Manual Therapy, Posturology & Rehabilitation Journal
Formely REVISTA TERAPIA MANUAL

RESEARCH ARTICLE

https://doi.org/10.17784/mtprehabjournal.2020.18.790

Twelve Pilates sessions improve muscle function but has no effect on cardiac autonomic modulation of sedentary patients with low-back pain

Daniel Iwai Sakabe, Fabiana Forti Sakabe, Ariane Cristina Dias de Souza, Alline Pereira Guerreiro.

Faculdades Integradas Einstein de Limeira, Limeira (SP), Brazil.

ABSTRACT
Background: Sedentary lifestyle is an important risk factor for several pathological conditions in different organ systems, increasing the incidence of musculoskeletal disorders such as low back pain, as well as the risk of cardiovascular diseases. **Objective:** evaluate the effect of 12 Pilates sessions on muscle parameters, functional capacity and cardiac autonomic modulation. **Methods:** 10 volunteers with chronic low back pain (25.1 ± 5.1 years) underwent 4 evaluations before and after training: hamstring flexibility, using photogrammetry; abdominal resistance, through the one-minute trunk flexion repetition test; functional capacity, through the Roland Morris questionnaire; autonomic modulation of heart rate, using the RMSSD index of the R-R intervals. The Pilates training program lasted 12 sessions, each one hour long, consisting of Pilates mat exercises. The paired Student's t test was used, with a significance level of 5%, for the comparison of pre- and post-training data. **Results:** A significant improvement ($p < 0.05$) in flexibility was observed (from 58.7 ± 8.2 degrees to 84.1 ± 10.3 degrees in right lower limbs and from 57.2 ± 9.1 degrees to 78.5 ± 11.9 in left lower limbs), abdominal resistance (from 28.3 ± 17.6 repetitions to 33.6 ± 16.0 repetitions) and functional capacity (from 6.2 ± 2.8 points to 3.3 ± 1.0 points). Heart rate variability did not change significantly ($p = 0.09$) after training (RMSSD of 37.5 ± 15.0 in the pre-training assessment and 39.0 ± 15.0 in the post-training assessment). **Conclusion:** It can be concluded that the proposed Pilates program was effective in improving muscle and function, but did not promote changes in cardiac autonomic modulation.
Keywords: Pilates; Low Back Pain; Flexibility; Heart Rate Variability.

BACKGROUND

Musculoskeletal disorders are the main cause of chronic pain and physical disability[1]. Chronic low back pain, characterized by persistent pain for more than 12 weeks[2], is an affection that will be experienced by up to 84% of the population, at some stage of life, and is usually associated with personal, social and economic complications[3]. Chronic low back pain is related to several factors, such as dysfunction of the deep abdominal muscles, the transversus abdominis being the most important, in addition to the pelvic floor, diaphragm, and the multifidus, causing a reduction in the stabilizing activity of the muscles that act in the lumbar spine[4]. The increase in the prevalence of this type of impairment is also directly related to lifestyle, with sedentary lifestyle being one of the most important[5].

The World Health Organization and the International Sports Federation estimate that half the world's population is physically inactive. In Brazil, about 60% of Brazilians do not practice any type of physical activity[6]. The sedentary lifestyle, in addition to the musculoskeletal implications that lead to various orthopedic disorders, has important repercussions on the cardiovascular system. The literature reports that subjects with an active lifestyle, who practice regular physical activity, have beneficial adaptations regarding the cardiac autonomic control. Davy et al.[7] and Buchheit et al.[8] refer that the practice of aerobic physical training promotes a considerable increase in heart rate variability, which would indicate a better sympathetic-vagal balance in the control of heart rate.

The practice of Pilates exercises is within the range of physical activities that can be used to improve low back pain. Wells et al.[9], in a review article on the effectiveness of Pilates training on improving pain and functionality in patients with chronic low back pain, states that studies in the literature show conflicting results, and that this makes it difficult to conclude about the effects of this therapeutic method on the management of patients with chronic low back pain.

In view of the above, the aim of the present study was to evaluate the effectiveness of the Pilates method on muscle parameters, such as hamstring flexibility and abdominal muscle resistance, the functional capacity of patients with chronic low back pain, and to investigate whether this type of training causes important changes on cardiac autonomic modulation.

