Research, Society and Development, v. 11, n. 14, e84111435975, 2022
(CC BY 4.0) | ISSN 2525-3409 | DOI: http://dx.doi.org/10.33448/rsd-v11i14.35975

Short-term Pilates protocol promotes improvement in the functional performance of juvenile soccer players

Protocolo de Pilates de curto período promove melhora da performance funcional de jogadores juvenis de futebol

Protocolo de Pilates corta duración promueve la mejora en el rendimiento funcional de futbolistas juveniles

Received: 09/29/2022 | Revised: 10/14/2022 | Accepted: 10/15/2022 | Published: 10/20/2022

Ana Laura Nogueira
ORCID: https://orcid.org/0000-0002-6840-1586
Federal University of Triângulo Mineiro, Brazil
E-mail: analaura_fisio@hotmail.com
Diego Brenner Ribeiro
ORCID: https://orcid.org/0000-0003-0187-2292
Federal University of Triângulo Mineiro, Brazil
E-mail: diego@anatomyfisioterapia.com.br
Franciele Carvalho Santos Parolini
ORCID: https://orcid.org/0000-0001-6765-6475
Federal University of Triângulo Mineiro, Brazil
E-mail: franciele_carvalho_santos@hotmail.com
Manoela de Abreu
ORCID: https://orcid.org/0000-0001-7848-287X
Federal University of Triângulo Mineiro, Brazil
E-mail: manuh-abreu94@hotmail.com
Bruno Sada Salerno
ORCID: https://orcid.org/0000-0003-1530-1853
Federal University of Triângulo Mineiro, Brazil
E-mail: brunosadasalerno@gmail.com
Alexandre de Paula Rogério
ORCID: https://orcid.org/0000-0001-5913-3703
Federal University of Triângulo Mineiro, Brazil
E-mail: alexprogerio@yahoo.com.br
Dernival Bertoncello
ORCID: https://orcid.org/0000-0002-4432-4651
Federal University of Triângulo Mineiro, Brazil
E-mail: dernival.bertoncello@uftm.edu.br

Abstract
The objective of the study was to investigate the effects of a training program with the Pilates Method on muscle fatigue in youth soccer players. Fifteen male soccer players, sub 13-15 category, with a mean age of 13.27 ± 0.45 years, were randomly divided into two groups: Control group (n = 7) and Pilates group (n = 8). In the Pilates group, an additional training protocol was performed with the Pilates Method alone. In both groups, the concentration of cytokines (TNFα, IL-10), the electrical activity of the rectus femoris, rectus abdominis, biceps femoris and gluteus maximus muscles was evaluated and the Side Hop Test was performed. In both groups, there were no significant changes in the cytokine profile and in the electrical activity of the evaluated muscles, but there was a significant difference in the time taken to perform the Side Hop test for the Pilates group. The application of the Pilates method (solo) as an additional training in youth soccer players did not show greater tolerance to muscle fatigue, however it may have generated an improvement in the functional performance of the athletes.
Keywords: Soccer; Fatigue; Exercise and movement techniques; Physiotherapy; Electromyography.

Resumo
O objetivo do estudo foi investigar os efeitos de um programa de treinamento com o Método Pilates solo sobre a fadiga muscular em jogadores juvenis de futebol. Foram avaliados 15 jogadores de futebol, da categoria sub 13-15, do gênero masculino, com média de idade 13,27±0,45 anos, divididos aleatoriamente em dois grupos: grupo Controle (n=7) e grupo Pilates (n=8). No grupo Pilates foi realizado um protocolo adicional de treinamento durante 5 semanas, totalizando 15 sessões de exercícios do Método Pilates solo. Nos dois grupos, avaliou-se a concentração de citocinas

(TNFα, IL-10), a atividade elétrica dos músculos reto femoral, reto abdominal, bíceps femoral e glúteo máximo e foi realizado o Side Hop Test. Em ambos os grupos, não houve alterações significativas no perfil das citocinas e na atividade elétrica dos músculos avaliados, porém houve diferença significativa no tempo de execução do Side Hop teste para o grupo Pilates. A aplicação do método Pilates (solo) como um treinamento adicional em jogadores juvenis de futebol não demonstrou maior tolerância à fadiga muscular, porém pode ter gerado melhora na performance funcional dos atletas.
Palavras-chave: Futebol; Fadiga; Técnicas de exercício e de movimento; Fisioterapia; Eletromiografia.

Resumen
El objetivo del studio fue investigar los efectos de un programa de entrenamiento con el Método Pilates sobre la fatiga muscular en jóvenes futbolistas. Quince futbolistas masculinos, categoría sub 13-15, con una edad media de 13.27 ± 0.45 años, fueron divididos aleatoriamente en dos grupos: grupo control (n = 7) y grupo pilates (n = 8). En el grupo Pilates se realizó un protocolo de entrenamiento adicional con el Método Pilates solo. En ambos grupos se evaluó la concentración de citocinas (TNFα, IL-10), la actividad eléctrica de los músculos recto femoral, recto abdominal, biceps femoral y glúteo mayor y se realize el Side Hop Test. En ambos grupos no hubo cambios significativos en el perfil de citoquinas y en la actividad eléctrica de los músculos evaluados, pero sí hubo diferencia significativa en el tiempo de realización del test Side Hop para el grupo de Pilates. La aplicación del método Pilates (solo) como entrenamiento adicional en futbolistas juveniles no mostró mayor tolerancia a la fatiga muscular, sin embargo pudo haber generado una mejora en el rendimiento functional de los deportistas.
Palabras clave: Fútbol; Fatiga; Técnicas de ejercicio y movimiento; Fisioterapia; Electromiografia.

