# CHANGES IN PHYSICAL FITNESS IN YOUNG FEMALE VOLLEYBALL PLAYERS AFTER AN 8-WEEK IN-SEASON PILATES TRAINING PROGRAM

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***ABSTRACT***

***Purpose***: *Volleyball is one of the world's most popular sports and many studies have been conducted in an attempt to understand the better method of training required to develop fitness performance by volleyball players. Among these, only a few studies have evaluated the effectiveness of Pilates training on the physical fitness of the volleyballers. Therefore, this randomized controlled study aimed to compare the effects of an eight-week in-season Pilates training program on some physical fitness components in young female volleyball players.*

***Methods***: *20 players (14-16 years) were randomly assigned to an 8-week experimental group (n = 10) that performed Pilates mat exercises (~30 min., twice a week) in association to volleyball team training or a control group (n = 10) that performed regular volleyball training (3 sessions a week, ~2 h·session-1). At baseline and after training all participants were tested on the sit and reach and vertical jump.*

***Results***: *A significant 'Time x Group' interaction was found for the sit and reach test only and the experimental group showed significant improvement than control (p < 0.0001; +3.8 cm; d = 0.38). No significant interaction effects were detected both for the jump height and power calculated during the squat jump and countermovement jump testing.*

***Conclusions***: *Results suggest that an 8-week Pilates mat exercises program could be capable of producing a statistically significant increase in hamstring flexibility but it is not enough to cause significant changes in lower limb explosive strength in young female volleyball players.*

***Keywords:*** *flexibility, explosive strength, mat-work.*

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## Introduction

Volleyball is a very popular sport, so many studies have tried to examine what was the best training program to develop a volleyball player's fitness performance[1, 24, 31]. To achieve success, developing muscle strength and specific technical skills are fundamental for young people[33] and for female athletes[6, 8, 12, 23, 27]. An important factor for success in volleyball is to develop the ability to jump[24]. Also developing flexibility is important because it increases joint ROM and could reduce injury risk[18].

Some physical educators, to improve athletes' physical and technical skills, also use Pilates exercises to increase strength and improve flexibility.

Pilates is a training system born in Germany about a hundred years ago[21].

Pilates exercises can be performed either on a floor mat (i.e. mat work)[15] or with apparatus (i.e. wunda chair, trapeze tables, barrel, Cadillac, reformer, spine corrector)[19]. Pilates method includes six principles: concentration, control, centring, precision, breath and flow[34]. These techniques can also be used in volleyball players to strengthen 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; a number of studies have looked at the benefits of Pilates-based exercises for low back pain[16, 17] but only a few studies have evaluated the effectiveness of Pilates training on the physical fitness of athletes[9, 10] and volleyballers in a specific way[1, 32]. While several previous studies demonstrated that Pilates training promotes improvements in the physical fitness of young athletes the studies by da Cruz et al.[9] and Greco et al.[32] did not. Moreover, all these studies show differences in the 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 or used a causal-comparative design[1, 10, 32]. Unfortunately, the scientific understanding of this issue remains unclear and to the best of our knowledge, there are no studies carried out with a rigorous experimental design on young athletes and especially on volleyballers. Therefore, the present study was designed to investigate the effects of an 8-week in-season Pilates training program on some physical fitness components in young female volleyball players. We hypothesized that Pilates training would improve the hamstring flexibility and explosive leg strength.

## Material and methods

### *Experimental design*

In this research, a randomized controlled study design was used that included evaluation at week 1 (pre-test) and week 8 (post-test) to examine the effects of Pilates training on the lumbosacral and hip joint (hamstring) flexibility (i.e., sit and reach test) and lower limb explosive strength (i.e., squat jump and countermovement jump test).

### *Participants*

Twenty female subjects between 14 and 16 years of age volunteered to participate in this study. They had the following characteristics: mean age, 15.1 ± 0.7 years; body mass, 55.3 ± 5.9 kg; and height, 166.9 ± 4.4 cm. All of the subjects were members of the Under 16 Women's Volleyball team in provincial level competitions and were involved in regular physical training 3 sessions•wk$^{-1}$.

An a priori power analysis was conducted ($\alpha = 0.05$ and $\beta = 0.20$) and has detected that 8 participants per group would be enough to observe medium 'Time x Group' interaction effects[11].

