

Artigo Original

Influence of Pilates training on muscular strength and flexibility in dancers

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Abstract: The purpose of the present study was to assess the effects of a Pilates training program on muscular strength and flexibility in dance students. Fifteen dance students were divided into 2 groups: experimental (n=7) and control (n=8). Both were assessed in beginning and in the end of the study. Muscular strength was assessed measuring the time supported in the technical skills *penché* and *developpé*. To assess flexibility, it was measured the angle between limbs in the technical skills *arabesque*, *developpé* and *cambré*. After the first moment of evaluation, the experimental group performed a Mat-Based Pilates Exercise during 11 weeks. The statistic analyses (two-way analysis of variance - ANOVA 2x2) showed significant differences ($p \leq 0,05$) in muscular strength and flexibility measurements between groups after the training program. It was concluded that Pilates training has a positive effect on muscular strength and flexibility in dance students.

Keywords: Dancers. Pilates. Muscular strength. Flexibility.

Influência de um programa de treino Pilates na força muscular e flexibilidade de bailarinos

Resumo: Foi objectivo avaliar o efeito de um programa de treino Pilates na força muscular e flexibilidade de bailarinos estudantes. Quinze bailarinos foram divididos em 2 grupos: experimental (n=7) e controlo (n=8). Ambos foram avaliados no início e final do estudo. A força muscular foi avaliada através do tempo de sustentação nos elementos técnicos *penché* e *developpé*. Para avaliar a flexibilidade foi medido o ângulo de amplitude entre os segmentos nos elementos técnicos *arabesque*, *cambré* e *developpé*. Após o 1.º momento de avaliação os bailarinos do grupo experimental participaram num programa de *Mat-Based Pilates Exercise* durante 11 semanas. A análise estatística (análise de variância para medidas repetidas - ANOVA 2x2) demonstrou diferenças significativas ($p \leq 0,05$) entre os grupos no âmbito da força muscular e flexibilidade após o programa de treino. Conclui-se que o Pilates induz alterações positivas ao nível da força muscular e flexibilidade de bailarinos.

Palavras-Chave: Bailarinos. Pilates. Força muscular. Flexibilidade.

Introduction

Dance is an art form and a mean of expression. However, a full development of several physical capacities are also needed, which turn dance into an artistic and athletic activity (KOUTEDAKIS; JAMURTAS, 2004). To achieve remarkable performances, it is required an expertise in the aesthetic and athletic side of the art, since the beauty of the technical skills presupposes a fully developed body (WELSH, 2009). Each movement has to be performed correctly, slowly, with control, without apparently effort (WELSH, 2009), being also necessary extreme range of motion at the ankle and hip joints (DEIGHAN, 2005). Therefore, a highly

development of muscular strength and flexibility are physical demands placed on dancers.

Since physical conditioning is essential to dancer's performance, dance research have examined the effects of supplemental training to traditional dance classes. Published data have been proving that a complementary strength and flexibility training program has positive effects on technical PERFORMANCE (STALDER; NOBLE; WILKISON, 1990; GROSSMAN; WILMERDING, 2000; KOUTEDAKIS; SHARP, 2004; KOUTEDAKIS; HUKAM; METSIOS; NEVILL; GIAKAS; JAMURTAS; MYSZKEWYCZ, 2007). However, Koutedakis and Jamurtas (2004) highlight that "any change in the traditional training regimens must be approached cautiously to

ensure that the aesthetic content of the dance is not affected by new training techniques". Therefore, it is important to understand the demands of dance to adapt the complementary training according to dance characteristics and principles, meeting the exact needs of dance technique.