*Corresponding author: Daniel Iwai Sakabe. E-mail: dsakabe@hotmail.com

Submission date 14 April 2020; Acceptance date 23 June 2020; Publication date 11 September 2020

METHODS

The study was approved by the institution's research ethics committee, with the number 13-05/229. All volunteers signed an informed consent form, in accordance with resolution 466/12 of the National Health Council. Evaluations and treatment were carried out at the institution´s physical therapy school clinic, in the afternoon. Ten subjects aged 18 to 35 years (25.1 ± 5.1 years), of both genders (2 men and 8 women), with low back pain for at least 3 months, with a sedentary life style were evaluated. The inclusion criteria for participation in the study were the presence of persistent low back pain for more than 3 consecutive months, sedentary lifestyle, and the absence of pharmacological or therapeutic treatment for low back pain. Exclusion criteria were the presence of cardiovascular or metabolic diseases, use of cardioactive medication, limitations of any nature that prevented practicing the Pilates method.

Procedures

The volunteers were evaluated at two different moments, before and after the training program with the Pilates method. The evaluations consisted of four experimental procedures: assessment of the autonomic modulation of heart rate at rest, hamstring muscle flexibility, abdominal muscle strength, and functional capacity using the Roland Morris questionnaire. Muscle flexibility of the hamstrings was assessed using photogrammetry. Markers were placed on the skin of the volunteer, on the bony points of the greater trochanter of the femur, on the lateral epicondyle of the femur and on the lateral malleolus at the ankle, bilaterally. After placing the markers, the extended leg elevation test was performed, with the other leg stabilized and fixed on the stretcher, and the photo was taken at the moment when the volunteer reported the onset of significant discomfort due to the muscle stretching performed.

The evaluation of photogrammetry was performed in the Corel Draw X4 (version 14.0.0.567). To measure the hip flexion angle, two lines were drawn: one that passed through the adhesive markers (from the greater trochanter to the lateral epicondyle of the femur) and another that crossed the marker from the greater trochanter of the femur and had a horizontal direction (parallel to the stretcher and the ground). The intersection of the lines formed the angle that was calculated mathematically in the Corel Draw. Abdominal musculature resistance was measured by the one-minute trunk flexion repetition test. The test consisted of performing the maximum number of trunk flexion repetitions, starting from the supine position with the arms crossed over the chest, until the scapulae left the ground, during the period of 60 seconds. The number of repetitions was counted by the researchers, who verbally encouraged the volunteer to perform as many repetitions as possible within the stipulated time. To assess functional capacity, the Roland Morris questionnaire was applied, translated and validated in Portuguese by Nusbaum el at.[10]. This questionnaire is specific for the evaluation of patients with low back pain and consists of 24 questions related to pain and function. The questions contained in this questionnaire bring aspects of activities of daily living, being an effective measure in assessing the impact of low back pain on the subject's function. The application was made in an explanatory way for the volunteer, and any doubts that might arise during the completion of the questionnaire would be resolved by the researchers.

The evaluation of the heart rate autonomic modulation was performed using a cardiofrequencimeter Polar RS800CX (Polar Electro Oy Professorintie 5 FIN-90440 KEMPELE). The heart rate collection, on a beat by beat basis, was performed with the volunteer at rest in the supine position, for ten minutes. Initially, skin cleaning and abrasion was performed with cotton and alcohol, for later fixation of the heart rate capture strap, in the infra-nipple region of the chest. During the collection of heart rate data, the researcher remained at the volunteer's side, who was instructed not to talk and to move as little as possible, keeping the breathing calm and natural. After data collection, it was calculated the RMSSD index of the R-R intervals, in milliseconds (ms), representative of vagal activity over cardiac autonomic control, to assess heart rate variability. For such analysis, the 8-minute stretch was selected within 10 minutes of collection, discarding the first and last minutes. The software used to calculate the RMSSD index of the R-R intervals was the Kubios HRV 2.2 (© Kubios Oy., Finland).