However, to avoid the experimental mortality, i.e. the loss of subjects, that could threaten the validity of the research design, more subjects were recruited.

*The inclusion and exclusion criteria for participation were*:

• had practised volleyball for at least 2 years,

• had no previous injury that could interfere with the study,

• was not currently using nutritional supplements.

All volunteers were accepted for participation. Upon completion of testing, the participants were randomly assigned to two groups: an experimental group (n = 10; mean age, 15.3 ± 0.7 years; body mass, 54.6 ± 5.9 kg; and height, 168.0 ± 4.3 cm) that performed a specific Pilates training program twice a week during the 8-wk period in addition to training for the volleyball team, or a control group (n = 10; mean age, 14.9 ± 0.7 years; body mass, 56.0 ± 6.1 kg; and height, 165.8 ± 4.6 cm) that only performed the volleyball team training (3 sessions•wk$^{-1}$). All participants and their parents received explanations and parents provided their informed written consent. The study was conducted following the Declaration of Helsinki, and the protocol was approved by the local Ethics Committee.

### *Procedures*

All study procedures were performed at a school sports facility. Initial and final test measurements were made at the same time of day (3:00-5:00 pm), always before the volleyball training and under the same experimental conditions. Before the test, the participants abstained from physical exercise for 1 day, did not drink caffeinated drinks for 4 hours and did not eat food for 2 hours. Before data collection, research assistants demonstrated the test procedures during an introductory session. Subsequently, the fitness tests were carried out ensuring the maximum effort of the participants through verbal encouragement. The same researchers then trained the participants.

*Each participant performed the tests on 2 separate days with a 24-hr interval between visits for the following procedures*:

• sit-and-reach test,

• vertical jump.

After 8 weeks, the same evaluations were repeated. The pre-test was performed a week before the intervention, whereas the post-test was performed a week after the intervention. During the evaluations, the training load (technical and tactical training) expected of the athletes was reduced. All the athletes continued to perform their regular technical and tactical training during this study (~2 hours•session$^{-1}$). The research protocol did not influence on team training.

### *Measures*

*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 participants 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, participants slowly bent forward toward the top of the box with one hand over the other. The technician ensured that the knees stayed in full extension and that movement was conducted slowly and smoothly. Participants performed 4 trials, each held for 1-2 seconds and the farthest reach was recorded in centimetres. A standardized warm-up procedure consisting of 5 min of jogging at a comfortable speed was performed before the test. The test-retest reliability reported high reliability for this test (ICC = 0.92).

*Vertical jump*: to assess the explosive strength of the lower limbs and the ability to use a stretch-shortening cycle with leg muscles[13] the Vertical jump was performed through the 1) 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. (2016)[26]. This app analyzes 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 (2): $h = t2 \times 1.22625$, with h being the jump height in meters and t being the flight time of the jump in seconds. 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 countermovement. 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 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 = 0.96) and countermovement jump (ICC = 0.98).

### *Pilates training program*

The subjects in the experimental group performed Pilates training twice a week (Tuesday and Thursday; ~30 minutes•session$^{-1}$) for 8 weeks. Thus, 16 sessions were performed that is the number needed to have comforting results with the Modern Pilates mat exercises[3]. Training with Pilates exercises was carried out by a graduate physical education instructor with Pilates certification. Participants followed a standardized exercise protocol and they were encouraged to make maximal efforts during the Pilates exercise sessions. The training program was divided into two parts: Protocol 1 which had as aim to familiarize the athletes with the Pilates exercises and Protocol 2 characterized by advanced exercises. Both protocols were preceded by the following warm-up exercises: Spinal rotation; Hip rotation; Shoulder stretch; Shoulder abduction and adduction; Palm rotation and twist; Shoulder elevation; Thoracic muscles stretch; Leg muscles stretch; and Cat stretch. Protocol 1 (first 4 weeks) consisted of the following exercises: Leg Circles (20 repetitions each leg); Up and Down (10 repetitions); Scissors (10 repetitions each leg); Side Kick (30 repetitions each leg); The Saw (10 repetitions); Spine Stretch (10 repetitions); and ending with the Rest Position. Protocol 2 (last 4 weeks) consisted of the following exercises: Scissors (20 repetitions); Shoulder Bridge, with hip sustained (10 repetitions each leg); Neck Pull (10 repetitions); The Saw (20 repetitions); Spine Stretch (10 repetitions); Push Up (10 repetitions); and finally, the Rest Position.

