ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 9, Issue, 01, pp.45888-45892, January, 2017

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

RESEARCH ARTICLE

DOES THE NUMBER OF REPETITIONS OF MAT PILATES EXERCISES AFFECT FLEXIBILITY IN FEMALE AMATEUR SOCCER PLAYERS?

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ARTICLE INFO

Article History:
Received 16th October, 2016
Received in revised form
18th November, 2016
Accepted 29th December, 2016
Published online 31st January, 2017

Key words:

Flexibility,
Range of motion,
ROM,
Pilates,
Athlete,
Soccer,
Dynamic stretching.

ABSTRACT

Flexibility is considered as an important factor of physical fitness among all athletes, which can be improved via static or dynamic type, muscle elongation. Although the ideal duration of static muscle elongation has been extensively researched, no one has examined the effect of dynamic muscle elongation and more precisely the proper duration of mat Pilates exercises required for flexibility improvement. The aim of the present study was to assess the acute effects of a low number of repetitions of mat Pilates exercises, performed in a single training session, on the joint flexibility of female amateur soccer players. The sample consisted of 16 volunteers, female amateur soccer players, with a mean age of 26.2±3.8 years old, height of 169.0±3.0 cm, body mass of 67.2±5.8 kg and 14.2±2.8 mean training years, all familiar with Pilates. Participants performed two distinct mat Pilates protocols on non-consecutive sessions, in random order. The first protocol consisted of initial flexibility measurements, selected mat Pilates exercises repeated 5 times (1x5)in a full range of motion (ROM) and final flexibility measurements. The second protocol was similar to the first, expect for the number of repetitions which were double (2x5) and the break intervals between sets lasted for 5 sec. ROM was measured passively during hip flexion, extension and abduction, knee flexion and ankle dorsiflexion on the right side of the body, with a flexometer. A 2x2 Analysis of Variance with repeated measures was applied to assess differences in the flexibility pre- and post-measurements, for both Pilates protocols. The results revealed that the selected mat Pilates exercises produced significant improvements on joint flexibility, whether performed 5 or 10 times with a 5 sec interval. Additionally, improvements in joint flexibility did not appear to be dependent on the number of repetitions, but most likely on the joint ROM. Thus, mat Pilates exercises, when performed in a full ROM, even in a low number of repetitions, could consist of an effective alternative training method for improving flexibility among amateur soccer players.

Citation: Konstantinos Famisis, Maria G. Grammatikopoulou, Aggelos Kyranoudis *et al.* 2017. "Does the number of repetitions of mat Pilates exercises affect flexibility in female amateur soccer players?", *International Journal of Current Research*, 9, (01), 45888-45892.

INTRODUCTION

Soccer, commonly known in Europe as football, consists of the most popular sport worldwide, played by both sexes and all age groups, at different levels, varying on skills and experience (Stolen *et al*., 2005). On the professional level, players are required to attain good technique and tactical knowledge, while performance is highly dependent on individual fitness levels, endurance, strength, speed, power and joint flexibility (Hoff 2005, Little and Williams 2005). According to Stolen *et al*. (2005) one of the main reasons for the sports' popularity stems from the fact that players are not required to score excellent in all the aforementioned performance indicators, but rather balance on a fair level of all needed skills. In the past, soccer coaches were aiming to improve individual player performance by focusing on the technical and tactical aspect of the game, an action often proved to be detrimental to the physical conditioning of players. Today, soccer training is equally focused on elements of physical conditioning, with emphasis on balancing lower extremities muscle strength and joint flexibility, mainly as a means to prevent injuries (Hartig and Henderson, 1999, Stolen *et al*., 2005). Flexibility is reflecting the ability of each joint to rotate on a physiological range of motion (ROM) (Chandlen *et al*., 1990), and is considered to be a pivotal factor affecting movement aptitude (Alter, 1996), muscle perception and movement coordination (Hardy 1985), preventing the onset of exercise-induced pain (Corbin and Noble 1980, Ekstrand and Gillquist, 1983) and injuries (Hartig and Henderson, 1999), as well as enhancing precision of movements, throughout the ROM of each joint (Van Gyn, 1986). Flexibility is ameliorated through static (Zakas *et al*. 2006) or dynamic type muscle elongation (Famisis, 2015), while recently, Pilates exercises are being incorporated in the training programs, aiming to ameliorate physical fitness (Bertolla *et al*., 2007, Famisis *et al*., 2016, El-

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Sayed *et al*., 2010) and expedite recovery from exercise and injuries (Blum, 2002). Pilates exercises are performed in a dynamic manner, in a slow pace while in full ROM, following the same concept as dynamic stretching exercises (Thoma *et al*., 2016). According to Joseph Pilates (1880-1967), inventor of the technique, the pivotal characteristic of this exercise form is the low number of repetitions required, since expected gains are actually obtained through attaining quality during exercise performance, instead of quantity (Latey 2001).