The training program using the Pilates method, which consisted of 12 training sessions, for 6 consecutive weeks, two weekly sessions lasting one hour each. On the first day of the training, the principles of the Pilates Method were explained, which consist of concentration, breathing, body positioning, and then the training was applied with 6 different exercises, with 10 repetitions of each exercise being performed. The exercises chosen for the program (conventional Roll Down and variation, Spine Stretch Forward, Single Straight Stretch, Double Straight Leg Stretch, Roll Over) advocated

the work of the abdominal muscles and the stretching of the hamstring muscles. For statistical analysis, the Graphpad Instat 3.0 software was used. Initially, the Kolmogorov-Smirnov data set test was used to verify the normality. As the data presented a normal distribution, the pre- and post-training variables were compared using the paired Student's t-test, with a significance level set at 5%.

RESULTS

There was a significant improvement (p = 0.00002) in the hamstrings' muscle flexibility (from 58.7 ± 8.2 degrees to 84.1 ± 10.3 degrees in the right lower limbs and from 57.2 ± 9.1 degrees to 78.5 ± 11.9 in left lower limbs, figure 1). Abdominal resistance also showed significant improvement (p <0.0004) after training (from 28.3 ± 17.6 repetitions to 33.6 ± 16.0 repetitions, figure 2). Regarding functional capacity, a significant improvement (p <0.006) was found in completing the Roland Morris questionnaire (from 6.2 ± 2.8 points to 3.3 ± 1.0 points, figure 3) after training with the Pilates method. However, heart rate variability did not change significantly (p = 0.09) after training (RMSSD index of RR intervals of 37.5 ± 15.0 in the pre-training evaluation and 39.0 ± 15.0 in the post-training evaluation, figure 4).

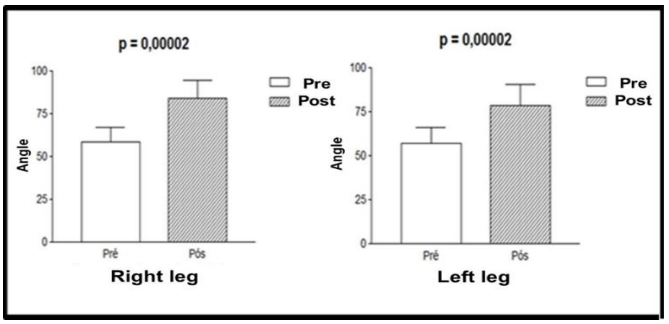

Figure 1. Hip flexion angle (degrees) of the right lower limb in the pre- and post-training evaluations with the Pilates Method, n=10.
***Note:** Significance level=5%.

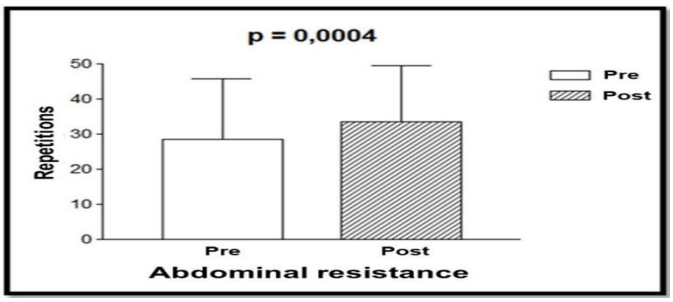

Figure 2. Number of repetitions per minute of the abdominal muscle resistance test in the pre and post training evaluations with the Pilates method, n=10.
*__Note:__ Significance level=5%.

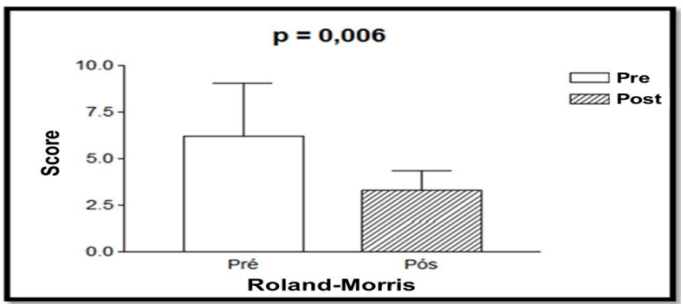

Figure 3. Score from the Roland Morris questionnaire for assessing functional capacity in pre- and post-training evaluations using the Pilates method, n = 10.
*__Note:__ Significance level = 5%.