From this point, we would like to highlight the Pilates method, that despite the frequent use, it has not been sufficiently investigated in relation to dance performance (BERNARDO; NAGLE, 2006). This technique is point out in the literature has beneficial to improve the general muscular strength and flexibility (SEKENDIZ; ALTUN; KORKUSUZ; AKIN, 2007; ROGERS; GIBSON, 2009; KLOUBEC, 2010), which are capacities essentials to dancers. Besides, the Pilates method has inherent principles such as control, concentration, centering, flow of movement, precision and breathing, involving likewise planes of movement similar to dance technique (AHEARN, 2006). Hence, as it is possible to recognize movement patterns and principles in Pilates method that converge with dance technique, and since it has been suggested that the ideally complementary training should fulfill with dance technique demands, the vital issue that arises is: Can Pilates technique be useful to improve dancers' performance, being a promise tool to be used as complementary strength and flexibility training?

The purpose of the present study was to test the effectiveness of a Pilates training program to develop muscular strength and flexibility in dance students.

Methods

Subjects

Fifteen dance students, 12 women and 3 men, with more than ten years of daily practice in dance voluntarily in the study. Dancers were from the same institution (Ginasiano Dancing School), and none of them present, until the moment, any kind of injury that could influence their performances. Subjects were assigned into experimental (EG) and control (CG) groups. The EG was composed by 7 dancers (6 women and 1 men; age: $15,7 \pm 0,8$ years old; experience of dance training: $11 \pm 2,7$ years), and the CG by 8 dancers (6 women and 2 men; age: $16,3 \pm 0,9$ years old; experience of dance training: $11,9 \pm 3,7$ years). All the groups participated in the classes of their scholar curricula. The EG attended 6 hours a week of

classical and modern dance technique, 1 hour and half of *pas de deux* and 1 hour of character dance. The CG attended 7 hours a week of classical and modern dance technique, 1 hour and half of *pas de deux* and 1 hour of character dance.

All subjects signed a written agreement in compliance with the University of Porto ethical committee.

Training Protocol

This is an experimental study with two moments of evaluation. After the first moment of evaluation (measurement of initial muscular strength and flexibility levels), only the EG performed a Mat-Based Pilates Exercises during 11 weeks (2 sessions per week of 60 minutes). After the Pilates sessions, both groups were submitted at a second moment of evaluation with the same features as the first one. During the research both groups attended the usual dance classes.

The Pilates training protocol was supervisor by a qualified Pilates instructor. Basic and intermediate exercises were employed; advanced exercises were added as technique and time of training progressed. At the beginning of the training protocol, all dancers performed, slowly, 3 sets of 8 repetitions of each exercise; increasing 1 repetition each week till 12 repetitions were reached. After reaching the 12 repetitions it was introduced the intermediate or advanced form of each exercise, performing 3 sets of 8 repetitions. In the sessions it was used exercises with a similarity with dance technique (e.g. "scissors", "the hundred", "side bend", "side kick", "back support"). Each session was set up in 3 phases: warm-up (15 minutes), Pilates exercises (35 minutes) and cool-down (10minutes).

Muscular strength measurement

It was evaluated the isometric strength of the lower limbs. Subjects were asked to maintain as long as possible, with both limbs, the technical skills *penché* and *developpé* (front, side, back) in the *barre*. It was timed how long each dancer could sustain the positions, without swinging the body. This protocol is used by the *Federation Internationale de Gymnastique* (Physical Testing Program), and its choice derives from the functional similarity with dance exercises. The evaluation tests were preceded by a period of warming.

Flexibility measurement

Three technical skills were assessed, collected on the right and left side: *arabesque*, *cambré* backward (in the *barre*) and *developpé* (front, side, back), also in the *barre*. Two high definition cameras, Casio Digital Camera EX-F1 were used to photograph the chosen movements. It was used a calibration scale placed next to a moving *barre* (Figure 1). The two cameras were directed to the calibration scale, one in the front, and other in the rear of the scale. During data collection, the positions of the cameras and calibration scale were not modified; it was only modified the position of the *barre* to assess the technical skills *developpé* front and *cambré*.



