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Kettlebell Training for Female Ballet Dancers: Effects on Lower Limb Power and Body Balance

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The aim of the present study was to evaluate the effects of 5 month kettlebell-based training on jumping performance, balance, blood pressure and heart rate in female classical ballet dancers. It was a clinical trial study with 23 female dancers (age = 21.74 ± 3.1 years; body height = 168.22 ± 5.12 cm; body mass = 53.69 ± 5.91 kg) took part in the study. Participants were divided into two groups: a kettlebell group (n = 13), that followed a commercial kettlebell training protocol named the "Simple & Sinister protocol", and a traditional dance training control group (n = 10). In the kettlebell group, kettlebell training completely replaced the jump and balance section of dance classes. Both groups performed balance and jumping tests before and after the training period. Blood pressure and the heart rate were also measured. The kettlebell group showed significant improvements in the balance tests (antero-posterior and medio-lateral oscillation) with both legs and eyes open as well as in all types of jump exercises (unrotated: +39.13%, $p < 0.005$; with a turnout: +53.15%, $p < 0.005$), while maximum and minimum blood pressure and the heart rate decreased significantly (max: -7.90%, $p < 0.05$; min: -9.86%, $p < 0.05$; Heart rate: -17.07%, $p < 0.01$). The results for the control group were non-significant for any variable. Comparison between groups showed significant differences for all variables analyzed, with greater improvements for the kettlebell group. Our results suggest that specific kettlebell training could be effective in improving jump performance and balance in classical dancers to a significantly greater degree compared to classical dance training.

Key words: *kettlebell, balance, ballet dancers.*

Introduction

Classical ballet is an artistic expression based on physically demanding dance performances (Koutedakis and Jamurtas, 2004). While there has been a growing interest in the physiological characteristics of dancing (Rodrigues-Krause et al., 2015), specific strength training (ST) in classical ballet is usually rejected by the Academies and is still poorly studied in scientific literature (Rafferty, 2010; Wyon, 2010). The negative view of ST is probably because muscular strength has not been considered important for success in dance; moreover, there is an unfounded believe that ST could increase dancers muscle mass, diminishing their aesthetic appearance and gracefulness (Stracciolini et al., 2016). This traditional view was refuted in the earlies '80s by Fitt (1981) who showed that ST was able to improve dance performance without increasing muscle mass. These results are coherent with the physiological basis of muscle growth (Gonzalez et al., 2016). To optimise muscle hypertrophy, it is necessary to manipulate many training variables and nutrition (Morton et al., 2015; Paoli, 2012; Paoli and Bianco, 2012; Witard et

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al., 2016). Therefore, merely "lifting weight" will not necessarily lead to significant muscle hypertrophy. Moreover, ST variables can be manipulated in order to maximise outcomes such as strength and muscle power while avoiding undesirable muscle growth, as is the case with explosive movements (Bemben and Murphy, 2001).

The kettlebell is an ancient training implement, a cast iron weight that looks like a cannonball with a handle, dating back to at least 1703 in Russia (Tsatsouline, 2013). The kettlebell's design offers some unique ergonomic benefits in both dynamic and static exercises. Unlike a barbell or a heavy dumbell, it can be safely moved between the legs in swings and snatches, enabling ballistic eccentric loading. Kettlebell swing can be divided into three phases: (a) a short and quick explosive initial phase of concentric action mediated by extension of the knee, hip and ankle at the same momentum, (b) a coasting phase that relies on the momentum generated in the initial phase, and (c) a deceleration phase sustained by eccentric muscle action (Jay et al., 2011, 2013a). It has been demonstrated that KT is effective in activating the back and hip musculature (Edinborough et al., 2016; Mcgill and Marshall, 2012), and specific training of the back musculature can reduce the risk of low back injury and improve arabesque aesthetics in dancers (Welsh et al., 1998). KT has also been shown to improve postural coordination and jumping performance (Jay et al., 2013b), increase power and strength performance (Lake and Lauder, 2012; Manocchia et al., 2013; Warning et al., 2016), and also increase cardiovascular fitness (Falatic et al., 2015; Fortner et al., 2014; Jay et al., 2011; Williams and Kraemer, 2015) and sympathovagal balance (Wong et al., 2017).

