Saúde e Pesquisa, Maringá (PR)
DOI: 10.17765/2176-9206.2020v13n2p353-361

PILATES REDUCES EXHAUSTION AND CHANGES MUSCLE ACTIVATION IN JUVENILE SOCCER PLAYERS

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ABSTRACT: The objective was to verify whether Pilates promotes changes in muscle activation of the lower limb and improvements in relation to exhaustion and functional performance of soccer players. Participants were 15 players divided into Pilates Group (GP, n = 7) and Control Group (GC, n = 8). The GP held 15 sessions over five weeks. Exhaustion and muscle activation [rectus femoris (RF), biceps femoris (BF), gluteus maximus (GM) and rectus abdominis (RA)] were evaluated during the side hop test before and after intervention. The GP on exhaustion showed a significant difference between pre- and post-intervention (compared to GP itself) with electromyography (EMG) (p = 0.01) and without EMG (p = 0.01). In relation to muscle activation, there was a decrease for all muscles, except for GC. Pilates is able to reduce exhaustion and changes muscle activation for possible motor learning; and as for functional performance, there was no significant improvement.

KEY WORDS: Adolescent; Electromyography; Exercise movement techniques; Soccer.

PILATES DIMINUI EXAUSTÃO E MODIFICA ATIVAÇÃO MUSCULAR DE JOGADORES JUVENIS DE FUTEBOL

RESUMO: O objetivo foi verificar se o Pilates promove mudanças na ativação muscular do membro inferior e melhorias em relação à exaustão e ao desempenho funcional dos jogadores. Participaram 15 jogadores, divididos em Grupo Pilates (GP, n=7) e Grupo Controle (GC, n=8). O GP realizou 15 sessões por cinco semanas. Avaliaram-se a exaustão e a ativação muscular [Reto Femoral (RF), Bíceps Femoral (BF), Glúteo Máximo (GM) e Reto do Abdome (RA)] durante o *side hop test* antes e após a intervenção. O GP sobre a exaustão mostrou diferença significativa entre pré e pós-intervenção (comparado ao próprio GP) com a eletromiografia (EMG) (p=0,01) e sem a EMG (p=0,01); em relação à ativação muscular, houve diminuição para todos os músculos, exceto para o GC. O Pilates é capaz de diminuir a exaustão e modificar a ativação muscular para possível aprendizagem motora; e quanto ao desempenho funcional não houve melhora significativa.

PALAVRAS-CHAVES: Adolescente; Eletromiografia; Futebol; Técnicas de exercício e de movimento.

Financial support: Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES), Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) e Fundação de Amparo à Pesquisa do Estado de Minas Gerais (FAPEMIG).

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Received in: 28/08/2019
Accepted on: 09/02/2020

INTRODUCTION

The Pilates Method (PM), created by Joseph Hubertus Pilates, in the early 20th century, is based on six principles: concentration; awareness; control; precision; breathing and flow of movement[1], and can be indicated for any age group, as it generates changes and adaptations for different individuals, respecting their characteristics and limitations[2]; in addition to its several benefits, which can improve general health, flexibility, degree of strength, muscular endurance and sports performance[3].

One of the sports that demands maximum and constant performance from players is soccer, in which athletes are subjected to intense training routines and this makes them susceptible to injuries[4,5]; therefore, several strategies should be considered to prevent them, in addition to improving the athlete functionality and, possibly, his/her performance in the field.

Exhaustion and functional performance, essential variables for the good profile of the athlete, are totally interconnected and their measurement is important since they guide to identify the ability of an athlete to tolerate the physical demands inherent in soccer6, as well as the electrical activity of the muscles, which also plays a key role in the athlete profile, since it is an indication of which muscle(s) are most recruited in a given body movement.

Some studies, such as Paz et al.[7] Silva et al.[8], Silva et al.[9], aimed to compare and/or analyze muscle electrical activity through surface electromyography during the Pilates exercises, in order to check which muscle is best activated during the full exercise. However, none of the studies have been conducted with athletes.