### *Statistical analysis*

Statistical analysis were carried out using SAS JMP® Statistics (Version <14.3>, SAS Institute Inc., Cary, NC, USA, 2018). Data were presented as group mean values and standard deviations and checked for assumptions of normality. An independent sample t-test was used to evaluate group differences at baseline. A two-way ANOVA (group (experimental/control) × time (pre/post-intervention)), with repeated measures on the time dimension, was conducted to examine the effect of the intervention on all dependent variables. When 'Group x Time' interactions reached the level of significance, group-specific post hoc tests (i.e., paired t-tests) were conducted to identify the significant comparisons. Partial eta squared ($\eta^2 p$) was used to estimate the magnitude of the difference within each group and interpreted using the following criteria: small ($\eta^2 p < 0.06$), medium ($0.06 \leq \eta^2 p < 0.14$), large ($\eta^2 p \geq 0.14$). Effect sizes for the pairwise comparisons were determined by Cohen's d and interpreted as small ($0.20 \leq d < 0.50$), moderate ($0.50 \leq d < 0.79$) and large ($d \geq 0.80$) (Cohen, 1992). 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. Percentage changes were calculated as [(post-training value - pretraining value)/pretraining value] x 100. An alpha level of $p < 0.05$ was considered statistically significant.

## Results

All participants attended all training sessions (100% compliance) and there were no injuries resulting from either training program. The experimental and control groups did not differ significantly at baseline in anthropometric characteristics and in fitness measures ($p > 0.05$). Pre- and post-intervention results for all outcome variables are presented in Table 1.

*Sit and reach test*: A significant 'Time x Group' interaction ($F_{1,18} = 10.14$, $p = 0.0051$, $\eta^2 p = 0.36$) and a significant main effect of 'Time' ($F_{1,18} = 5.97$, $p = 0.0251$, $\eta^2 p = 0.25$) were found. Furthermore, no significant main effect of 'Group' was detected. The post hoc analysis revealed a significant improvement in sit and reach from pre- to post-test for the experimental group ($p < 0.0001$; +3.8 cm; $d = 0.38$) whereas no differences were highlighted from pre- to post-training for the control group ($p > 0.05$).

*Squat jump test*: Statistical analysis revealed only a significant main effect of 'Time' for the jump height ($F_{1,18} = 21.06$, $p = 0.0002$, $\eta^2 p = 0.54$) whereas no significant main or interaction effects were detected for the jump power.

Countermovement jump test: Statistical data showed only a significant main effect of 'Time' both for the jump height ($F_{1,18} = 18.32$, $p = 0.0004$, $\eta^2 p = 0.50$) and jump power ($F_{1,18} = 7.20$, $p = 0.0152$, $\eta^2 p = 0.29$). No significant main effect of 'Group' or interaction 'Time x Group' were detected for both.

| | Experimental (n = 10) | | | Control (n = 10) | | |
|---|---|---|---|---|---|---|
| Variables | Pre-test | Post-test | Δ% | Pre-test | Post-test | Δ% |
| Sit and reach (cm) | 31.0 (10.5) | 34.8 (9.3)*† | 12.3 | 30.2 (6.4) | 29.7 (5.5) | -1.6 |
| *Squat Jump* | | | | | | |
| Height (cm) | 7.4 (3.1) | 8.1 (3.1)* | 9.5 | 7.9 (2.8) | 8.2 (2.7)* | 3.8 |
| Power (W) | 419.2 (115.6) | 463.6 (129.6)* | 10.6 | 471.4 (145.2) | 467.7 (109.6) | -0.8 |
| *Countermovement jump* | | | | | | |
| Height (cm) | 6.8 (1.0) | 7.8 (1.2)* | 14.7 | 7.9 (2.0) | 8.2 (2.0) | 3.8 |
| Power (W) | 402.5 (55.5) | 459.2 (63.2)* | 14.1 | 469.8 (120.7) | 479.7 (105.1) | 2.1 |

**Table 1**: Comparison of sit and reach and vertical jump test performance between Pilates training group (experimental) and control group before and after the 8-week intervention. Data are mean (±SD).