Based on its characteristics, KT may be particularly suited to classical ballet's performance improvement because it requires explosive and precise movements. Thus, we sought to investigate the effects of a KT protocol on jump and balance performance in classical female ballet dancers.

Methods

Experimental Approach

In order to investigate the effect of KT in a homogeneous group of female dancers, a randomized trial with two experimental groups was adopted: a kettlebell group (KG) and a control group (CG). All participants performed identical dance training, but the KG substituted the main part of the lesson with a KT session, while the CG performed traditional ballet training (Figure 1). Participants were tested before and after 5 months of training.

Participants

Twenty-three female ballet dancers (21.74 ± 3.1 yrs; 168.22 ± 5.12 cm; 53.69 ± 5.91 kg) were recruited from a local dance school. All participants had at least 10 years of ballet training experience and trained three times a week with total training duration of 9 hours per week. Participants were randomly assigned to one of the two groups: the kettlebell group (KG, n = 13) and the control group (CG, n = 10). During the study participants did not engage in any physical activity other than dance. Before participation, all dancers provided their informed consent. The study was approved by the local ethics committee (HEC-DSB 02/15).

Experimental Sessions

Ballet training was the same for both groups and involved a ballet class consisting of three main segments: warm up, barre and centre/KT.

The warm up (10 min) prepared dancers for the barre work with general exercises for shoulder, spine, hip, knee and ankle mobility and gentle stretches for the calf, quad, hamstring and spine muscles. The barre work (35 min) consisted of the following exercises: plié, grand plié, battement tendu, battement jeté, rond de jambe a terre, fondu, frappé, rond de jambe en l'air, petit battement, developpé, adagio, and grand battement. Each exercise was performed at first with the right leg moving from the initial fifth position of feet, and holding the left hand on the barre, then the same exercise was performed with the other leg and holding the right hand on the barre, with no rest between sides. The initial pliés were the only exercises that always required an execution in each feet position, from the first one to the fifth (sometimes the third was omitted being similar to the fifth). The other exercises started and ended in the first or more often, the fifth position and they were performed "en croix"; a classical ballet term meaning "in the shape of a cross". Dancers performed 16 or more rond en de dehors and 16 or more en dedans, often combining different types of ronds. The barre works ended with a stretch of 5 minutes called jambe sur la barre performed before or after the final grand battements.

The CG went on performing the traditional “centre”. The “centre” is the work in the middle of the room (20 min). In the first part, port de bras (movements of the arms) and “adagios” (combinations of barre exercises in form of small choreography) emphasise transfer of weight and provide a gradual transition from the stability of the barre to the centre (balance training). When the teacher showed the sequence to the dancers (1-2 min), that time was considered a rest interval. Each sequence was performed once with each leg, with no rest interval between them. In the second part, the “allegro” (jump work) started with a warm up of 32 small jumps: 8 jumps in each feet position (except the third). Then a “petit allegro” and “batterie”, consisting in a choreographic combination of small jumps as petit assemblées and jetés, and a “medium allegro”, choreographic combination of 5-6 jumps including sissonne, cabriole and entrechat, were performed symmetrically with legs and with no rest interval in between. At the end, the “grande allegro”, consisting of 5-6 grand jetés, cabrioles, fouettes en l’air and other difficult jumps (in choreographic combination also) were performed at the highest height a dancer could reach. The rest interval was the teacher’s explanation of the sequence (1-2 min) before starting each allegro.

