



Isokinetic evaluation of the musculature involved in trunk flexion and extension: Pilates® method effect

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ABSTRACT

Trunk extensors and flexors muscles imbalance is strong indication of the etiology of low back pain. The aim of the present study was to verify the effect of Pilates® method upon trunk flexors and extensors isokinetic function. To do so, we selected 20 volunteers (16 women 34.06 ± 7.21 yrs; 4 men 33.5 ± 6.68 yrs) capable to perform the intermediate-advanced level of Pilates® method (25 sessions) during 12 weeks. Trunk extensor function was improved in all parameters evaluated (peak torque – 25%, $p = 0.0004$; total work – 28%, $p = 0.0002$; average power – 30%, $p = 0.0002$; set total work performed – 21%, $p = 0.002$). Trunk extensors showed a slight increase in total work (10%, $p = 0.0003$) and set total work performed (10%, $p = 0.002$). The trunk flexors:extensors ratio were decreased after Pilates® training (peak torque – 24%, $p = 0.0001$; total work – 23%, $p = 0.002$; average power – 25%, $p = 0.01$; set total work performed – 14%, $p = 0.04$). The Pilates® method seemed to be an efficient tool to strengthen the trunk extensors muscles, thus attenuating the imbalance between the muscles involved in trunk extension and flexion.

INTRODUCTION

The vertebral column stabilization incapacity caused by the trunk extensors and flexors muscles imbalance is strong indication of the etiology of low back pain⁽¹⁾. Currently, there are evidences suggesting the inclusion of exercises aimed at the strengthening of the muscles involved in the trunk extensors and flexors in the low back pain rehabilitation and prevention programs (low back pain)^(2,3).

Low back pain is one of the most common problems of the modern society, being responsible for high expenses in the public health area. Epidemiological data demonstrate that in the United States, low back pain is the most frequent cause of physical work disability in people with less than 45 years of age⁽⁴⁾. It is estimated that the yearly expense related to this problem (average costs and indemnities) was around US\$ 20 billion during the decade of 90^(5,6). The forecast for the next decade is that these expenses exceed US\$ 50 billions^(5,6).

The low back pain prevention and treatment difficulty is due to its multifactorial etiology and also due to the fact that some of its causes are still unknown. Low back pain is frequently associated to physical inactiveness, being considered as one of the most common hypokinetic diseases⁽⁷⁻¹⁰⁾. Despite theoretical evidences indicate the importance of the physical activity in the low back pain prevention; there are no specific recommendations for the elaboration of training programs for the prevention of such problem⁽¹¹⁾.

Key words: Training. Pilates®. Skeletal muscles. Extension. Flexion. Trunk.

The Pilates® method, developed by Joseph Pilates at the beginning of the decade of 20 is based on the concept called *contrology*⁽¹²⁾. According to Pilates⁽¹²⁾, *contrology* is the conscious control of all muscular movements of the body. It deals with the correct use and application of the most important principles of the forces that are applied to each of the skeleton bones with the full knowledge of the functional mechanisms of the body and the full understanding of the balance and gravity principles applied to each movement at the active state, in rest and sleeping. The exercises included in the Pilates® method are mostly performed in lying position with decrease on the impact on the body's sustentation joints at the orthostatic position and especially in the vertebral column, thus allowing the recovery of the muscular, articular and ligament structures, particularly of the sacral lumbar region^(12,13). The basic system includes an exercise program that strengthens the abdominal and paravertebral musculature as well as the column flexibility muscles, besides exercises for the entire body. On the other hand, in the intermediate-advanced system, the trunk extension exercises are progressively introduced, besides other exercises, in an attempt to improve the agonistic-antagonistic balance relation⁽¹²⁻¹⁴⁾. Once the Pilates® method commends the improvement of the muscular relations (agonistic and antagonistic), our objective was to assess the effect of this training method on the isokinetic torque of the trunk extensor and flexor muscles measured at the angular velocity of 120 degrees per second.

MATERIAL AND METHODS

Sample

20 volunteers (16 women 34.06 ± 7.21 yrs; 4 men 33.5 ± 6.68 yrs) who were capable of performing the intermediate-advanced level of Pilates® method (25 sessions) during 12 weeks participated in the study. The individuals selected to compose the sample performed the Pilates® method exclusively, therefore, performed no other type of physical training. Individuals who had already undergone the initial level of the Pilates® method were also selected to participate in the study. According to the specific resolution of the Health National Agency (# 196/96), all participants were informed in detail about the procedures which would be accomplished and agreed in participating by signing a consent form and privacy protection.