1. Introduction

Football is a sport of wide reach and popularity, requires high and constant performance of athletes from initiation to sport. To meet this demand, sportsmen undergo intense training routines dedicating themselves almost exclusively (Costa et al., 2019), and evidencing in several situations that their intensity has become a stressful factor for the athletes' body (Freitas et al., 2007).

When considering the stages of life, adolescents are more vulnerable to sports injuries not only because they participate earlier and more intensely in sports practice, but also in a process of rapid growth and neurobiological maturation, in an increasingly competitive and selective psychosocial environment. The occurrence pattern of injuries (types, causes and their distribution) in young adolescents is similar to that in adult professional sportsmen (AAOS, 2003).

In sports training, five physical capacities which must be trained can be highlighted: endurance, strength, speed, flexibility and coordination (Gomes, 2009). In addition, it is necessary for athletes to develop good physical fitness, motor control, knowledge of sports gesture, excellent level of physical preparation and mental preparation (Steinman et al., 2000).

Strategies that can somehow minimize muscle fatigue and eventually injuries, can provide an important competitive advantage, since in football a game is won through a single motor action. Thus, many resources have been used within the sports field in order to optimize muscle recovery (Pastre et al., 2009).

In view of the above, the Pilates Method offers practitioners several benefits, such as postural alignment, physical conditioning, flexibility, strength, balance and body awareness (Latey, 2001), besides helping in the prevention and mitigation of injuries and dysfunctions of the musculoskeletal system (Phrompaet et al.,2011). Some examples on topics investigated in relation to Pilates are those which refer to the effects on the method on lumbar spine issues (da Luz et al., 2013; Rydeart et al., 2006; Lim & Poh Wong, 2011), to gain strength and muscle endurance (Herrington & Davies, 2005; Sekendiz et al.,2007) and also to rehabilitation and quality of life (Anderson, 2000; Gladwell et al., 2006). It is also considered the importance of studies that investigate the effects of Pilates exercises as a complement to the training of athletes.

In order to monitor performance, it is essential to obtain indicators which point out the limitations and development during the training process and the use of recovery techniques that accelerate the regeneration and restoration of body homeotase,

reducing the level of muscle fatigue and the frequency of injuries. There is a need to optimize methods oriented to the young population, which are individualized, effective and that can keep up with the needs of this population within the sport.

Therefore, the aim of the study was to verify whether additional training with Mat Pilates exercises would influence muscle fatigue in soccer players belonging to U-13 and U-15 categories.

2. Methodology

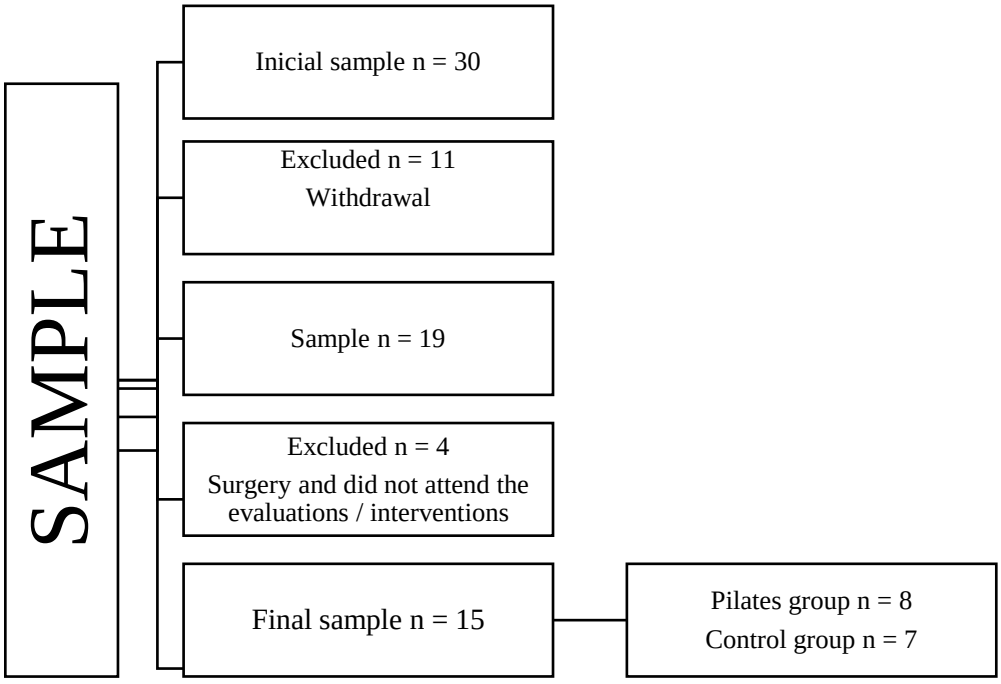
This was an experimental, controlled, randomized study with a quantitative approach. Experimental research consists of determining an object of study, selecting the variables that would be able to influence it, defining the forms of control and observation of the effects that the variable produces on the object (Gil, 2007).

2.1 Sample

The study sample was selected for convenience, 30 soccer players between 13 and 15 years old, linked to Uberaba Sport Club, were invited. This team plays in the third league of the state championship.

The inclusion criteria applied were: to belong to the sub13-15 category, attending the club's training at least three times a week with a weekly training schedule of at least nine hours. Athletes who did not present the Informed Consent Form (TCLE) signed by their parents or legal guardians, suspended from the training program, who presented muscle injury or orthopedic surgery in the knee, hip or ankle during the intervention period and/or evaluation were excluded in the study, and athletes who did not attend the evaluations and/or intervention for two consecutive days. It is important to emphasize that in all scientific research there is a lack of assiduity on the part of the volunteer. This is due to several reasons such as not a research idea, sociocultural factors and also psychosocial factors. The initial sample consisted of 30 individuals, 15 individuals were excluded (n=11 application of eligibility criteria, n=3 did not attend the evaluations/interventions, n=1 surgery). The flowchart, presented below, shows the path taken to select the sample.