The KG did not perform “centre”, moving from the warm-up to the barre and then to KT. KT involved a commercially available routine called the “Simple & Sinister” (S&S) protocol as described in Tsatsouline (2013). The S&S protocol included, without interruption: one hand 100 swings (50 on the left and 50 on the right) in 5 minutes and 10 Turkish get-ups (TGUs) in 10 minutes. In the one-arm swing the athlete swung the kettlebell back between her legs and then in front of herself. The arm remained straight and the work was done by the hips and legs - the motion was similar to a standing vertical jump with the feet remaining on the ground. The exercise was performed in a ballistic manner. TGUs, in contrast, were performed slowly. The dancer lay down on the floor, picked up the kettlebell with two hands, then pressed it with one arm. Keeping the arm straight and nearly vertical at all times, the dancer propped herself up with the other arm, kneels, and stands up repeating this sequence 5 times. Then the movement was repeated with the other arm for another 5 repetitions.

Measures

All evaluations were performed at the beginning and after 5 months of training. The balance evaluation consisted of a battery of four static postural stability tests:

1. Standing on both legs with eyes opened;
2. Standing on both legs with eyes closed;
3. Standing on the left leg with eyes opened;
4. Standing on the right leg with eyes opened.

A force plate (RGMD S.p.a., Genova, Italy) was used to measure the center of pressure (CoP) trajectory in the anterior-posterior (AP) and medio-lateral (ML) direction, at a sampling rate of 100 Hz. The protocol of the balance test has been described in detail elsewhere (Marcolin et al., 2016). Briefly participants had to stand on the platform without shoes, with an angle between feet of 30°. In the first trial with eyes opened (OE) they were asked to look ahead gazing a target on the wall at 1 m of distance while in the second trial with eyes closed (CE) they were instructed to maintain the upright posture for all the duration of the trial keeping their eyes closed (Falatic et al., 2015). Afterwards all participants repeated the same procedure, but standing only on a right and thereafter, a left leg. Each test lasted 30 s. The rest interval between the trials was set to 60 s.

Maximal oscillation in the anterior-posterior (AP) and medio-lateral (ML) direction [mm], the sway path velocity [mm/s], the area of the confidence ellipse [mm^2], and the sway area velocity [mm^2/s] were calculated. Moreover the sway area was calculated as the sum of the areas of the triangles having as vertexes the barycenter of the CoP path and two consecutive points of the CoP path. Sway area velocity represented the area swept per time unit. The Romberg coefficient was computed for all the variables described above.

Lower limb performance

Participants performed six countermovement jump tests, repeated three times, each recorded with the Optojump Next Microgate (Bolzano, Italy). The Optojump is an optical measurement system consisting of a transmitting and receiving bar that communicates continuously. The system detects any interruptions in communication between the bars and calculates their duration allowing to measure flight and contact times with an accuracy of 0.001 s.

The following tests were performed for both the right and left foot jump in a "natural position" (unrotated) using the Optojump system. For every test we used the mean of the three attempts.

- Jump with both feet in the "natural position"
- Jump with the right foot in the "natural position"
- Jump with the left foot in the "natural position"
- Technical right foot jump (rotated) "temps levé"
- Technical left foot jump (rotated) "temps levé"
- Technical both feet jump (rotated) "first position"

Blood Pressure and Heart Rate

The measurements of BP and the HR were made with OMRON M10-IT, an automatic blood pressure monitor, operating on the oscillometric principle. We utilized the mean of three consecutive measurements. BP measurements were taken before balance and jump tests.

Statistical Analysis

Results are presented as mean ± standard deviation. Sample size was obtained assuming an interaction of a Root Mean Square Standardized Error (RMSSE) of 0.25 with a fixed power of 80% and an alpha risk of 5% for the main variable. The Shapiro-Wilk's W test was used to test assumptions of normality of distribution. An independent samples t test was used to evaluate baseline differences within groups. ANCOVA was performed to compare post-treatment values using pre-treatment values as covariates. All differences were considered significant at $p < 0.05$. Post-hoc analyses were performed using the Bonferroni test. The analysis was performed with SPSS statistical software (version 23, SPSS, Inc., Chicago, IL, USA).