Figure 1. Assembling material for data collection

Each dancer was marked in the following anatomical points: ankle joint, knee joint, iliac crest, shoulder joint, elbow joint and wrist joint. After, each dancer performed the different technical skills inside the calibration scale; both cameras captured the images (10 frames per second at 3 megapixel resolution).

After data collection, it was selected only one photo for each skill, taking as selection criterion the most corrected technical execution and the highest point for limbs extension.

The angles among body segments were assessed through Matlab routines (Figure 2). For the technical skills *arabesque*, *developpé* back and *developpé* side, points were marked in the inner sides of ankle and knee joints of both limbs. For the *developpé* front the points were marked in the inner side of ankle and knee joints (supporting limb) and in the external side of ankle and knee joints (elevating limb). For assessing the angle between the trunk and the lower limbs in the technical element *cambré*, points were marked in

the knee joint, iliac crest, shoulder joint and elbow joint.



Figure 2. Example in how angle between body segments were obtained; asterisks represent the anatomical points marked for obtain the angle between body segments in this technical skill (*arabesque*). For each technical skill were marked different anatomical points.

Statistical Analyses

Mean (\pm sd) was calculated for all parameters.

Data from experimental and control groups were normally distributed. Comparisons between the first and second moment of evaluation and between experimental and control groups were made using two-way analysis of variance - ANOVA 2x2 (group X moment), with moment being a repeated factor.

All statistical analysis were performed using SPSS (Statistical Package for the Social Sciences, 19.0), and the criterion for significance was set at $p \leq 0,05$.

Results

Significant results can be analyzed in table 1 and 2.

Table 1 presents results for muscular strength pre and post-Pilates training in EG and CG. EG and CG had similar pre-Pilates muscular strength range in all technical skills evaluated. However, after Pilates training, EG increased their range in all technical skills. This increasing were not followed by CG, being stated a significant group x moment interaction ($p \leq 0,05$) in all technical skills evaluated. This significant interaction revealed that muscular strength was significantly higher in the EG after Pilates training.

Table 1. Muscular strength measures (seconds) pre and post-Pilates training.