The use of PM exercises for athletes has not been sufficiently investigated, especially when it comes to prevention. Bertolla et al.[10] and Chinnavan, Gopaladhas, Kaikondan (2015)[11] showed that PM was effective in relation to the flexibility of healthy young soccer players. Pertile et al.[12] analyzed muscle strength and flexibility in youth soccer athletes, in 12 sessions of the PM, and concluded that the short intervention time made it impossible to verify the effectiveness of Pilates, showing that the method still needs further evidence. Likewise, the study by Cruz et al.[13], with young basketball athletes, also pointed out that 12 weeks were not enough to cause significant changes in physical fitness and body composition.

In this sense, this study aimed to elucidate the effectiveness of the PM, and to verify whether training with PM promotes changes in muscle activation (MA) of the lower limb and improvements in relation to exhaustion and functional performance of the players. The hypothesis was that the PM promotes changes in lower limb MA and reduced exhaustion, in addition to better functional performance of the players.

MATERIAL AND METHODS

The research was approved by the Research Ethics Committee of the Federal University of Triangulo Mineiro (opinion 2.827.678 of 2018), according to the guidelines proposed in resolution 196/96 of the National Health Council and in the Brazilian Registry of Clinical Trials (ReBEC) under identification RBR-6Z2DHD PILATES NO FUTEBOL. All volunteers signed the Assent Form (AF) and the legal guardians signed the Informed Consent Form (ICF).

Tratou-se de um estudo de abordagem quantitativa, com delineamento longitudinal e experimental.

The sample was taken by convenience, composed of 15 youth soccer players, male, aged between 13 and 15 years old, linked to the Uberaba Sport Clube, with training frequency of more than three times a week. Participants were randomly assigned by drawing numbers generated by Microsoft Excel with the function (= RAND ()), to the Pilates group (PG) n = 7 and the control group (CG) n = 8 (Figure 1).

The control group did not carry out any additional training.

Before the assessments, all volunteers were interviewed for sample characterization and underwent physical examinations, which consisted of a general anthropometric assessment. Each player was always evaluated by the same researcher, properly trained for this. They were weighed on a Tanita® digital scale, with a maximum capacity of 150 kg, coupled to a stadiometer. Each player, wearing only training shorts, barefoot, stepped on the scale and remained looking ahead, throughout the process of weighing and measuring height. Afterwards, the player was subjected to the functional test, with evaluation by electromyography.