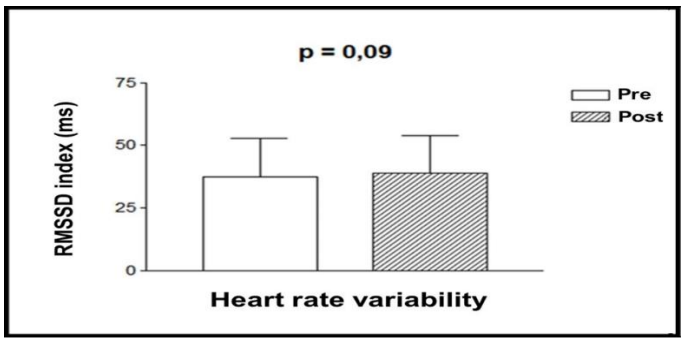

Figure 4. Values of the RMSSD index of the R-R intervals (in milliseconds) in the pre- and post-training evaluations with the Pilates method, n = 10.
*__Note:__ Significance level = 5%.

DISCUSSION

The results found in the present investigation suggest that the training with the Pilates method, even though it was of short duration, promoted significant and beneficial modifications on the muscles worked in the training, which may have positively favored the functional capacity of these subjects in face of chronic low back pain; however, the twelve Pilates training sessions did not promote significant changes in the autonomic modulation of heart rate.

In the study of Donzelli et al.[11], the Pilates method was compared in relation to the traditional physiotherapy treatment in 43 subjects with chronic low back pain. The volunteers were divided into two groups, 21 with treatment based on Pilates and 22 with conventional treatment, which included stretching and muscle strengthening exercises, breathing exercises and postural reeducation. Before starting the training, the visual analogue pain scale and the Oswestry disability index were applied, being reassessed after one, three and six months after the start of treatments. The authors report that both training sessions were effective in

reducing pain and disability of patients with chronic low back pain, with the group treated with the Pilates method more accepting of treatment and greater adherence to it, compared to the traditional method. In the present investigation, an important functional improvement was also observed with the Pilates method, even in a much shorter training time.

Similar results were found in the study of Conceição and Mergener[12], who evaluated 7 women with chronic low back pain, submitted to an exercise program using 25 sessions of the Pilates method. The authors observed a significant improvement in pain and functional disability measured by the Oswestry index after training with Pilates, suggesting that the exercises, because they are of low impact and generally performed in postures with low joint overload, have marked efficacy when treating subjects with physical limitations, such as those with low back pain.

Pinheiro et al.[13] conducted a study with 13 elderly women, who underwent Pilates training for 12 sessions, each session lasting 50 minutes, with 3 sessions per week. The proposed exercises were based on the solo modality, focusing on activities that advocated stretching and strengthening exercises, associated with the Swiss ball, Theraband® and flex ring. At the end of the training, the authors observed a significant improvement in the increase of strength and myoelectric activation of the paravertebral muscles and an improvement in the contraction capacity of the transverse abdomen muscle, using surface electromyography, force transducer and pressure biofeedback unit for evaluation.

The authors suggest that the improvement in the observed muscular capacity can be explained by an improved neuromuscular activation, with the practice of training with the Pilates method, as well as the accentuated use of the abdominal muscles by the breathing pattern typical of the method. The results of the present investigation corroborate the findings mentioned, since we also observed an improvement in abdominal resistance after short training with Pilates exercises.

According to Kolyniak, Cavalcanti and Aoki[14], the deep breathing used in the Pilates method explains the increased activation of contraction of the transverse abdominal muscle. The exercises proposed by the method use inspiration for relaxation and preparation for movement, and use exhalation to perform the movements, thus activating the abdominal muscles, such as the rectus abdominis, transversus abdominis and oblique muscles.

González-Gálvez et al.[15] conducted a study with a sample composed of 66 high school students, applying the short-term Pilates method as an intervention. The training was carried out twice a week for six weeks. Each session lasted 55 minutes and warm-up, exercises with the Pilates method and relaxation were performed. The authors observed a significant increase in the levels of flexibility of the hamstring muscles of the studied population, suggesting that the method can be used to improve posture and to treat low back pain in young subjects as well. Such results are similar to those found in the present investigation, in which a significant improvement in muscle flexibility and functional capacity of volunteers with chronic low back pain was also observed.

The results of the Pilates method's effectiveness on muscle and functional parameters were not followed in the evaluation of heart rate variability. No study evaluating the effects of the Pilates method on autonomic heart rate modulation has been found in the literature, showing the scarcity of materials in this area of knowledge.

