each jump was performed 3 times per test, separated by 1-minute intervals, to complete the highest jump. The highest jump in the trials was recorded as the dependent variable and used in subsequent analyses. The test-retest reliability reported a high reliability for squat jump (ICC = 0.94) and countermovement jump (ICC = 0.95).

Statistical analyses

All analyses were performed using SAS JMP® Statistics (Version <14.1>, SAS Institute Inc., Cary, NC, USA, 2018) and the data are presented as group mean values and standard deviations. The reliabilities of the sit and reach and vertical jump test measurements were assessed using intraclass correlation coefficients; scores from 0.8 to 0.9 were considered as good, while values above > 0.9 were considered as high[42]. Normality of all variables was tested using Shapiro-Wilk test procedure. Levene's test was used to determine homogeneity of variance. Comparison between the groups for each outcome variable was performed with a one-way ANOVA. Eta squared (η^2) effect size was used to estimate the magnitude of the difference between the groups and interpreted using the following criteria (10): small ($\eta^2 < 0.06$), medium ($0.06 \leq \eta^2 < 0.14$), large ($\eta^2 \geq 0.14$). Significance was accepted at the $p < 0.05$ level with 95% CI.

Results

Pilates training and standard volleyball training groups did not differ significantly at baseline in anthropometric characteristics ($p > 0.05$). Statistical analysis of the data revealed no significant differences between the groups for the sit and reach test ($F_{1,54}$ = 0.005, p = 0.9436), squat jump test (Height: F1,54 = 0.008, p = 0.9311; Power: $F_{1,54}$ = 1.531, p =0.2213) and countermovement jump test (Height: $F_{1,54}$ =0.607 , p = 0.4394; Power: $F_{1,54}$ = 2.972, p = 0.0905).The following Table 1 summarizes the measures obtained by the groups in the fitness testing. In the following figure 1 the comparison between the groups regarding the sit and reach test was graphically represented. Figure 2 shows the comparison between the groups with respect to the height reached (cm) and power exerted (W) in both vertical jumps.

Variables	Pilates (n = 28)	Standard (n = 28)	*P* (η^2)
Sit and reach (cm)	29.21 ± 7.38 (26.36-32.07)	29.36 ± 7.67 (26.50-32.21)	0.944 (0.00)
Squat Jump			
Height (cm)	6.78 ± 2.65 (5.78-7.78)	6.84 ± 2.64 (5.84-7.84)	0.931 (0.00)
Power (W)	458.27 ± 177.93 (400.04-516.50)	407.45 ± 124.84 (349.21-465.68)	0.221 (0.03)
Countermovement jump			
Height (cm)	8.33 ± 6.11 (6.63-10.03)	7.40 ± 1.70 (5.70-9.10)	0.439 (0.01)
Power (W)	501.30 ± 205.72 (441.79-560.80)	428.94 ± 93.77 (369.43-488.44)	0.090 (0.05)

Table 1: Comparison of sit and reach and vertical jump test performance between Pilates training group (≥ 2 years practice) and standard volleyball training group.
Data are presented as mean ± SD (95% confidence interval). None of the group differences were significant (p > 0.05). η2 was interpreted as small (η2 < 0.06), medium (0.06 ≤ η2 < 0.14), large (η2 ≥ 0.14).

Discussion and conclusions

The aim of this preliminary causal-comparative study was to examine the effects of Pilates training on some physical fitness components in young female volleyball players. We compared performance of two young female players groups (one practicing Pilates and the other not) on hamstring flexibility and explosive leg strength. The main finding was that Pilates training group showed no significant differences (p > 0.05) compared to the standard training volleyball group with respect to sit and reach test, height reached in squat jump, countermovement jump test, power exerted in squat jump and countermovement jump test. As a result, our study does not confirm the findigs of Bertolla et al.[3] that evaluated the effect of four weeks of Pilates mat-work training and observed significant changes in flexibility (sit-and-reach test) in futsal athletes with no significant changes in the control group. Furthermore, our findings are in disagreement with other studies with healthy subjects that reported Pilates training significantly improved flexibility[22, 37, 38, 40], even if it was sedentary and physically active subjects[22, 38] of which the results cannot be reflective of the athletic population. However, our findings are in agreement with Pertile et al., who found no significant improvement in flexibility (sit-and-reach test) after four weeks of Pilates training without apparatus (mat-work) in young soccer athletes[36]. Unlike us, in their study El-Sayed et al. noted significant improvements in vertical jump with young volleyball players after Pilates mat-work training in association with specific volleyball team training[14]. Furthermore, Hutchinson et al. investigated the improvements in leaping ability of elite female rhythmic gymnasts by using Pilates training with apparatus in association with pool training over a 4-week period and found an improvement in ground reaction time, height jump, and power[21]. However, the results of these studies may not be conclusive with respect to the effectiveness of a Pilates training program because both studies did not use a control group[14, 21]. So, our finding could mean that, likely, the synergistic effect of Pilates with standard volleyball team training does not cause the gains necessary to increase fitness performance in female players, although there are studies in the scientific literature that confirm the effectiveness of combined training methods in a conditioning program aimed at maximizing fitness performance in youth[16, 17]. This investigation was subject to some limitations. A major limitation of the present study is related to use of a causal-comparative study design providing weaker evidence for causation as there is no manipulation of the independent variable. Because the independent variable was not manipulated, internal validity (i.e., the extent to which there is a causal link between the independent and dependent variables) of causal-comparative designs cannot be guaranteed. Furthermore, causal-comparative designs lack control of most extraneous variables that may also influence between-group differences, they provide a limited indication of cause and effect relationships.