Although few repetitions are required for each exercise, in literature the majority of studies are using a greater number of repetitions instead. Amorim and Wyon (2014) experimented with an 11-week program performed twice/week, by dancers. The protocol started with 3 sets of exercises, each one repeated 8 times during the first 7 weeks, gradually reaching 12 repetitions for each set, at the end of the training protocol. da Cruz *et al*. (2014) designed a 6-week program for basketball players, using 2 sets of 15 repetitions for each exercise during the first 4 weeks, and 3 sets, each repeated 20 times, during the following 2 weeks. All of the above researchers examined the effects of Pilates exercises on physical fitness indicators, as well as on the body composition of participants, thus a greater training load was required in order for the corresponding adaptations to take place (da Cruz *et al*., 2014). Two studies, one by Thoma and associates (2016) and the second by Famisis *et al*. (2016), used samples of untrained younger/elder women, or female amateur soccer players respectively, in order to assess changes in the lower extremities flexibility, under acute conditions. Ten repetitions were performed for each exercise (1x10), which was repeated twice (2x10). Several static (Roberts and Wilson, 1999, Zakas, 2005) and dynamic stretching techniques (Famisis, 2015) have examined the proper duration of muscle elongation needed to increase muscle length and joint ROM.

Roberts and Wilson (1999) used a 5-week training program performed 3 times per week, consisting of 2 protocols of static stretching lasting for a total of 45s (9x5s and 3x15s, respectively) in men and women, members of a university sports club. Zakas (2005) examined 3 different training protocols of static stretching, lasting for a total of 30s (1x30s, 2x15s and 6x5s, respectively), under acute conditions, on adolescent soccer players. Famisis (2015) examined 2 dynamic elongation protocols using calisthenics exercises performed for 20s (1x10s and 2x10s, respectively). According to Van der Poel (1998), muscle length is directly depended on the way each muscle is used during movement. During static and dynamic stretching exercises, the muscle is enduring greater elongation on each repeated stretch, while the joint is demonstrating greater ROM. Although the effect of different duration of static and dynamic stretching exercises on the joint ROM has been examined thoroughly, literature is scarce on the result of fewer repetitions of each Pilates exercise on the joint ROM. Given that the performance of Pilates exercises with multiple repetitions improves lower extremities joint flexibility and those athletes, and in particular soccer players tend to incorporate such dynamic exercises with a varying number of repetitions into their training programs, it would be useful to evaluate the effect of fewer repetitions on joint flexibility. Thus, the aim of the present study was to assess the direct effects of a single training session, with fewer mat Pilates exercises repetitions, on the lower extremities joint flexibility of female amateur soccer players.

MATERIALS AND METHODS

Participants

A total of 16 volunteer female amateur soccer players, with a mean age of 26.2±3.8 years old, height of 169.0±3.0 cm, body mass of 67.2±5.8 kg and a total of 14.2±2.8 training years. The study was performed 10 days after the end of the competitive season. During these 10 days, the players were participated in 6 light soccer training sessions and performed 2 sets of mat Pilates exercises which were incorporated in the training protocols, by a certified mat Pilates trainer. The performance of mat Pilates exercises ended 6 days before the start of the present study. Each player agreed to abstain from any form of strenuous physical activity for 6days before, as well as during participation in the present study. To the best of our knowledge, all participants were apparently healthy, without a history of musculoskeletal injuries or neurological disease. A sports medicine accredited doctor examined each player physically, prior to the experiment. All participants and their managers were informed of the aim, nature and possible risks associated with the study, before providing oral consent for participation. For the duration of the study, participants were asked to retain all everyday activities. The protocol was performed in a Pilates hall. The study was conducted in accordance to the rules and regulation of the research Ethics Committee, of the Aristotle University of Thessaloniki.