Description of the Pilates® method

The intermediate-advanced level training sessions with 45 minutes average duration were performed in five groups of four participants each, using specific devices of the method: Reformer, Cadillac, Wunda-chair, Electric-chair, Pedi-pull, Barrel, Magic circles, as well as exercises with no devices (Mat)⁽¹³⁾. The training session started at the Reformer device in which the following exercises were performed: foot work series, the hundred, short spine mas-

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sage, coordination, rowing III-IV-V-VI, pulling straps I and II, back-stroke with reverse, teaser, short box series, long stretch, down stretch, elephant, stomach massage (round, hands back, reach up, twist), tendon stretch, semicircle, chest-expansion, thigh stretch, arm-circles with variation, corkscrew, leg circles frog, knee stretch series, running, pelvic lift. The exercise Swan in the Barrel device was performed between exercises rowing and pulling straps. Subsequently, the exercises with no devices were performed (Mat): single leg stretch, double leg stretch, single straight, double straight, criss cross. After the exercises with no devices (Mat), the Wunda-chair device was used for the following exercises: pushing down with hands, pull up, balance control front, the table, and teaser. Later, the Cadillac device was used for the following exercises: leg circle, walking, beats and pull up hanging. The session ended in the Pedi-pull device in which the chest expansion exercise was performed, followed by Magic circles series.

The exercises for elongation and strengthening of the column extensor muscles, performed with no trunk hyperextension, are: short box (round, flat side to side, and tree); stomach massage (round, hands back, reach up, twist). Later, the following exercises were introduced in the advanced system: rowing III, IV, V and VI. The exercises introduced in the intermediate system, with trunk hyperextension, are: pulling straps I and II and swan on the barrel. Finally, the power house strengthening exercises: stomach massage, short box, teaser, long stretch, performed in the Reformer device; Mat abdominal series (single leg stretch, double leg stretch, single straight, double straight, criss cross) and in the Wunda-chair device, the exercises: pushing down with hands, pull and teaser.

Isokinetic evaluation of the trunk extension and flexion function

The method of isokinetic evaluation used is an objective and reproducible method of muscular evaluation^(15,16). The individuals were evaluated before and after training sessions through the equipment Cybex® 6000, module TFE (Trunk Flexion Extension), identically, in other words: by fixing the equipment at the lower limbs level, leaving only the trunk extension and flexion movements free. The axis movement is fixed at the joint L5-S1 level, where two concentric isokinetic repetitions were performed at 120 degrees per second in each evaluation, being the individual instructed to perform all movements he was able to within measurable parameters of the equipment. The angular velocity of 120 degrees per second was chosen by being considered as the safest for column extension and flexion tests⁽¹⁷⁾. The parameters evaluated were: peak torque (maximum torque reached at the test velocity, given in newtons per meter), total work of the best repetition expressed in joules, power (indicative of work at the time unit expressed in watts), set total work performed and the relation between the values found in the trunk extension and flexion. The isokinetic tests were performed in the HCFMUSP Orthopedics and Traumatology Institute.

Statistical analysis

The average values of the data obtained in both pre and post-training evaluations were compared through the t-Student test for dependent samples with significance level of $p < 0.05$.

TABLE 1
Determination of the peak torque (PT), total work (TT), power and set total work performed (QTT) in isokinetic test performed at 120 degrees of angular velocity of the trunk extensor muscles

	PT (N.m ⁻¹)	TT (J)	Power (W)	QTT (J)
Pre (n = 20)	132.6 ± 36.0	128.9 ± 39.4	136.2 ± 36.8	479.2 ± 147.2
Post (n = 20)	166.8 ± 34.4*	166.1 ± 40.9*	177.9 ± 40.1*	580.0 ± 149.0*
P	0.0004	0.0002	0.0002	0.002

* statistical difference in relation to the pre-training situation. The minimum significance level (P) established was of $p < 0.05$. N.m⁻¹ = newtons per meter; J = joules; W = watts.

TABLE 2
Determination of the peak torque (PT), total work (TT), power and set total work performed (QTT) in isokinetic test performed at 120 degrees of angular velocity of the trunk flexor muscles

	PT (N.m ⁻¹)	TT (J)	Power (W)	QTT (J)
Pre (n = 20)	169.0 ± 22.6	187.9 ± 29.1	202.0 ± 40.6	715.2 ± 22.8
Post (n = 20)	171.6 ± 21.3	206.6 ± 25.7*	213.2 ± 25.9*	780.8 ± 106.9*
P	0.1	0.0003	0.2	0.002

* statistical difference in relation to the pre-training situation. The minimum significance level (P) established was of $p < 0.05$. N.m⁻¹ = newtons per meter; J = joules; W = watts.

TABLE 3
Determination of the flexor:extensor ratio in the peak torque (PT), total work (TT), power and set total work performed (QTT) during isokinetic test performed at 120 degrees of angular velocity of the trunk extensor muscles

	PT (N.m ⁻¹)	TT (J)	Power (W)	QTT (J)
Pre (n = 20)	133.9 ± 40.6	158.3 ± 48.5	160.5 ± 54.2	162.1 ± 50.4
Post (n = 20)	107.6 ± 29.4*	128.9 ± 40.0*	128.3 ± 38.0*	142.1 ± 45.0*
P	0.0001	0.002	0.01	0.04

* statistical difference in relation to the pre-training situation. The minimum significance level (P) established was of $p < 0.05$. N.m⁻¹ = newtons per meter; J = joules; W = watts.