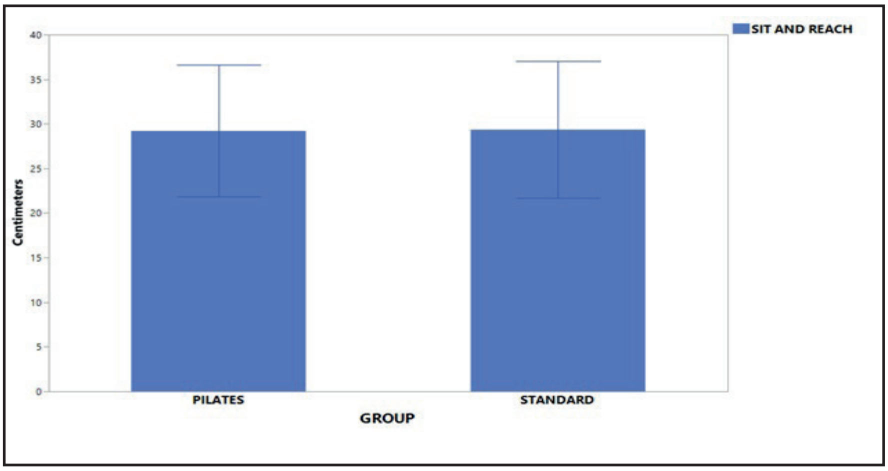

Fig. 1:. Sit and reach test comparison. None of the group differences were significant (p > 0.05). Values are represented as M ± SD.

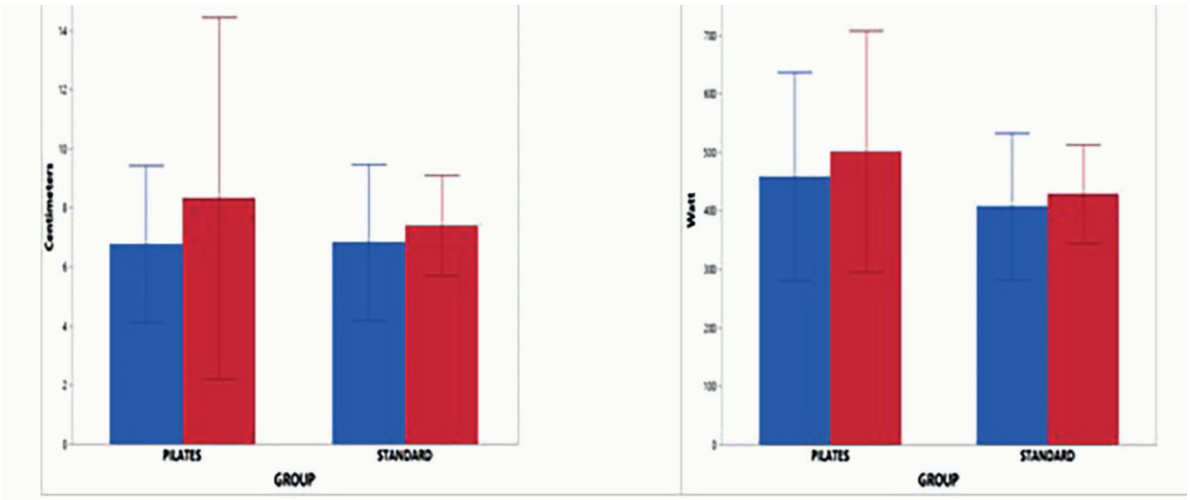

Fig. 2: Vertical jump test comparison. None of the group differences were significant (p > 0.05). Values are represented as M ± SD.

Accordingly, in the absence of internal validity, external validity assumes even greater importance. For this reason, we tried to use the appropriate statistics like the a priori power analysis to select sufficient number of participants and to ensure that research sample is representative of the population along as many relevant demographic characteristics as possible. Last but not least, Pilates group was trained by a physiotherapist and not a graduate in sport sciences. It must be stressed that only an expert in sports science has the skills to manage training volumes and load intensity, knows the effects of the physical exercise, fully understands the physiology and biomechanics of the movement to prevent musculoskeletal injury, and has the pedagogical and educational fit tools to improve sports performance[19].

Finally, this study suggests that Pilates exercises program could be not sufficient to cause significant improvement in some physical fitness components (i.e., hamstring flexibility and lower limb explosive strength) in young female volleyball players. Future research with rigorous experimental design is required to assess the influence of the Pilates training programs in young athletes and various sports performance parameters.

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