Results

The KG showed significant improvements in balance tests (antero-posterior and medio-lateral oscillation) with both legs and eyes open and closed from baseline to post intervention, while the CG did not. Between groups comparison revealed that changes for the KG were significantly higher than for the CG (Table 1). Although there were trends for improvement in the KG for the other balance tests (sway path velocity, the area of the confidence ellipse, and the sway area velocity), the results did not achieve significance and there were no significant differences between treatments.

The KG improved significantly in all types of jump tests, while the CG did not improve in any jump test. Between groups comparison revealed that the KG had significantly higher improvements than the CG (Table 2).

As showed in Table 3, SBP, DP and HR values decreased significantly for the KG. For the CG, SBP and HR significantly increased, while DBP did not change significantly. There were significant differences between groups in all variables analyzed.

Discussion

As far as we know, this is the first study to investigate the effects of a KT protocol on jump and balance performance, as well as on BP and HR values, in female classical ballet dancers. The main finding was improvement, after kettlebell training, in jump test performance and bipodalic balance (both open and closed eyes). Therefore, this study provides the first evidence that 5 months of KT can improve the skills of ballet dancers in comparison to traditional training.

The mechanical analysis of kettlebell swing may explain the benefits in jump and balance performance. The kettlebell swing is an explosive movement and its performance requires coordinated and powerful contractions of the lower body and trunk muscles, in addition to highly demanding eccentric muscle actions (Jay et al., 2011). KT has been shown to have an acceleration phase similar to Olympic weightlifting, promoting similar gains in trunk extensor muscle strength (Jay et al., 2011). Moreover, previous studies showed similar improvements in jump performance and strength after 6 and 8 weeks of KT when compared to baseline values, and this improvement was similar to that achieved in a combination of weightlifting and traditional heavy resistance training (Jay et al., 2011; Otto et al., 2012). Besides being considered an indicator of performance in many sports (Paoli et al., 2012), the increase in jump performance along with improved balance may be important during classical ballet dance presentations.

An interesting observation was that dancers in the KG reported taking the kettlebell to the theatre for their warm up because they considered S&S to be effective for their preparation, even preferable to specific ballet exercises.

Table 1

Maximal oscillation in the anterior-posterior (AP) and medio-lateral (ML) direction during balance tests in the kettlebell and control group.

	Kettlebell group			Control group			
	pre	post	*p*	pre	post	*p*	*p* between group
AP Both legs eyes open (mm)	25.18 ± 13.36	15.76 ± 6.29	0.014	19.46 ± 5.45	26.60 ± 11.75	ns	0.041
ML Both legs eyes open (mm)	20.07 ± 10.74	9.15 ± 2.73	0.0045	17.24 ± 7.95	24.08 ± 12.06	ns	0.003
AP Both legs eyes closed (mm)	28.41 ± 17.17	18.78 ± 8.33	0.038	21.58 ± 8.67	32.90 ± 18.15	ns	0.023
ML Both legs eyes closed (mm)	22.41 ± 17.82	9.88 ± 3.18	0.029	17.03 ± 10.32	26.72 ± 21.86	ns	0.0047
AP Right leg eyes open (mm)	36.63 ± 11.77	29.02 ± 6.32	ns	45.03 ± 11.17	53.69 ± 27.34	ns	ns
ML Right leg eyes open (mm)	25.49 ± 7.10	22.63 ± 8.56	ns	37.00 ± 9.69	32.48 ± 9.34	ns	ns
AP Left leg eyes open (mm)	37.98 ± 13.97	33.95 ± 11.73	ns	47.94 ± 22.97	58.92 ± 22.78	ns	0.05
ML Left leg eyes open (mm)	25.25 ± 6.64	23.20 ± 10.22	ns	29.41 ± 9.62	34.63 ± 13.80	ns	ns

Table 2

Jumping performance in the kettlebell and control group.