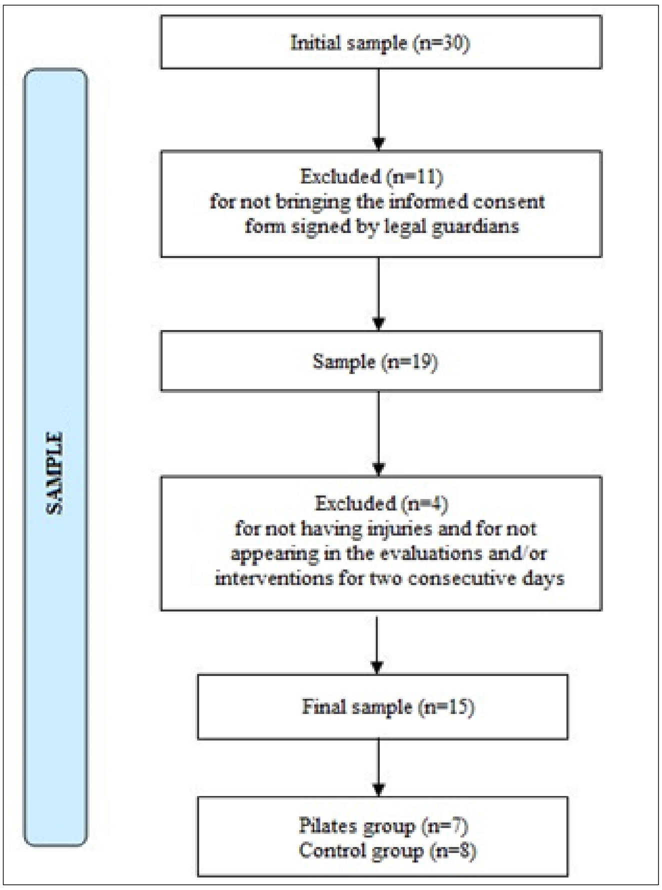

Figure 1. Flowchart of sample screening

ASSESSMENT

Surface electromyography (sEMG): the four-channel Miotool 400 USB equipment (Miotec®, Porto Alegre, Rio Grande do Sul, Brazil) was used, with square Ag/AgCl electrodes, 16 Bits A/D converter; 2000x gain per channel, four active bipolar surface sensors, 1000Hz acquisition rate per channel, common rejection rate ≥ 100dB, preamplifier gains = 20, system impedance = 109Ohms//2pF, signal noise rate ≤ 3 μV RMS. The signal was treated in the Miotec Suite software (Miotec®, Porto Alegre, Rio Grande do Sul, Brazil), being filtered by 20-100 Hz bandpass filters, fourth order Butterworth.

For the placement of the electrodes, the skin was prepared according to Hermens et al.[14] as well as the positioning of the electrodes on the rectus femoris (RF), biceps femoris (BF) and gluteus maximus (GM) muscles also followed the recommendations of SENIAM (surface electromyography for non-invasive assessment of muscles), and on the rectus abdominis (RA) followed the reference of Perotto et al.[15] (for placement of the electrodes and for the maximum isometric voluntary contraction tests (MIVC). The records were taken on the dominant limb (determined by kicking the goal).

MIVC is composed of three 5-second (sec) records of electromyographic signals with 30-second rest intervals and the collection during Side hop test (SHT) took place until exhaustion and interruption of the test. The same researcher was always responsible for placing the electrodes, giving the command and explanation to the subject. Another researcher was responsible for monitoring the data record for all players.

Analysis of sEMG data: the variable RMS (Root Mean Square) was used in microvolts (μV). With the registration of the side hop test and MIVC, data were normalized by the formula meanRMS (SHT)/meanRMS (MIVC) x 100; for RMS, an average of the three MIVC records for each muscle was calculated.

Side hop test (SHT): functional performance test, validated for children and adolescents, in which athletes jump on one foot (dominant limb) laterally a distance of 30 cm for ten repetitions as quickly as possible with the hands close to the body with elbow flexion[16]. The time for the ten repetitions was recorded with a stopwatch. If the athlete fell or supported his contralateral foot on the floor, the test was restarted until ten complete repetitions. They continued the test and recorded to exhaustion.

SHT was performed during sEMG, and on another assessment day, without sEMG, to verify that the wires did not prevent movement, limiting the test.

INTERVENTION PROTOCOL

The protocol with the PM was carried out in five weeks, three times a week, lasting 30 minutes, totaling 15 sessions. The first week was for adaptation, starting one week after the assessment; the second and third weeks consisted of basic exercises and the fourth and fifth weeks, intermediate exercises.

The protocol consisted of 12 exercises with ten repetitions each, aiming at flexibility, improving muscle strength, body awareness and balance. The interventions were directed by professionals with experience in the method.

The exercise sequences based on Pilates and Miller[17] are shown in Figure 2 (A and B).