Experimental Protocols

All participants performed 2 different protocols on non-consecutive sessions, each separated by at least 1 week from the next. The order of the protocols was random, so that the results would not be affected by the learning factor. The experimental part of the study included selected mat Pilates exercises, which elongated the competition muscles of the examined joints, to their maximum ability. Participants were already familiar with Pilates from previous participations in relevant courses and were additionally familiar with the flexibility measurements. All players were advised to abstain from any form of physical activity during the day preceding the experimental protocol, as well as on the day the measurements took place. Before each Pilates session, a short introductory pre-Pilates session, lasting for 5 min, was performed, aiming to prepare the lumbar spine and trunk in a neutral position, through diaphragmatic breathing and concentration, as suggested when practicing Pilates. In both protocols, the exercises were performed on both sides of the body, under the same conditions, in full ROM and in a continuous pace, using gentle and slow movements, coordinated with the subjects' breathing. The first protocol comprised of a) initial flexibility measurements, b) selected Pilates exercises performed 5 times (1x5) and c) final flexibility measurements. The second protocol was similar to the first, expect for the number of repetitions, which was double (2x5) and the break-interval between the two repeated sets lasted for a total of 5 sec. On both protocols, the involved working muscle groups included the hamstrings, quadriceps, adductors, hip flexors and soleus. Both protocols were performed on the same hall, during the same time of day, and more precisely, between 15:00 and 17:00 from two experienced researchers who were supervising the procedure. Throughout the study, the same researcher was responsible for the same activities. Specific instructions were provided in all participants concerning the performance of both protocols.

The results of each measurement were recorded in a specific lab book, by the same researcher.

Mat Pilates exercises

All mat Pilates exercises were selected based on the muscle groups involved during their implementation. The exercises were selected and supervised by a certified Pilates trainer. A total of 5 exercises were included in the study, each involving one of the examined muscle groups: (1) The *Front-Back,* dynamically elongating the 5 iliopsoas muscles,(2) The *Single-Straight-Leg Stretch Modification,* dynamically elongating the rear thigh muscles,(3) The *Up-Down*, dynamically elongating the adductor muscles, (4) The *Leg Pull-Down,* dynamically elongating the rear calf muscle groups, and (5) The *Single-Leg Kick,* dynamically elongating the front thigh muscles.

Flexibility measurement

A total of five lower extremities ROMs -hip flexion, hip extension, hip abduction, knee flexion and ankle dorsiflexion with the knee flexed-, were measured before and after the experimental protocol. A Myrin flexometer (Lic Rehab. 17183 Solna, Sweden) was used to measure all joints, by the same, experienced researcher, in accordance to the Ekstrand *et al*. (1982) method. The selected flexometer consists of a modification of the Leighton flexometer, comprising of a circular scale with a gravity-controlled weighed pointer, attached in the centre. The variation coefficient for the goniometric measurements was high (1.9±0.7%). An adjustable bench was used for all measurements, except for ankle dorsiflexion. Results from the right side of the body were recorded because the analyses of the recruitment data did not depict any differences between the right and left body sides of the participants ($p>0.05$). Initial and final positions for each movement were passively measured, starting from a 0° point, as defined by the American Academy of Orthopaedic Surgeons (1965). Maximum flexibility was determined at the point where each joint attained end-range, which, in term, was the point at which muscle restriction was noted (Ferber *et al*. 2002). All pre- and post-test measurements were taken at approximately the same time of day, with participants abstaining from any type of training or exercise for the 48h preceding the experiment. The reliability coefficient of each measurement was high: r=0.90 for the knee flexion, r=0.92 for the hip flexion, r=0.90 for the hip abduction, r=0.90 for the hip extension and r=0.90 for the dorsiflexion.

Statistical Analyses

The 21st version of SPSS (SPSS, Hong Kong, Ho) was used for data analyses. Since all tested parameters were normally distributed, parametric tests were conducted. A 2x2 analysis of variance (ANOVA) model, with repeated measures was applied on both parameters. The first repeated measure was flexibility, having two levels (initial and final). The second repeated measure was the Pilates protocol, having 2 levels according to the number of repetitions (1x5 and 2x5). Paired student t-test was applied to assess differences between mean observed values. In regards to the lateral deviation, we used data from the right side of the body, given that there was no significant difference in comparison to the left side. Significance was set at 95% ($p<0.05$).