In the study of Tinoco-Fernández et al.[16], evaluating sedentary subjects who underwent a program of 30 training sessions with the Pilates method, a significant improvement of spirometric parameters was observed during the test of submaximal physical effort, suggesting that the method may have a positive effect on cardiorespiratory parameters in subjects with sedentary life pattern starting the Pilates training.

The literature reports that training with the Pilates method promotes benefits in risk factors for cardiovascular diseases. Monteiro et al.[17], evaluating 303 women aged 60 to 70 years, without any chronic disease, observed improvement in parameters related to body composition and anthropometric measures, suggesting a possibly reduced cardiovascular risk after 24 weeks of training with the method. In the study of Fourie et al.[18], also evaluating elderly women, a decrease in levels of systemic arterial hypertension was reported after 8 weeks of training using the Pilates method, again showing the importance of physical activity for the control of risk factors for cardiovascular diseases. Sedentary lifestyle is also considered an important risk factor for cardiovascular diseases; in the present study, no significant changes in heart rate variability were observed after 12 training sessions with the Pilates method, possibly due to the short training period. The fact that the population evaluated is of young subjects also minimizes the impact of physical inactivity on cardiovascular risk, the characterization of training being more preventive than rehabilitation.

Assessing the acute effects of a 60-minute session of the Pilates method, Magalhães et al.[19]

recruited 12 volunteers with a mean age of 29.5 years, normotensive and sedentary. The training sessions consisted of Pilates exercises on the ground and equipment. In this study, the authors report that the acute changes in heart rate and blood pressure, which occur during a training session with the Pilates method, were within acceptable limits for the practice of physical activity, that is, they did not generate negative repercussions of these variables. In the present study, the acute effects of the session with the Pilates method were not evaluated, but the post-training effects; however, no significant changes were observed in the volunteers' resting heart rate variability after the training period.

Heart rate variability is an important tool for assessing the functioning of the body under normal and pathological conditions[20]. The literature states that physical exercise can beneficially modulate the autonomic control of heart rate, mainly in reducing sympathetic activity on the sinus node and decreasing the level of circulating catecholamines[21].

In the present study, the variation in the R-R intervals of the electrocardiogram was not modified after the training program was performed using the Pilates method, showing that there were no significant changes in the levels of heart rate variability. This fact can be explained by the short training time that the volunteers of the present work were submitted, as well as the nature of the training.

The literature reports that the regular practice of aerobic physical activity promotes greater and more beneficial changes in autonomic activity, with a positive change in the sympathetic-vagal balance, in relation to anaerobic activities or muscle strength gain[22]. Considering that the Pilates method can be characterized as training to gain muscle strength and endurance, as well as increased flexibility, the absence of changes in heart rate control observed in the present study can also be explained by the fact that the proposed exercises are not intended to improve the aerobic condition of the volunteers.

CONCLUSION

In view of the results, it can be concluded that short-term training with the Pilates method was effective in improving the muscular flexibility of the hamstrings, abdominal muscle resistance and the functional capacity of patients with chronic low back pain, but did not promote significant changes in the autonomic modulation of the heart rate, possibly due to the short training period, as well as the nature of it.

Authors' contributions: DIS: Adviser, article writing, application of assessment tools, data analysis. FFS: article writing, statistical analysis of the data. ACDS: article writing, intervention application. APG: article writing, intervention application.

Financial support: Programa de Apoio à Pesquisa e Iniciação Científica (PAPIC - Support Program for Research and Scientific Initiation) of the Faculdades Integradas Einstein de Limeira.

Conflict of interest: The authors declare that there was no conflict of interests.