## Discussion

This study was to examine the effects of an 8-week in-season Pilates training program on some physical fitness components in young female volleyball players. The main finding was that the experimental training group enhanced their hamstring flexibility significantly over the short period of Pilates training in association with specific volleyball team training. Flexibility of the lumbosacral and hip joint increased only for the experimental group (+12.3%) while no significant changes were found in the control group (-1.6%) which was in line with the findings of Bertolla et al. (2007) 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(4).

Another study showed no significant improvement in the flexibility and explosive strength of the lower limbs, but this was a comparative cross-sectional and not an experimental study. Instead, our findings are in agreement with other studies with healthy subjects that reported Pilates training significantly improved flexibility, even if it was sedentary and physically active subjects of which the results cannot be reflective of the athletic population(5, 14, 22).

Regarding the Pilates training effects on the explosive leg strength, in the experimental group were observed significant increments in height and power of the jumps both for the squat jump (9.5 and 10.6%, respectively) and countermovement jump (14.7 and 14.1%, respectively) after Pilates training period. Moreover, the control group also showed a significant increase in the jump height (+3.8%) from pre- to post-testing. However, statistical analysis found no significant interaction effects for the squat jump and countermovement jump. Therefore, these improvements could be due to regular training of the volleyball team and not to the Pilates exercise program, or the synergistic effect of the two training. It is known that combined and multilateral training methods in a conditioning program aimed at maximizing fitness performance in youth[29, 30].

The literature showed significant improvements in the vertical jump with young volleyball players after Pilates mat-work training in association with specific volleyball team training. Also, Hutchinson et al.[10] investigated the improvements in the leaping ability of elite female rhythmic gymnasts by using Pilates training with apparatus in association with pool training over 4 weeks and found an improvement in ground reaction time, height jump, and power[10]. However, the results of these studies may not be conclusive concerning the effectiveness of a Pilates training program because both studies did not use a control group, unlike our study[1, 10].

It is well known that in the sports, flexibility is concerned with both muscular injuries and sportive performance[18, 20]. In the present research, results showed a significant increase in hamstring flexibility due to experimental intervention, conversely, improvement in height and power of the jumps were not due to Pilates workout plan. A previous study on the flexibility characteristics of elite female and male volleyball players[7] demonstrated that greater hip flexibility may benefit men more than women for jumping ability. Furthermore, previous research suggests that hamstring flexibility improves if stretching is done for 30-60 seconds[28].

In Pilates, the stretch lasts 2-3 seconds and repeated 4-8 times for each series of exercise. Although it is a dynamic exercise with short stretches, in this study Pilates caused improvements to the flexibility of hamstrings. Therefore, further studies that focus on the effectiveness of the hamstring flexibility in female volleyballers are needed to provide clarity. Instead, regarding the Pilates training effects on the vertical jump, it is known that the neural and muscular adaptations associated with improvements in power and muscle strength occur predominantly in type II muscle fibres[25].

Therefore, considering that the Pilates method is not a high-intensity exercise (i.e., low number of maximum repetitions), the stimulus and adaptations for muscle fiber recruitment of high threshold fibres (type II) were not reached in these athletes. This could be a crucial factor for improving performance on vertical jumps. This investigation was subject to some limitations. First, the short duration of the experimental intervention does not allow us to adequately study what is caused by the manipulation of the independent variable. So, Pilates training may need more time to improve physical fitness in athletes. Second, before the study, the biological maturation was not evaluated but could differ between groups. Third, sit-and-reach tests only evaluated lumbosacral and hip joint flexibility. Perhaps other flexibility tests could be used to identify the effects of Pilates on other joints. Lastly, our findings were limited to female adolescent athletes. Future studies should extend these observations to males, to other age groups, and other levels of competition. Also, observations with different intensities, volumes, and methods of Pilates training are needed to better understand the effectiveness of this method on the components of physical fitness.

## Conclusions

In summary, this study demonstrated that participating in an 8-week Pilates mat exercises program was capable of producing a statistically significant increase in hamstring flexibility but it was not enough to cause significant changes in lower limb explosive strength in young female volleyball players. Volleyball coaches and especially, physical education teachers it may be helpful to take into account that Pilates training should be combined with regular volleyball training to transfer the gains in flexibility which is recognized to be important for injury prevention and sports performance.

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