RESULTS

Analysis of the data failed to reveal any differences in the joint ROM between the two training protocols performed in a different number of repetitions ($F=1.25$, $p>0.05$), indicating that joint ROM is more affected by the way each exercise is performed, rather than the number of repetitions. The analysis of variance did not reveal any significant interaction between initial and final joint ROM and the different protocols performed, revealing that the selected mat Pilates exercises ameliorated lower extremities joint ROM in a similar degree, whether performed 5 times (1x5), or 10 times (2x5).

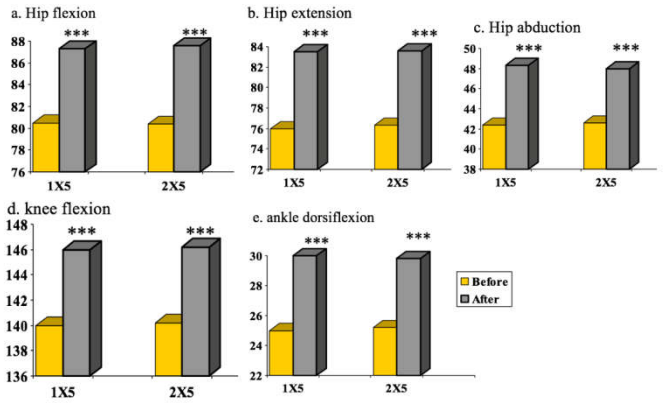

Figure 1. ROM during a. hip flexion, b. hip extension, c. hip abduction, d. knee flexion, e. ankle dorsiflexion, before and after the performance of selected mat Pilates exercises, according to the 2 experimental protocols (1x5 and 2x5). ROM values are expressed in degrees. *** p<0.001

Repeated measures ANOVA however, revealed significant differences in the pre-and post-1x5-repetition Pilates protocol measurements, concerning hip flexion ($F=105.30$, $p<0.000$), extension ($F=80.10$, $p<0.000$), and abduction ($F=66.56$, $p<0.000$), knee flexion ($F=185.46$, $p<0.000$) and ankle dorsiflexion ($F=92.40$, $p<0.000$). Additionally, differences between the pre- and post-2x5 repetition Pilates protocol were revealed concerning hip flexion ($F=106.20$, $p<0.000$), extension ($F=81.25$, $p<0.000$) and abduction ($F=65.48$, $p<0.000$), knee flexion ($F=184.88$, $p<0.000$) and ankle dorsiflexion ($F=92.68$, $p<0.000$). According to the paired t-test, a significant improvement in the ROM ($p<0.001$) was revealed on all examined joints, measured after the performance of the two mat Pilates protocols (Figure 1a-e). These improvements in joint ROM ranged from 5.0 to 7.5° after the experimental protocol of 1x5 repetitions, and 4.6 to 7.3°, after the performance of the 2x5 repetitions.

DISCUSSION

The present study was designed to examine whether a relatively low number of repetitions of a mat Pilates exercise (n=5), under acute conditions, is capable of inducing increments in the lower extremities joint ROM of female amateur soccer players, given that a low number of repetitions is actually suggested by the Pilates inventor and that literature is lacking such evidence, either on athletes or untrained individuals. Additionally, the study herein aimed to assess the effect of 10 repetitions of the same exercise on the joint ROM, and compare the results of the two protocols with different numbers of repetitions. The results suggest that the selected mat Pilates exercises performed in a slow and gentle manner