Figure 1. Sample flowchart.



Source: Authors.

The criteria were met by 15 juvenile players, with mean age of 13.27 ± 0.45 years, mean body mass 51.90 ± 5.98 kg, mean height 164.26 ± 5.39 cm and body mass index 19.17 ± 2.38 kg/m².

Fifteen individuals were included in the study, considering, as a basis, published articles relating the Pilates method and sports, recognizing the limitations and difficulties of working with research in human beings (Bertolla et al., 2007; Cruz et al., 2014; Pertile et al., 2011).

Soon after the initial selection of volunteers, the randomization process was performed through a table with random numbers generated through Microsoft Excel®, which distributed the volunteers into two groups: Pilates group (n = 8) and Control group (n=7).

Both groups underwent the same evaluations and reevaluations. However, at first, only the Pilates group received as intervention the protocol with exercises of the Mat Pilates method (added to conventional training) while the Control group maintained the conventional training offered by the club only. After the end of the intervention, the reevaluation was performed in both groups and the Control group was offered the same protocol with exercises of Mat- Pilates Method, as required by the Ethics and Research Committee. The evaluations and data collection took place in the Human Movement Analysis Laboratory of the Federal University of Triângulo Mineiro, performed by duly trained professionals. The procedures were always collected in the morning, in an environment with adequate temperature and luminosity.

All volunteers and their guardians were informed of the objectives and methodology of the research. The study was conducted after approval by the Research Ethics Committee (CEP) whose opinion number is 2,827,678, issued in 2018 and registered with the Brazilian Registry of Clinical Trials (ReBEC) under identification RBR-6Z2DHD PILATES IN SOCCER.

2.2 Instruments

All volunteers were evaluated, control group and pilates group, on the week before the beginning of the intervention with the Mat Pilates method and reevaluated after five weeks of intervention.

2.3 Evaluation of Muscular Electrical Activity

For surface electromyography, the four-channel Miotool 400 USB (Miotec®) device was used, with quadrangular Ag/AgC electrodes. The signal was analyzed for filtration purposes. An analog/digital converter (A/D) of 16-bit resolution was used; EMG amplifier with total amplification gain of 2000 times per channel, four surface active bipolar electrodes, with acquisition rate of 1000 Hz per channel, common rejection rate ≥100 dB, preamp gains (cables) =20, system impedance=109 Ohms//2pF, signal noise rate≤ 3μV. Raw data were filtered with 60 Hz "notch" filter, high pass of 20 Hz and *low pass* of 500 Hz.

Skin preparation and electrode placement were performed following the guidelines of Hermens et al., (2000).

Electromyographic data were collected from four muscles: rectus femoris, femoral biceps, gluteus maximus and abdominal rectus. The rectus femoris, femoral biceps and gluteus maximus muscles followed the guidelines of the SENIAM protocol (Suface Electromyography for Non-Invasive Evaluation of Muscles) with the exception of the abdominal rectus that followed the reference of Perotto et al., (2011). The reference electrode was positioned in the synoid process of the homolateral ulna.

The variable analyzed was median frequency, which is the characteristic of the electromyographic signal which best demonstrates the changes in the conduction velocity of skeletal muscle fibers allowing to observe the process of muscle fatigue. The collection was performed during the Side Hop Test and was performed under verbal command, where the individual started the test and ended it after feeling exhaustion and interrupting the test.

For the consideration of the values, based on the raw data, the highestpeak contraction value – among the 3 obtained – both in the evaluation and in the reevaluation were used.

Every signal was considered for general analysis purposes, but only the last five seconds were considered. It is assumed that there may have been fatigue, based on the decrease in the values.

2.4 Functional Performance Evaluation (SIDE HOP TEST)

The Side Hop Test aimed to evaluate the ability to produce power speed, balance and control of the lower extremity over a lateral and horizontal distance.

To perform the test, the athlete was positioned next to the demarcated starting line on the ground, with the dominant lower limb supported on the ground and the other lower limb with knee flexion to avoid contact. The test consisted of performing lateral jumps in unipodal support between the two demarcated ends separated thirty centimeters away, with hands on the hips, on back or free. The individual was instructed to perform the test at high speed until he reported fatigue. The test was timed.

In addition to measuring the time to evaluate the functional athletes' performance, the test was also performed during surface electromyography in the rectus femoris, femoral biceps, gluteus maximus and abdominal rectus muscles to evaluate the fatigue of these muscles.

2.5 Blood Collection and Sample Preparation

Blood collection was performed, under the responsibility of an accredited biomedical scientist, following all hygiene care and asepsis. The blood was collected in vacuum tubes containing separator gel (Vacutainer – Becton Dickinson), so as to obtain the serum, using 21G needles (Vacutainer) by means of venous puncture in the cubital fossa region.

Blood samples (5ml) were collected at rest and immediately after the Side Hop Test. The material was centrifuged at 1200 rotations per minute for fifteen minutes, after separation, the serum was stored in eppendorf tubes stored at -80 °C.