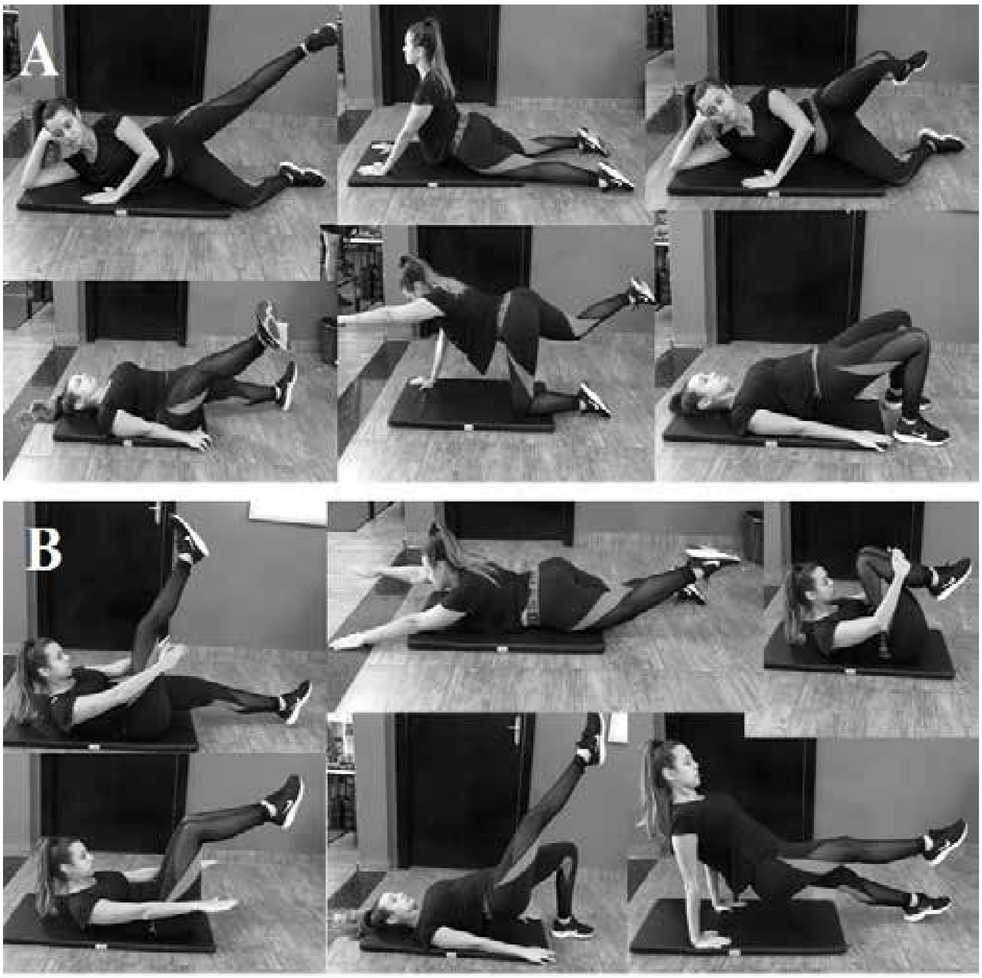

Figure 2. A: Basic exercises above, in order, *Side kick; Shoulder bridge; Clamshell; One Leg Circles; Quadruped; The Swan Dive*. B: Intermediate exercises above, in order: *Scissor; Swimming; one-leg Shoulder bridge; Hundred; The Double Leg Stretch; Leg Pull*.
Source: The authors.

STATISTICAL ANALYSIS

For statistical analysis, the software SPSS (Statistical Package for Social Sciences), version 13.0 for Windows, was used. To check the normality of data, the Shapiro-Wilk test was applied. Continuous data were standardized and expressed as mean ± standard deviation. Variations in measurements at the beginning and end of the study were expressed as delta values (Δ).

For continuous variables in relation to the baseline, the paired Student's t-test (normal distribution) or Wilcoxon test (non-normal distribution) was used. The comparison of means between groups was performed using the Student's t-test (normal distribution) or Mann-Whitney U test (non-normal distribution). To check the degree of dimension of the phenomenon in the sample, Cohen's d index18 was used, in which the effect size was classified as follows: <0.2 insignificant; 0.2 to 0.5 small; 0.5 to 0.8 medum and > 0.8 large. A two-tailed significance level of <0.05 was considered statistically significant.

RESULTS

Table 1 lists the age and anthropometric characteristics of the athletes. No significant differences were detected in any of the variables, ensuring homogeneity of the sample.

Table 2 indicates that the two groups had similar physical performance at pre-intervention; there was a significant difference in the activation of the rectus femoris muscle (p = 0.04*) pointing to a greater MA in the CG during SHT.

Table 3 lists the results of SHT, evidencing a significant difference for PG in relation to exhaustion, both with sEMG (p = 0.01) and without sEMG (p = 0.01); and MA, in which it is observed by means ± SD and median/IQ that all the muscles of the PG decreased activation. In relation to the CG, the BF and RA values decreased their activation, but remained close to the pre-intervention values; RF increased its MA.