were equally effective in improving joint ROM, when performed dynamically in a full ROM, repeated 5 or 10 times each, indicating that the level of joint ROM improvement among female amateur soccer players does not appear to be affected by the number of repetitions alone, but could be multi factorial. Unfortunately, the results herein cannot be directly compared to previous studies on athletes or untrained individuals, due to differences in the methodology used. Thoma *et al*. (2016) examined untrained younger and elder women and Famisis *et al*. (2016) used female amateur soccer players and both researchers revealed significant improvements in the lower extremities joint ROM, after a total of 20 repetitions for each Pilates exercise, using the exact same mat Pilates exercise as herein, under acute conditions. Amorim and Wyon (2014) observed significant improvements in joint ROM after the performance of an 11-week protocol performed twice a week, consisting of 3 sets of exercises, repeated 8 times during the first 7 weeks, with a gradual increase in repetitions reaching to 12 at the end of the experimental protocol. Sinzato and associates (2013) observed significant improvements in joint ROM among young women aged 18-30 years old, through the performance of 8 repetitions for each exercise, twice a week, for a total duration of 10 weeks. Research on futsal athletes (Bertolla *et al*. 2007) demonstrated improvements in the flexibility, after the adoption of a 4-week training schedule, where each exercise was performed in a different pace (10 repetitions for up and down exercises, 20 repetitions for leg circles and 30 repetitions for the sidekicks).

However, it should be noted that the results herein are in disagreement with the study by Cruz *et al*. (2014). In this study, no significant improvements were observed in the lumbosacral and hip joint flexibility, according to the sit-and-reach test, among young basketball players, after the performance of 2 sets of 15 repetitions for each exercise during the first 4 weeks, followed by 3 sets of 20 repetitions in the final 2 weeks of the protocol. The different results could be due to discrepancies in the methodological approach observed between the two studies (i.e. mat exercises vs. apparatus), the level of participants' physical fitness, as well as to the fact that basketball players in the Cruz *et al*. study were already involved in regular physical training sessions (5-7 sessions/week). Additionally, in the latter research, prior to the flexibility measurements, all subjects participated in a warming-up procedure, including 3 min of jogging at a comfortable speed. Thus, it is highly likely that this warming-up session affected the flexibility measurements. As Shrier and Gossal (2000) have suggested, the performance of a light activity during warm-up will increase muscle temperature, decrease muscle stiffness and increase joint ROM, whereas, according to McNair and Stanley (1996), running alone, is capable of decreasing the stiffness of the calf muscles. Thus, the ideal number of repetitions needed for each Pilates exercise is still under debate. According to Taylor *et al*., (1990), when static stretching exercises are performed, the greatest change in muscle/tendon length occurred during the first four stretches. Further stretching failed to result in any further significant increases in muscle/tendon length. Wiktorsson-Moller *et al*. (1983) suggested that five–six repetitions are sufficient for increasing hip, knee, and ankle ROM. The present study observed similar improvements in joint ROM after each exercise was repeated 5 or 10 times. Although the results cannot be directly compared to previous studies, research using static stretching exercises has demonstrated akin findings. Borms *et al*. (1987) suggested that static hip stretching for 10, 20 and 30s significantly improved hip flexibility, without any differences between the three durations attained. In agreement to Borms, Bandy and Irion (1994) postulated that when the duration of stretching is increased from 30 to 60s, no further increments in flexibility are noted. These studies indicate that the level of ROM improvement does not rely solely on the number of repetitions performed, but appears to be equally affected by the ROM of the joint undergoing static or dynamic elongation. During static stretching, the joint is on full ROM and the competitive muscle is expressing full elongation. In the present study, all repetitions were performed in a full ROM, in both experimental protocols. The data collected in the present study could not suggest a specific mechanism explaining the results. However, it is commonly accepted (Sapega *et al*., 1981) that stretching affects joint flexibility due to the extensibility of the connective tissue, in relation to the amount and duration of the applied force. In contrast, Hutton (1992) proposed that the impact of connective tissue as a stimulus for stretching seems overestimated, whereas on the other hand, the myogenic constraints in determining ROM appear to be underestimated. According to Hill (1968) and Magid and Law (1985), the initial resistance observed during muscle elongation is due to the myosin bridges, some of which are connected to actin.When a muscle is passively or dynamically elongated, a certain proportion of myosin bridges are being disconnected from actin, resulting in an increased muscle length. Van der Poel (1998) suggested that muscle length is completely dependent on how the muscle is used, however, further studies are required in order to delineate the exact mechanisms responsible for improving ROM under acute muscle-elongation conditions.

Conclusion

The present study showed that among female amateur soccer players, the performance of selected mat Pilates exercises with 5 or 10 repetitions, in a single training session, form a stimulus for lower extremities joint ROM improvement. Additionally, joint ROM appears to be equally improved when the selected mat Pilates exercises are performed in full ROM.

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