	Experimental group		Control group		Effects	F	p
	Pre-Pilates x ± sd	Pos-Pilates x ± sd	Pre-Pilates x ± sd	Pos-Pilates x ± sd			
Penché Right limb	25,1 ± 11,3	47,6 ± 22,3	24,9 ± 4,3	26,8 ± 3,2	Group	3,324	0,091
					Moment	20,764	0,001
Penché Left limb	35,1 ± 13,4	49,4 ± 17,8 1	24,5 ± 8,1	24,4 ± 7,7	Group X Moment	14,851	0,002
					Group	8,806	0,000
Developpé front Right limb	12,9 ± 5,1	19,9 ± 6,2	14,8 ± 4,1	14,3 ± 4,2	Moment	14,264	0,002
					Group X Moment	14,772	0,002
Developpé front Left limb	17,7 ± 7,1	23,9 ± 8,2	12,3 ± 2,7	12,4 ± 3,1	Group	0,678	0,425
					Moment	8,073	0,014
Developpé side Right limb	15,0 ± 4,0	22,9 ± 11	14,0 ± 4,2	14,1 ± 4,6	Group X Moment	10,748	0,006
					Group	8,891	0,000
Developpé side Left limb	16,6 ± 8,9	24,7 ± 6,5	12,5 ± 2,9	12,8 ± 2,4	Moment	21,733	0,000
					Group X Moment	20,034	0,001
Developpé back Right limb	29,3 ± 11,9	49,0 ± 14,9	24,9 ± 7,4	25,0 ± 6,0	Group	2,571	0,133
					Moment	10,456	0,007
Developpé back Left limb	40,9 ± 9,2	52,7 ± 12,6	26,9 ± 4,8	26,9 ± 5,7	Group X Moment	9,812	0,008
					Group	8,359	0,013
Arabesque Right limb	99,3 ± 8,9	109,2 ± 12,7	96,4 ± 4,2	97,0 ± 4,7	Moment	20,306	0,001
					Group X Moment	17,959	0,001
Arabesque Left limb	102,2 ± 12,1	109,5 ± 11,0	93,4 ± 6,5	95,0 ± 4,5	Group	8,929	0,010
					Moment	18,465	0,001
Developpé front Right limb	102,3 ± 12,7	112,0 ± 13,1	102,4 ± 10,2	101,5 ± 8,7	Group X Moment	16,266	0,001
					Group	26,638	0,000
Developpé front Left limb	102,2 ± 13,5	110,3 ± 13,3	95,5 ± 5,3	96,2 ± 5,7	Moment	8,415	0,012
					Group X Moment	8,415	0,012
Developpé side Right limb	115,7 ± 21,9	125,7 ± 18,7	110,1 ± 13,4	110,7 ± 12,5	Group	8,231	0,013
					Moment	3,708	0,076
Developpé side Left limb	113,9 ± 88,1	121,5 ± 18,0	108,8 ± 14,4	109,7 ± 12,9	Group X Moment	8,809	0,011
					Group	7,530	0,017
Developpé back Right limb	112,2 ± 10,1	119, 8 ± 12,9	103,8 ± 6,9	102,2 ± 5,8	Moment	4,450	0,055
					Group X Moment	7,048	0,020
Developpé back Left limb	113,8 ± 13,1	117, 3 ± 12,9	102,6 ± 4,2	102,2 ± 4,4	Group	0,046	0,833
					Moment	1,855	0,196
Cambré backward Right limb	91,9 ± 24,1	88,0 ± 23,3	88,1 ± 14,0	87,6 ± 15,9	Group X Moment	1,023	0,330
					Group	0,012	0,913
Cambré backward Left limb	95,2 ± 20,4	88,9 ± 20,4	93,9 ± 17,7	92,4 ± 15,8	Moment	5,220	0,040
					Group X Moment	2,035	0,177

Table 2. Flexibility measures (degrees) pre and post-Pilates training.