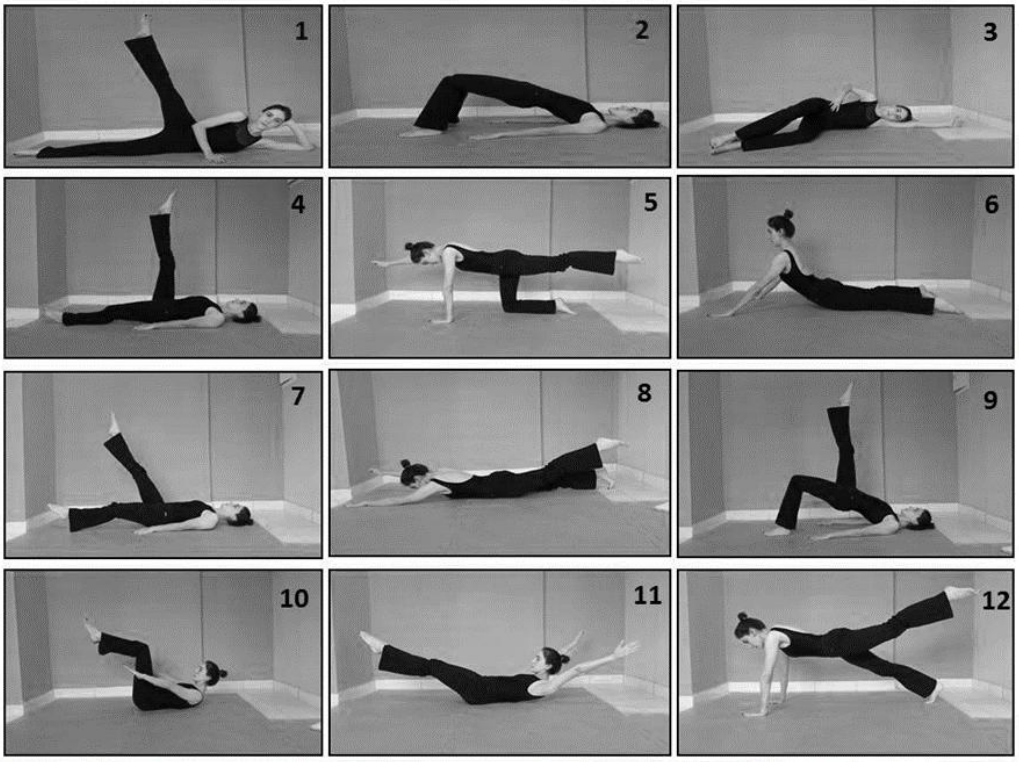
The circulating concentrations of TNF-α and IL-10 were determined by using quantitative enzymatic ELISA (R&D System) kits.

2.6 Procedures

The training program with the Mat Pilates Method was carried out for five weeks, with a frequency of three times a week on alternate days. The participants of the Pilates group performed a total of fifteen sessions of exercises of the Solo Pilates Method lasting thirty minutes each session. The first session was used as introduction and familiarization to the Method, the volunteers were instructed on the principles of the method (breathing, contraction of the strength center, concentration, control, precision and fluidity) which needed to be respected during the execution of each exercise. The next sessions were divided as follows, seven sessions of the basic module for beginners and seven sessions of the intermediate module. The interventions were conducted by an experienced, Pilates certified professional.

Below we can see the demonstration of the exercises performed with the volunteers, the perspective of the exact work of the muscle groups worked.

Figure 2. Exercise protocol of the Mat Pilates Method.



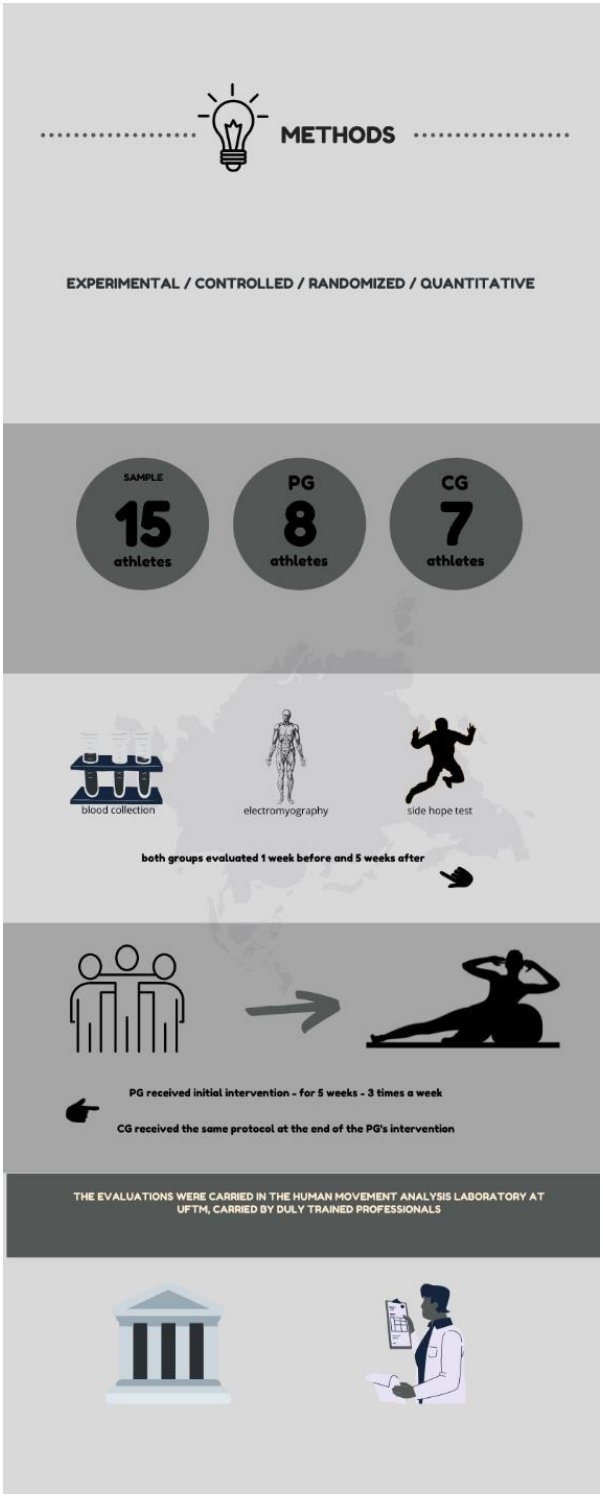
Source: Authors.