Table 1. Age and anthropometric characteristics of the Uberaba Sport Clube soccer athletes

Characteristic	GC (n=8)	GP (n=7)	p
Age in years (mean ± SD)	13,25 ± 0,46	13,28 ± 0,49	0,88
Weight (kg, mean ± SD)	51,37 ± 7,99	51,13 ± 6,82	0,95
Height (m, mean ± SD)	1,66 ± 0,37	1,63 ± 0,07	0,32
BMI (kg/m2, mean ± SD)	18,64 ± 2,59	19,17 ± 2,79	0,71

SD: standard deviation; BMI: body mass index; n: number of respondents for each variable; kg: kilograms; m: meters; p: probability of significance

Table 2. Base Line (comparison between the control and Pilates groups at pre-intervention)

Variáveis	GC pré (n=8)	GP pré (n=7)	p
SHT exhaustion (s)	44,63±21,64	44,79±29,59	0,99
SHT repetitions (s)	10,24±1,08	9,33±2,84	0,41
SHT exhaustion EMG(s)	66,62±39,51	56,14±31,09	0,58
RMSn BF(μV)	49,81±15,19	85,5±61,9	0,18
RMSn RF(μV)	49,74± 24,11	125.85±92,61	0,04*
RMSn RA(μV)	23,83±12,03	30,32±17,27	0,41
RMSn GM(μV)	63,49±30,63	58,44±25,28	0,74

GC: control group; GP: Pilates group; n: number of respondents for each variable; SHT: *side hop test*; s: seconds; EMG: electromyography; RMSn: normalized *Root Mean Square*; BF: biceps femoris; RF: rectus femoris; RA: rectus abdominis; GM: gluteus maximus; μV: microvolts; *p≤0.05.

Table 3. Side hop (SH) test in seconds (s) and normalized RMS (Root Mean Square) in microvolts (μV)

Variable	Group	Pre	Post	Δ	p (p x p)	p (dif.)	Cohen
SHT	GC	44,64±21,64	76,94±65,92	32,30±49,31	0,09	0,21	0,48*
Exhaustion (s)	GP	44,79±29,59	98,64±58,61	53,85±40,14	0,01*		
SHT	GC	10,2±1,1	9,4±1,5	0,8±1,3	0,11	0,09	0,96*
Repetitions (s)	GP	9,33±2,84	9,70±2,35	0,37±1,26	0,47		
SHT	GC	66,62±39,51	98,00±62,39	31,37±31,01	0,01*	0,15	0,81*
Exhaustion EMG (s)	GP	56,14±31,09	114,71±62,77	58,57±36,61	0,01*		
RMSn	GC	49,81±15,19	61,69±46,36	11,89±45,05	0,78	0,35	-0,44
BF	GP	85,55±61,95	70,41±39,39	-15,13±81,23	0,64		
RMSn	GC	49,74±24,11	66,35±34,83	16,61±31,98	0,26	0,03*	1,48
RF	GP	125,85±92,61	52,34±11,94	-73,51±94,6	0,09		
RMSn	GC	23,83±12,03	23,59±14,06	-0,23±10,76	0,89	0,07	-1,02
RA	GP	30,32±17,27	17,21±10,71	-13,11±14,72	0,06		
RMSn	GC	63,49±30,63	46,41±15,01	-17,08±22,94	0,07	0,39	0,49*
GM	GP	58,44±25,28	58,43±29,30	-0,01±48,62	0,73		

Δ: delta; p x p: pré x pó**s;** GC: control group; GP: Pilates group; s: segundos; dif: difference; EMG: electromyography; BF: biceps femoris; RF: rectus femoris; RA: rectus abdominis; GM: gluteus maximus; SH: *side hop*;*p≤0.05.

DISCUSSION

The study aimed to verify whether the training with the PM promotes changes in the electrical activation of the muscles of the lower limb and also improvements in relation to the functional performance of the players against the SHT. In general, the muscle activity of the PG decreased, without a significant difference; the performance (SHT repetitions) of the PG remained close to the pre-intervention, with no significant difference; and exhaustion (SHT with EMG and without EMG) of the PG improved significantly, that is, athletes who practiced Pilates exercises had less exhaustion after the intervention period

The sample homogeneity ensures better treatment of the data. The base line did not indicate significant differences between the two groups at pre-intervention, only the RF had a significant difference between the groups, in which the PG had better activation. Despite not having the information of the positions of the individuals in the matches, a possible explanation was that the PG had more players with the attacker position and one of the main muscles responsible for the kick is the RF, a factor not specifically considered in this research.