	Experimental group		Control group		Effects	F	p
	Pre-Pilates x ± sd	Pos-Pilates x ± sd	Pre-Pilates x ± sd	Pos-Pilates x ± sd			
Arabesque Right limb	99,3 ± 8,9	109,2 ± 12,7	96,4 ± 4,2	97,0 ± 4,7	Group	3,467	0,085
					Moment	19,349	0,001
Arabesque Left limb	102,2 ± 12,1	109,5 ± 11,0	93,4 ± 6,5	95,0 ± 4,5	Group X Moment	15,158	0,002
					Group	6,946	0,021
Developpé front Right limb	102,3 ± 12,7	112,0 ± 13,1	102,4 ± 10,2	101,5 ± 8,7	Moment	8,485	0,012
					Group X Moment	3,451	0,086
Developpé front Left limb	102,2 ± 13,5	110,3 ± 13,3	95,5 ± 5,3	96,2 ± 5,7	Group	0,886	0,364
					Moment	7,413	0,017
Developpé side Right limb	115,7 ± 21,9	125,7 ± 18,7	110,1 ± 13,4	110,7 ± 12,5	Group X Moment	10,457	0,007
					Group	4,161	0,062
Developpé side Left limb	113,9 ± 88,1	121,5 ± 18,0	108,8 ± 14,4	109,7 ± 12,9	Moment	22,870	0,000
					Group X Moment	16,012	0,002
Developpé back Right limb	112,2 ± 10,1	119, 8 ± 12,9	103,8 ± 6,9	102,2 ± 5,8	Group	1,450	0,250
					Moment	19,449	0,001
Developpé back Left limb	113,8 ± 13,1	117, 3 ± 12,9	102,6 ± 4,2	102,2 ± 4,4	Group X Moment	15,063	0,002
					Group	1,048	0,325
Cambré backward Right limb	91,9 ± 24,1	88,0 ± 23,3	88,1 ± 14,0	87,6 ± 15,9	Moment	30,312	0,000
					Group X Moment	18,712	0,001
Cambré backward Left limb	95,2 ± 20,4	88,9 ± 20,4	93,9 ± 17,7	92,4 ± 15,8	Group	8,231	0,013
					Moment	3,708	0,076
Arabesque Right limb	99,3 ± 8,9	109,2 ± 12,7	96,4 ± 4,2	97,0 ± 4,7	Group X Moment	8,809	0,011
					Group	7,530	0,017
Arabesque Left limb	102,2 ± 12,1	109,5 ± 11,0	93,4 ± 6,5	95,0 ± 4,5	Moment	4,450	0,055
					Group X Moment	7,048	0,020
Developpé front Right limb	102,3 ± 12,7	112,0 ± 13,1	102,4 ± 10,2	101,5 ± 8,7	Group	0,046	0,833
					Moment	1,855	0,196
Developpé front Left limb	102,2 ± 13,5	110,3 ± 13,3	95,5 ± 5,3	96,2 ± 5,7	Group X Moment	1,023	0,330
					Group	0,012	0,913
Developpé side Right limb	115,7 ± 21,9	125,7 ± 18,7	110,1 ± 13,4	110,7 ± 12,5	Moment	5,220	0,040
					Group X Moment	2,035	0,177
Developpé side Left limb	113,9 ± 88,1	121,5 ± 18,0	108,8 ± 14,4	109,7 ± 12,9	Group	8,231	0,013
					Moment	3,708	0,076
Developpé back Right limb	112,2 ± 10,1	119, 8 ± 12,9	103,8 ± 6,9	102,2 ± 5,8	Group X Moment	8,809	0,011
					Group	7,530	0,017
Developpé back Left limb	113,8 ± 13,1	117, 3 ± 12,9	102,6 ± 4,2	102,2 ± 4,4	Moment	4,450	0,055
					Group X Moment	7,048	0,020
Cambré backward Right limb	91,9 ± 24,1	88,0 ± 23,3	88,1 ± 14,0	87,6 ± 15,9	Group	0,046	0,833
					Moment	1,855	0,196
Cambré backward Left limb	95,2 ± 20,4	88,9 ± 20,4	93,9 ± 17,7	92,4 ± 15,8	Group X Moment	1,023	0,330
					Group	0,012	0,913
Arabesque Right limb	99,3 ± 8,9	109,2 ± 12,7	96,4 ± 4,2	97,0 ± 4,7	Moment	5,220	0,040
					Group X Moment	2,035	0,177

Table 2 presents results for flexibility pre and post-Pilates training in EG and CG. EG and CG were found to have similar flexibility range in all technical skills measured at the first moment of evaluation, but EG had significantly greater flexibility increases in the technical skills *arabesque* (right limb), *developpé* front, *developpé* side and *developpé* back after Pilates training. This meant that EG had better flexibility range at the final measurement, being stated a significant group x moment interaction ($p \leq 0,05$) in these technical skills. However, analysis revealed that there were no significant main or interaction effect on the technical skill *cambré* backward and *arabesque* (left limb), being the group x moment interaction not significant ($p \geq 0,05$). This meant that both groups did not improve significantly their flexibility range in these technical skills. However, despite not being significant, EG had increased their flexibility range in 7,3 degrees on the technical skill *arabesque* (left limb).

Discussion

The main aim of this study was to investigate the effects of Pilates training on muscular strength and flexibility in dancers, trying to test that this technique can be useful to dancers. For the purpose of this study, it was selected a range of technical skills that require the use of flexibility and muscular strength. Since dance skills are usual performed with each limb in separate, data were collected with both limbs, measured separately. However, it is not purpose of this study to establish comparisons between limbs.