The exercises were performed in a set of ten repetitions, in an attempt to work out the method within its traditional precepts, which aim body awareness and balance, in addition to improving flexibility as well as muscle strength.

The Mat Pilates Method exercise protocol was elaborated emphasizing the lower limbs and the core aiming at preparing for the impacts of a soccer match that requires fast and explosive movements, and also seeking to contemplate, through exercises, the progressive strengthening, stability, sports gesture improvement and consequently performance improvement.

The exercise protocol was performed in the athletes' training environment, in a space properly prepared at room temperature and also adequate luminosity.

Figure 3. Methods Infographic.



Source: Authors.

The infographic brings and overview of the entire methodology used in the work. With its reading and visualization, it is possible to describe in a short time what was described in the methodology.

2.7 Statistical analysis

The data were expressed in ± standard deviation (x ± sd). The variations in measurements at the beginning and at the end of the study were expressed as delta values (Δ).

Normality test (Shapiro Wilk) was applied in order to verify the distribution of the sample and then t-test for comparison between groups for normal data, both initial and final, or Mann Whitney, if there was no normality.

Cohen's d-index was performed to verify the dimension degree of the phenomenon in the sample, in order to better predict the results for clinical situations. Considering the size of the effect being <0.2 insignificant; 0.2 to 0.5 small; 0.5 to 0.8 moderate and >0.8 large.

The evaluation of the results of the cytokine concentration was performed by analysis of variance (ANOVA), followed after Tukey's< test. The significance level adopted was 5% ($p<0.05$).

3. Results

Table 1 shows the characterization of the sample regarding age, mass, height and body mass index. The volunteers were healthy young people, aged between 13 and 15 years, male, with right-handed dominance of the lower limb.

It is observed that there was no significant difference between the control and Pilates groups in relation to these variables, thus it can be affirmed that there is homogeneity between the experimental and control groups, and therefore they are comparable.

Table 1. Characterization of the sample.

Variables	Total Sample (n=15)	Pilates Group (n=8)	Control Group (n=7)	*p*
Age (years)	13.2 ± 0.4	13.2 ± 0.4	13.2 ± 0.4	0.8
Mass (kg)	51.9 ± 5.9	54.3 ± 5.9	49.2 ± 5.2	0.8
Height (cm)	164.2 ± 5.3	164.5 ± 4.6	164.0 ± 6.4	0.1
BMI (kg/m^2)	19.1 ± 2.3	19.8 ± 2.2	18.3 ± 2.4	0.3

Source: Authors.

By reading table 1, it is possible to verify all the variables of the volunteers, facilitating understanding and reasoning about the work developed. This question is extremely important for the follow-up of the research.

Table 2 shows the median frequency values on average ± standard deviation for the rectus femoris, abdominal rectus, gluteus maximus and femoral biceps muscles, fatigue time during side hop test execution, the values of p, delta (final FM-initial FM), difference p and Cohen's d.

Table 2. Values of the median frequency (hertz), the execution time of the Side Hop Test (seconds), p value, delta, k-difference p and Cohen's d of the Pilates and Control groups before and after the intervention with the Mat Pilates Method.

Muscle	Group	Pre Pilates **MF** (hertz)	Post Pilates **MF** (hertz)	*p*	Delta	*p* (dif)	Cohen's D
Rectus Femoris	**Pilates**	123.7±23.5	123.8±19.2		0.04±11.4		
	Control	114.5±19.5	118.6±16.8	0.09	4.0±17.7	0.60	-0.28
Abdominal Rectus	**Pilates**	89.2±21.0	96.7±28.6		7.5±23.2		
	Control	85.9±20.3	84.9±14.6	0.39	-1.4±9.9	0.81	0.52
Gluteus Maximus	**Pilates**	57.3±6.1	60.4±7.6		3.0±5.9		
	Control	67.0±19.0	58.8±6.6	0.23	-8.2±14.8	0.06	1.12
Femoral Biceps	**Pilates**	103,1±20.0	100.9±27.5		-2.2±17.1		
	Control	96.8±19.6	95.2±32.6	0,40	-1.5±14.7	0.94	-0.04
Time (seg)	**Pilates**	51.6±32.7	123.1±60.4		71.5±43.5		
	Control	60.0±39.8	89.5±66.9	0.01	29.5±34.5	0.03	1.07

Source: Authors.

There were no statistically significant differences in relation to the median frequency for any of the muscles mentioned above in both groups, but regarding the execution time of the Side Hop Test, there was statistical significance for the Pilates and Control groups (p=0.01), and the Pilates group presented a mean time after intervention (123.1±60.4) (higher than the Control group (89.5 ± 66.9) (Table2).

Table 3 shows the concentration (pg/ml) of tumor necrosis factor α (TNF-α) and interleukin-10 (IL-10) of the Control and Pilates groups. Cytokine dosage was performed at two moments in the evaluation (pre-intervention), before and immediately after the Side Hop Test and at two moments in the reevaluation (post-intervention), before and immediately after the Side Hop test.