Although no significant differences were detected for the PM in four weeks of intervention (15 sessions), our study was supported by Bertolla et al.10 e Chinnavan, Gopaladhas, Kaikondan (2015)[11], which showed significant results; besides the unavailability of the sample due to long championships.

Regarding the SHT, it was confirmed that the PM can improve physical fitness. The PG improved significantly in relation to exhaustion (with and without EMG) and according to Cohen's "d" values, the intervention was clinically positive even with a small sample. Indirectly comparing with Nogueira et al.[19], who evaluated the localized muscle strength (LMS), after the PM in healthy subjects, in which they increased their performance improving the LMS, concluding the effectiveness of the PM on performance.

As for MA, for the PG, it was reduced in all muscles, which may mean that the PM helped in recruiting the muscles for the test, assuming an improvement or an increase in motor learning during the task. In the same way, one of the hypotheses also for the PG to decrease MA is that, when training using the principles of the PM, exercise control is one of the goals and, thus, those who perform it are able to control the muscular movements performed[20]. In view of this finding, which requires further future studies, attention is drawn to one of the positive points of this study, as it verifies that more muscles, or more motor units of the same muscle can be recruited to perform the analyzed movement.

This finding, on motor learning, has already been proposed by Silveira et al.[21], who analyzed the immediate effect of a PM session on the pattern of co-contraction of superficial and deep trunk muscles in individuals with and without chronic nonspecific low back pain during the localized muscle endurance test (Biering-Sorensen test).

The study by Silveira et al.[21] concluded that the PM has the intention of promoting a change in neuromuscular programming and that this new pattern may reduce the need to recruit the trunk muscles, proposing that they learn to recruit other muscles so as not to "overload" the agonists, and thus the energy expenditure during the task is reduced, contributing to the occurrence of less muscle fatigue and reducing the chances of injuries.

For soccer players, it is important that there is motor learning appropriate to the movements required on the field/court, whether for new players or for athletes in the phase of biological maturation. This probably occurred with our sample, in order to improve their performance and lead to the best physical and athletic performance. It reinforces the fact that the soccer players have to have better torso stabilization and greater balance between muscles, in order to determine their best performance in the field.

In the CG, it was not observed the same pattern mentioned above: RF increased MA, and although their activation decreased, BF and RA remained close to the pre-intervention values, which is in line with the possible explanation for the benefits of this type of training.

There is a growing demand for the PM as a form of rehabilitation, whether for athletes or non-athletes, with few studies evaluating it as a preventive method. A systematic review conducted in 2015[22] confirms this and shows that no intervention program mentions the PM. In other words, the need for more work, with good scientific evidence, becomes essential for the protocols to be administered in a more coherent manner and with better resolution. Our study seeks to fill this gap, as well as being indicative of a complement for medium-sized clubs that train players in the base categories.

As for the number of sessions, Pertile et al.[12] and Cruz et al.[13], who had the same focus and similar samples, used 12 sessions and concluded that they were not enough to show significant results. Nevertheless, Bertolla et al.[10] and Chinnavan, Gopaladhas, Kaikondan (2015)[11] used 12 and 20 sessions with the PM, respectively, and reached significantly positive results in relation to the method. The intervention time of these articles was taken as a basis and, given the different objective proposed, it was concluded that this time was short to obtain significantly positive results. However, it is important to emphasize the fact that few sessions are already sufficient to promote the results found in our study, for this sample.

Another point to consider, the sample size, although it seems small, we worked with practically all the players of the club in the championship season, which is representative of Brazilian mid-sized city clubs.

CONCLUSION

It is concluded that the exercise protocol based on the PM, with 15 training sessions, can reduce exhaustion, change the muscular electrical activity and improve the functional performance of young soccer players.

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