REFERENCES

1. Woolf AD, Zeidler H, Haglund U, Carr AJ, Chaussade S, Cucinotta D, et al. Musculoskeletal pain in Europe: its impact and a comparison of population and medical perceptions of treatment in eight European countries. Ann Rheum Dis. 2004;63(4):342–47.
2. Airaksinen O, Brox JI, Cedraschi C, Hildebrandt J, Klaber-Moffett J, Kovacs F, et al. Chapter 4. European guidelines for the management of chronic nonspecific low back pain. Eur Spine J 2006;15(Suppl 2):S192–S300.
3. Balagué F, Mannion AF, Pellisé F, Cedraschi C. Non-specific low back pain. Lancet 2012;379(9814): 482–91.
4. da Fonseca JL, Magini M, de Freitas TH. Laboratory gait analysis in patients with low back pain before and after a Pilates intervention. J Sport Rehabil 2009;18(2):269-82.
5. Beaglehole R, Bonita R, Horton R, Adams C, Alleyne G, Asaria P, et al. Priority actions for the non-communicable disease crisis. Lancet. 2011;377(9775):1438-1447.
6. Toscano JJO, Egypto EP. A influência do sedentarismo na prevalência de lombalgia. Rev Bras Med Esporte 2001;7(4): 132-37.
7. Davy KP, de Souza CA, Jones PP, Seals DR. Elevated heart rate variability in physically active young and older adult women. Clin Sci. 1998;94(6): 579-84.
8. Buchheit M, Simon C, Viola AU, Doutreleau S, Piquard F, Brandenberger G. Heart rate variability in sportive elderly: relationship with daily physical activity. Med Sci Sports Exerc. 2004;36(4):601-05.
9. Wells C, Kolt GS, Marshall P, Hill B, Bialocerkowski A. Effectiveness of Pilates exercise in treating people with chronic low back pain: a systematic review of systematic reviews. BMC Med Res Methodol. 2013;19(13):7.

10. Nusbaum l, Natour J, Ferraz MB, Goldenberg J. Translation, adaptation and validation of the Roland-Morris questionnaire – Brazil Roland-Morris. Braz J Med Biol Res. 2001;34(2):203-10.
11. Donzelli S, Di Domenica E, Cova AM, Galletti R, Giunta N. Two different techniques in the rehabilitation treatment of low back pain: a randomized controlled trial. Eura Medicophys 2006;42(3):205-10.
12. Conceição JS, Mergener CR. Eficácia do método Pilates no solo em pacientes com lombalgia crônica. Relato de casos. Rev Dor. 2012;13(4):385-8.
13. Pinheiro KRG, Rocha TCC, Brito NMS, da Silva MLG, de Carvalho MEIM, Mesquita LSA, et al. Influence of Pilates exercises on soil stabilization in lumbar muscles in older adults. Rev Bras Cineantropom Desempenho Hum. 2014,16(6):648-57.
14. Kolyniak IEG, Cavalcanti SMB, Aoki MS. Avaliação isocinética da musculatura envolvida na flexão e extensão do tronco; efeito do método Pilates. Rev Bras Med Esporte. 2004;10(6):487-90.
15. González-Gálvez N, Poyatos MC, Pardo PJM, Vale RGS, Feito Y. Effects of a pilates school program on hamstrings flexibility of adolescents. Rev Bras Med Esporte. 2015,21(4):302-07.
16. Tinoco-Fernández M, Jiménez-Martín M, Sánchez-Caravaca MA, Fernández-Pérez AM, Ramírez-Rodrigo J, Villaverde-Gutiérrez C. The Pilates method and cardiorespiratory adaptation to training. Res Sports Med. 2016;24(3):281-6.
17. Ruiz-Montero PJ, Castillo-Rodriguez A, Mikalački M, Nebojsa C, Korovljev D. 24-weeks Pilates-aerobic and educative training to improve body fat mass in elderly Serbian women. Clin Interv Aging. 2014;9:243-248.
18. Fourie M, Gildenhuyr M, Shaw I, Shaw B, Toriola A, Goon DT. Effects of a mat pilates program on cardiometabolic parameters in elderly women. Pak J Med Sci. 2013;29(2):500-4
19. Magalhães F, Albuquerque AP, Pyrrho C, Navarro F. Comportamento da pressão arterial e da frequência cardíaca em uma aula utilizando o método pilates. Rev Bras Presc Fisiol Exerc. 2009;3(15):208-16.
20. Lopes FL, Pereira FM, Reboredo MM, Castro TM, Vianna JM, Novo Jr JM, et al. Redução da variabilidade da freqüência cardíaca em Indivíduos de meia-idade e o efeito do treinamento de força. Rev Bras Fisioter. 2007;11(2):113-19.
21. Zouchal H, Jacob C, Delamarche P, Gratas-Delamarche A. Catecholamines and the effects of exercise, training and gender. Sports Med. 2008;38(5):401-23.
22. Carter JB, Banister EW, Blaber AP. The effect of age and gender on heart rate variability after endurance training. Med Sci Sports Exerc. 2003;35(8):1333-1340.