Table 3. Changes in serum levels TNF-α and IL-10 in the Pilates and Control groups in the pre-intervention evaluation and post-intervention reevaluation, before and immediately after the Side Hop test.

GROUPS	TNF-α (mean ± SEM pg/mL)	IL-10 (mean ± SEM pg/mL)
CG EV. BEFORE	8.97 ± 8.97	ND
CG EV. AFTER	26.99 ± 26.99	ND
CG REEV. BEFORE	ND	12.09 ± 12.09
CG REEV. AFTER	ND	11.10 ± 11.10
PG EV. BEFORE	129.43 ± 76.84	1.55 ± 1.55
PG EV. AFTER	144.87 ± 79.77	ND
PG REEV. BEFORE	212.02 ± 106.46	ND
PG REEV. AFTER	ND	ND

Captions: CG EV. BEFORE – Control Group Evaluation, Collection before Side Hop Test; CG EV. AFTER Control Group Evaluation, Collection after Side Hop Test; CG REEV. BEFORE - Control Group, Reevaluation, Collection before Side Hop Test; CG REEV, AFTER - Control Group, Reevaluation, Collection after Side Hop Test; PG EV. BEFORE – Pilates Group, Evaluation, Collection before Side Hop Test; PG EV. AFTER - Pilates Group, Evaluation, Collection after Side Hop Test; PG REEV. BEFORE - Pilates Group, Reevaluation, Collection before Side Hop Test; PG REEV AFTER - Pilates Group, Reevaluation, Collection after Side Hop Test; ND- Not detected. Source: Authors.

Regarding cytokines, it was observed that there was no difference in TNF-α concentration in the Control group before and after the execution of the Side Hop pre-intervention test and, after the intervention, the limit for plasma detection was not reached. In the Pilates group, there was a slight increase after the performance of the pre intervention functional test, and in the reevaluation after the intervention, it was not possible to detect the concentration of TNF-α in plasma. In relation to IL-10, it was only possible to detect its concentration in the Control group, in the reevaluation, before and after the Side Hop test, while in the Pilates group, a low concentration was observed in the evaluation before the fatigue test.

4. Discussion

The intrinsic factors to fatigue are related to the levels of physical exertion and the soccer players' physiological demand (Greig, 2008; Reilly et al., 2008). Our results indicated improvement in the athletes' performance.

Thus, psychological, motor, physiological and biochemical variables have been used as parameters to quantify intensity and fatigue indices of a stimulus, whether during competitions or training.

In this context, from the results obtained here, it seems convenient to discuss the behavior of motor and biological capacity in the face of the training program used.

Regarding the Side Hop Test, there was no significant difference in fatigue resistance for the muscles analyzed, but when analyzing the muscle activity values of the rectus and gluteus maximus before and after training with the Mat Pilates

Method, it is observed that there is an increase in the median frequency in the Pilates Group for these muscles, suggesting that even with little training time, there may have been a greater resistance to fatigue on the rectus and the gluteus maximus.

Gonzáles-Galvéz et al., (2019) evaluated the effects of the Pilates method on muscle strength and resistance of extensor and flexor muscles of the trunk in a group of adolescents with low back pain. The sample consisted of 101 students, divided into two groups: experimental group (EG= 81) and control group (CG = 20). The intervention was performed twice a week for six weeks for 55 minutes. Six weeks after Pilates implantation, the muscle strength of the flexors as well as the trunk extensors increased in the adolescents.

Another study conducted by Silveira et al., (2018) analyzed the immediate effect of a Pilates method exercise session on the co-contraction pattern (agonist/antagonist) of the superficial (iliocostal lumbar and abdominal rectus) and deep (internal oblique and multifid) muscles of the trunk in individuals with and without low back pain, it was observed that only one training session with Pilates method exercises was able to reduce the co-contraction between the trunk muscles (in individuals with and without nonspecific low back pain). Consequently, with the reduction of trunk muscle co-contraction, the energy consumption during the task can be reduced, which contributes to the occurrence of less muscle fatigue.

A possible justification for greater resistance to fatigue of the gluteus maximus and abdominal rectus is that the Pilates Method exercises focus its performance on the central part of the body, known as powerhouse or core, which has stabilization as its main function.

Regarding the execution time of the Side Hop Test, both groups obtained a significant increase in exhaustion during the test, but the tolerance to exhaustion occurred in the Pilates Group was higher when compared to the control group. This suggests that there may have been an increase in the players' functional capacity, indicating that Pilates acted as an additional training to the conventional one so that there was an improvement in the result of the physical test.

Kamonsek, et al., (2018) determined the reliability, measurement error and validity of the Side Hop Test construction in children and adolescents. The test was performed in 36 healthy male individuals aged 10 to 16 years. The results support the use of the Side Hop Test to evaluate children and adolescents. The measurements showed good intra-rater reliability and very good reliability among evaluators.

Arliani et al., (2012), also analyzed the effects of the physical effort in a football match on the functional capacity and stability of the lower limbs in young soccer players through a Hop test protocol. Ten soccer players were analyzed, submitted to functional capacity evaluation of the lower limbs through a Hop Test protocol and evaluation of the postural stability level through the Biodex Stability System, before and immediately after a friendly soccer match lasting 45 minutes. The results of the study show that there is a decrease in stability and functional capacity of the lower limbs after the match. These results can indicate lower limbs muscle fatigue as a possible factor in the presence of a higher incidence of injuries that occurred in the last 15 minutes of each half of a soccer match. From the point of view of the team's tactical performance, the coach can use the activity to develop the principles of the game model adopted by him, aiming to optimize the training process and maximize the athletes' performance.