From the analyses, the present results demonstrated that Pilates training increased dancers' muscular strength levels. Since there are not similar studies, it is not possible to compare directly these results. Studies realized with other populations corroborate our results. So, several authors have demonstrated that a Pilates training program had a positive impact on muscular strength levels in sedentary populations ([SEKENDIZ](#); ALTUN; KORKUSUZ; AKIN, 2007; [ROGERS](#); GIBSON, 2009; [KLOUBEC](#), 2010).

Apparently, the nature of Pilates training can explain the strength gains found in the present study. Analyzing dancers training patterns, abdominal muscle development is neglected, what rises the importance for the training of this crucial musculature. Abdominal muscles in normal dance training is only stimulated by the characteristic

attitude of dance, which emphasizes the pelvic retroversion position. Pilates training, continuously stimulating the abdominal musculature provides a stronger core, which is essential for set and support the kinetic chains required to raise lower limbs. Better improvements can be verified in the technical skills *penché* and *developpé* back. The constant gluteal muscles contraction required by Pilates exercises, is probably the main cause for the greatest improvements on muscular strength in these technical skills.

The present study showed significant increase on the flexibility assessed by the technical skills *arabesque* and *developpé*. No other studies with dancers were found, however several authors have noted positive impacts of Pilates training on the flexibility of sedentary subjects ([SEKENDIZ](#); ALTUN; KORKUSUZ; AKIN, 2007; [KLOUBEC](#), 2010) and soccer players ([BERTOLLA](#); BARONI; JUNIOR; OLTRAMI, 2007). However, it is necessary to highlight that these studies used different methods and different body zones measurements. We want to reinforce the present data validity because the sample of the present study was composed by subjects who already had great levels of global flexibility. However, some assumptions should be considered. Albeit the literature suggest that static stretching improves flexibility better than dynamic stretching ([BANDY](#); IRON, 1994; [BANDY](#); IRION; BRIGGLER, 1997; [ROBERTS](#); WILSON, 1999; [HEDRICK](#), 2000), the present study showed significant flexibility gains through dynamic exercises. Furthermore, it can be speculate that flexibility gains noted in the present study could also be related to muscular strength gains after the Pilates training. The relationship between muscular strength and flexibility has been stated by several authors ([LEIGHTON](#), 1964; [FATAUROS](#); TAXILDARIS; TOKMADAKIS; KLAPOTHARAKOS; AGGELOUSIS; ATHANASOPOULOS; ZEERIS; KATRABAS, 2002; [FATAUROS](#); KAMBAS; KATRABASSAS; LEONTSINI; CHATZINIKOLAOU; JAMURTAS; DOUROUDOS; AGGELOUSIS; TAXILDARIS, 2006; [SANTOS](#); RHEA; SIMÃO; DIAS; SALLES; NOVAES; LEITE; BLAIR; BUNKER, 2010), however flexibility benefits obtained by strength training require maximum range of motion during strength exercises ([STONE](#); FLECK; TRIPLETT; KRAMER, 1991). It should be pointed out the

importance of muscular strength training in dancing, since dancers often show great levels of flexibility, but do not have strength enough to perform movements with maximum range of motion. Facing the impossibility of knowing exactly the contribution of muscle strength to flexibility gains noted in the present study, it can be only speculate that the execution of movements with full range of motion and with some static sustenance require high strength levels besides a great neuromotor coordination between agonist and antagonist muscles.

Pilates training did not improve flexibility in the technical skill *cambré*. Probably this is due to the weak stimulation of dorsal and lumbar muscles elicited by the Pilates exercises used. Therefore, the slight flexibility gains noticed in *cambré*, are probably due to the usual stimulus provided by dance classes.

As a conclusion, the present data confirmed that Pilates training can significant improve dancers' muscular strength and flexibility, affecting positively dance performance. As Pilates exercises emphasizes movements with some kinetic similarity to dance technique, we believe that this type of training is suitable for dancers to improve muscular strength and flexibility.

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