RESULTS

The trunk extensors function presented increase in all parameters analyzed (peak torque – 25%, $p = 0.0004$; total work – 29%, $p = 0.0002$; average power – 30%, $p = 0.0002$; set total work performed – 21%, $p = 0.002$) in relation to the pre-training period. Regarding to the flexor muscles, a slight increase on the total work (10%, $p = 0.0003$) and set total work performed (10%, $p = 0.002$) was detected. When trunk flexors:extensors ratio is analyzed, significant reduction in all parameters analyzed was detected in relation to the indexes obtained in the pre-training period (peak torque – 24%, $p = 0.0001$; total work – 23%, $p = 0.002$; average power – 25%, $p = 0.01$; set total work performed – 14%, $p = 0.04$).

DISCUSSION

The functioning of the lumbar column in human beings is unique. In other primates, a posture bent forward with no low back pain is observed. The presence of low back pain is frequent in quadrupeds; however, in these animals, the spine does not work under an axial force as in human beings that present erect posture. The muscle responsible for the maintenance of the lordotic posture in human beings is the multifidus muscle. Its function is associated with the trunk extension. It has been demonstrated that the function of this muscle is impaired in patients with low back pain⁽¹⁸⁻²¹⁾. On the other hand, the function of the trunk flexors seems not to be altered in patients with low back pain, thus reinforcing the importance of the performance of exercises for the extensor musculature⁽²²⁾. The physical inactiveness is directly related to the weakness of the musculature involved in the trunk extension and hence, it is considered as a risk factor for back pain^(23,24).

In a recent study⁽²⁵⁾, it was observed that patients with low back pain presented 40% of decrease on the trunk extensors strength if compared to asymptomatic individuals (control group). After strength training with emphasis in the trunk extensor muscles for eight weeks, the patients presented a gain of 100% in strength of these muscles in relation to the beginning of the training. On the other hand, the gain for the control group was only of 10% in relation to the initial value. Still in this study, magnetic resonance images in the transversal section of the multifidus muscle demonstrated hypertrophy of this muscle in patients with low back pain after training. One limitation of the present study was the lack of control group, however, according to study conducted by Mooney

et al.⁽²⁵⁾ it was verified that in physically inactive individuals (control group), the strength gain was not significant in relation to the relevant increase observed in the trained group. Our results demonstrated that in all parameters evaluated (peak torque – 25%, total work – 30%, average power – 30% and set total work performed – 21%), a significant increase on the post-training value was verified in relation to the pre-training value.

Other study also using strength training for trunk extensor muscles followed 400 individuals who reported low back pain for one year⁽²⁶⁾. After eight weeks of training (twice a week), 80% of the participants reported attenuation of the low back pain symptoms. After one year of study, a reuse rate of only 11% of the medical services due to low back pain was verified.

In a case study, Blum⁽¹⁴⁾ reported that the Pilates® method was effective on the treatment of a patient with scoliosis. Our results demonstrated that the Pilates® method was effective on increasing in all parameters evaluated (peak torque, total work, average power and set total work performed) during trunk extension in relation to the pre-training value. We have also verified that this increase was responsible for the drop on the flexor:extensor ratio in all parameters evaluated (peak torque, total work, average power and set total work performed), approximating this ratio to the ideal value considered as 100 (balance between flexors and extensors).

In relation to the flexor muscles, a slight improvement was detected in total work parameters and total set work performed. In study of Greve *et al.*⁽²⁷⁾, when physically inactive individuals were compared with trained individuals, it was verified that the function of the trunk flexor muscles (torque, work and power) was similar, indicating that the trunk flexor musculature is less susceptible to the lack of training. In our results, we could verify that the musculature involved in the trunk flexion was also less responsive to the stimulus of the Pilates® method. Despite the belief that the reinforcement of the trunk flexor musculature (abdominal muscles) is a priority in exercise programs and rehabilitation of the lumbar col-

umn, recent evidences do not corroborate this hypothesis⁽²⁸⁾. Some believed that the increase on the intra-abdominal pressure would reduce the compression on the spine and the intervertebral disks, thus attenuating low back pain. However, in a recent literature review, it was not possible to verify the relation between increase on the intra-abdominal pressure and attenuating of the low back pain⁽²⁸⁾. Additionally, the intra-abdominal pressure is not increased during the contraction of the abdominal muscles⁽²⁹⁾. It was also observed that the strength training emphasizing this musculature was not sufficient to further increases on the intra-abdominal pressure⁽²⁹⁾.

CONCLUSION

There are convincing evidences that the performance of an exercise program with emphasis on the strengthening of the trunk extensor musculature restores the function of the lumbar column and prevents the appearance of the low back pain. The Pilates® method (intermediate-advanced level) showed to be effective to further increases on the peak torque, total work, average power and set total work performed of muscles related to the trunk extension. These results indicate that this training method may be used as strategy for the strengthening of this musculature, thus attenuating the imbalance between the functions of the muscles involved in the trunk flexion and extension.

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