The agility and speed performances contribute to the evaluation and control of the training of children involved in modalities in which agility and speed are determinant. In addition, identifying the magnitude of the contribution of jumps to the performance of speed and agility makes it possible to prescribe specific strength training to increase these capabilities.

In the analysis of tumor necrosis factor (TNF-α) and Interleukin-10 (IL-10) concentration, there was no significant difference in the concentrations of the Control and Pilates group before and after the side hop test, before and after the intervention.

The non-significant change in the profile of inflammatory cytokine TNF-α found in the study is in agreement with Kim et al., (2014), who verified the effects of Pilates during 8 weeks on lipid metabolism, on the expression of mRNA and

inflammatory cytokines in young people. It was found that the expression of TNF-α showed significant effect in the Pilates and control groups, which does not indicate correlation of Pilates with the increase of cytokine, that is, the exercises of the Pilates Method did not induce an inflammatory response in the body.

Another study conducted by Gronesova et al., (2018), measured the plasma levels of 27 cytokines of healthy volunteers obtained before and after two weeks of Pilates exercise. Pilates has been observed to improve the immune response of NK cells and the inflammatory environment in plasma in healthy women, but did not cause changes in IL-10 and TNF-α.

Taking into account the studies above and the results found, a possible justification is that as individuals were trained, the protocol with Pilates method exercises, under the conditions it was applied, has not been characterized as an intense exercise capable of causing significant change in the profile of TNF-α and IL-10 cytokines and acting significantly in increasing fatigue resistance of the muscles analyzed. Thus, the Pilates Method deserves further studies for a clearer view of the physiological phenomena involved. However, the aforementioned training model could serve as an important tool for coaches in improving the athletes' physical condition. Caution is required in the prescription of additional training to the regular one. The training intensity should be maintained so that it does not cause extreme muscle fatigue to the players.

As limitations of the study, we can mention the low training time with Pilates method exercises due to the sample availability, although this fact may also be important as an indication of short-term clinical activity. Although we verified there was an improvement in the athletes' functional activity who trained with Pilates exercises, the athletes also became limited when considering the amount of muscles which had the electrical signal analyzed and also the amount of exercises that can be explored through the Method.

Considering the growing demand of young individuals for the practice of high intensity physical exercises, it would be appropriate for future studies to be stimulated with different samples and intervention time.

5. Conclusion

It is concluded that the exercise protocol presented here improves the functional performance of the athletes. Pilates method exercises are supplementary to the athlete's sports training. Future work should be encouraged in order to better elucidate the benefits of the Pilates method in high-performance athletes.

Acknowledgments

The authors would like to thank Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – CAPES, Fundação de Amparo à Pesquisa do Estado do Minas Gerais – FAPEMIG, Conselho Nacional de Desenvolvimento Científico e Tecnológico – CNPq and the participants of this study. There was no conflict of interest between the parties.

References

AAOS. (2003). Pay attention to high school sports injuries. American Academy of Orthopaedic Surgeons (AAOS).

Anderson, B. D. & Spector, A. (2000). Introduction to Pilates-based rehabilitation. *Orthopaedic Physical Therapy Clinics of North America*, 9 (3), 395-410.

Arliani, G. G., Almeida, G. P. L., Santos, C. V., Venturini, A. M., Astur, D.C. & Cohen, M. (2013). O efeito do esforço na estabilidade postural em jovens jogadores de futebol. *Acta Ortopédica. Brasileira*, 21 (3), 155-158. 0.1590/S1413-78522013000300005.

Bertolla, F., Baroni, B. M., Junior, E. C. P. L. & Oltramari, J. D. (2007). Efeito de um programa de treinamento utilizando o método Pilates na flexibilidade de atletas juvenis de futsal. *Revista Brasileira de Medicina do Esporte*, 13 (4), 222-226. 10.1590/S1517-86922007000400002

Costa, C. F. T. Costa, A. C. S. & Vargas, M. M. (2019). Lesão física, estresse psicológico e enfrentamento em atletas de Futebol. *Revista Brasileira de Futsal e Futebol*, 11 (43), 208-214. Available in: http://www.rbff.com.br/index.php/rbff/article/view/744

Cruz, T. M. F., Germano, M. D., Crisp, A. H., Sindorf, M. A. G., Verlengia, R., Mota, G. R. & Lopes, C. R. (2014). Does Pilates training change physical fitness in young basketball athletes? *Journal of Exercise. Physiology Online*, 17 (1), 1-9. Available in: https://www.asep.org/asep/asep/JEPonlineFEBRUARY2014_da%20Cruz_Lopes.pdf

Freitas, D. S., Silva, V., Castro, P. L., Lima, J. P. & Filho, M. B. (2007). Análise do efeito da carga de treinamento sobre a variabilidade da freqüência cardíaca em repouso durante um macrociclo de treinamento. *Coleção Pesquisa em Educação Física*, 1(6), 67.

Gladwell, V., Head, S., Haggar, M. & Beneke, R. (2006). Does a program of Pilates improve chronic non-specific low back pain? *Journal of Sport Rehabilitation*, 15 (4), 338-350. 10.1123/jsr.15.4.338

Gil, A. C. (2007). *Como elaborar projetos de pesquisa*. (4a ed.). Atlas.

Gomes, A. C. (2009). *Treinamento desportivo: estruturação e periodização*. (2a ed.). Artmed Editora.

González-Gálvez, N., Marcos-Pardo, P. J. & Carrasco-Poyatos, M. (2019). Functional improvements after a pilates program in adolescents with a history of back pain: A randomised controlled trial. *Complementary Therapies in Clinical Practice*, 35, 1-7. 10.1016/j.ctcp.2019.01.006

Greig, M. (2008). The influence of soccer-specific fatigue on peak isokinetic torque production of the knee flexors and extensors. *The American Journal of Sports Medicine*, 36 (7), 1403-1409. 10.1177/0363546508314413.

Gronesova, P., Cholujova, D., Kozic, K., Korbuly, M., Vlcek, M., Penesova, A., Imrich, R., Sedlak, J. & Hunakova, L. (2018). Effects of short-term Pilates exercise on selected blood parameters. *General Physiology and Biophysics*, 37 (4), 443-451. 10.4149/gpb_2018007.

Hermens, H. J., Freriks, B., Disselhorst-Klug, C. & Rau, G. (2000). Development of recommendations for SEMG sensors and sensor placement procedures. *Journal of Electromyography and Kinesiology*, 10(5), 361–374. 10.1016/s1050-6411(00)00027-4.

Herrington, L. & Davies, R. (2005). The influence of Pilates training on the ability to contract the transversus abdominis muscle in asymptomatic individuals. *Journal of Bodywork and Movement Therapies*, 9 (1), 52-57. 10.1016/j.jbmt.2003.12.005

Kamonseki, D. H., Cedin, L., Tavares-Preto, J. & Calixtre, L. B. (2018). Reliability, validity, and minimal detectable change of Side Hop Test in male children and adolescents. *Physical Theraphy in Sports*, 34, 141-147. 10.1016/j.ptsp.2018.09.009.

Kim, H. J., Kim, J. & Kim, C. S. (2014). The effects of pilates exercise on lipid metabolism and inflammatory cytokines mRNA expression in female undergraduates. *Journal of Exercise Nutrition & Biochemistry*. 18 (3), 267-75. 10.5717/jenb.2014.18.3.267.

Latey, P. (2001). The Pilates method: history and philosophy. *Journal of Bodywork and Movement Therapies*, 5 (4), 275–82. 10.1054/bwmt.2001.0237.

Lim, E. C. W., Poh, R. L. & Wong, W. P. (2011). Effects of Pilates-based exercises on pain and disability in individuals with persistent nonspecific low back pain: a systematic review with meta-analysis. *Journal of Orthopaedic & Sports Physical Therapy*, 41 (2), 70-80. 10.2519/jospt.2011.3393.

da Luz, M. A., Costa, L. O. P., Fuhro, F. F., Manzoni, A. C. T., Oliveira, N. T. B. & Cabral, C. M. N. (2013). Effectiveness of mat Pilates or equipment-based Pilates in patients with chronic non-specific low back pain: a protocol of a randomized controlled trial. *Musculoskeletal Disorders*, 14:16. 10.1186/1471-2474-14-16

Pastre, C. M., Bastos, F. N., Junior, J. N., Vanderlei, L. C. M. & Hoshi, R. A. (2009). Métodos de recuperação pós exercício: uma revisão sistemática. *Revista Brasileira de Medicina do Esporte*, 15 (2), 138-144. 10.1590/S1517-86922009000200012

Perotto, A. O., Delagi, E. F., Iazzetti, J. & Morrison D. (2011). *Anatomical guide for the electromyographer: The limbs and trunk.* (5a ed.). Charles C Thomas Publisher.

Pertile, L., Vaccaro, T. C., Marchi, T. D., Rossi, R. P., Grosselli, D. & Mancalossi, J. L. (2011). Estudo comparativo entre o método pilates e exercícios terapêuticos sobre a força muscular e flexibilidade de tronco em atletas de futebol. *ConScientiae Saúde,* 10 (1), 102-111. 10.5585/ConScientiaeSaude/2011/v10n1/2454.

Phrompaet, S., Paungmali, A., Pirunsan, U., & Sitilertpisan, P. (2011). Effects of Pilates Training on Lumbo-Pelvic Stability and Flexibility. *Asian Journal of Sports Medicine*, 2 (1), 16-22. 10.5812/asjsm.34822.

Reilly, T., Drust, B. & Clarke, N. (2008). Muscle fatigue during football match-play. *Sports Medicine*, 38 (5), 357-367. 10.2165/00007256-200838050-00001

Rydeard, R., Leger, A. & Smith, D (2006). Pilates-based therapeutic exercise: effect on subjects with nonspecific chronic low back pain and functional disability: a randomized controlled trial. *Journal of Orthopaedic & Sports Physical Therapy*, 36 (7), 472-484. 10.2519/jospt.2006.2144

Sekendiz, B., Altun, Ö., Korkusuz, F. & Akin, S. (2007). Effects of Pilates exercise on trunk strength, endurance and flexibility in sedentary adult females. *Journal of Bodywork and Movement Therapies*, 11 (4), 318-326. 10.1016/j.jbmt.2006.12.002

Silveira, A. P. B., Nagel, L. Z., Pereira, D. D., Morita, A. K., Spinoso, D. H., Navega, M. T. & Marques, N. R. (2018). Efeito imediato de uma sessão de treinamento do método Pilates sobre o padrão de cocontração dos músculos estabilizadores do tronco em indivíduos com e sem dor lombar crônica inespecífica. *Fisioterapia e Pesquisa*, 25 (2), 173-181. 10.1590/1809-2950/17594425022018.

Steinman, J., Vasconcelos, E. H., Ramos, R. M., Botelho, J. L. & Nahas, M. V. Epidemiologia dos acidentes no surfe no Brasil. *Revista Brasileira de Medicina do Esporte*, 6 (1), 9-15. 10.1590/S1517-86922000000100004