	Kettlebell group			Control group			
	pre	post	*p*	Pre	post	*p*	*p* between group
Jump with both feet in "natural position" (cm)	17.62 ± 4.22	24.52 ± 4.89	<0.001	18.15 ± 4.44	17.80 ± 3.73	0.638	<0.001
Right foot jump in "natural position" (cm)	6.75 ± 2.60	10.94 ± 3.14	<0.001	7.30 ± 2.05	7.88 ± 1.87	0.34	<0.001
Left foot jump in "natural position" (cm)	6.94 ± 2.43	10.62 ± 3.13	<0.001	7.02 ± 1.94	7.,61 ± 1.47	0.402	0.003
Technical both feet jump (rotated) "first position" (cm)	15.36 ± 3.66	23.52 ± 5.15	<0.001	17.40 ± 3.93	16.75 ± 3.47	0.843	<0.001
Technical right foot jump (rotated) "temps levé" (cm)	4.87 ± 1.75	9.41 ± 2.96	<0.001	6.39 ± 1.89	6.83 ± 1.75	0.520	0.01
Technical left foot jump "temps levé" (cm)	4.58 ± 1.84	9.12 ± 3.14	<0.001	5.42 ± 1.47	6.01 ± 1.52	0.344	<0.001

Table 3

Cardiovascular variables in the kettlebell and control group.

	Kettlebell group			Control group			
	pre	post	*p*	pre	post	*p*	*p* between group
Systolic blood pressure (mmHg)	122.69 ± 14.57	113.00 ± 9.29	0.005	118.00 ± 7.59	125.4 ± 10.15	0.048	0.001
Diastolic blood pressure (mmHg)	74.92 ± 9.14	67.54 ± 7.35	0.004	73.40 ± 6.47	79.7 ± 6.51	0.026	<0.001
Heart rate (bpm)	76.61 ± 8.01	63.53 ± 6.04	<0.001	79.5 ± 9.45	81.40 ± 10.85	0.389	<0.001

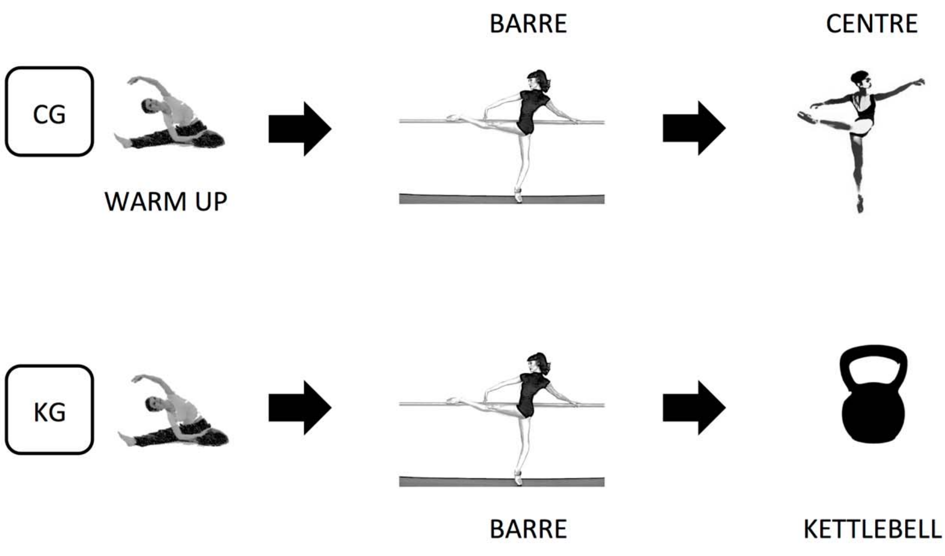

Figure 1

Scheme of the experimental design.

These reports are similar to Jay et al. (2013b) where participants reported improvements in desire to exercise and physical energy in daily life. Before and during the pauses of their presentations dancers performed swings as a warm up, which might be an important strategy to improve balance during artistic performance and to prevent injury (Lin et al., 2016). Although this study did not evaluate incidence of injury, there is evidence which relates KT to a decrease in neck/shoulder and low back pain after 8 weeks of ballistic KT (Jay et al., 2011), though specific training of the back musculature including KT (Edinborough et al., 2016), can result in a reduced injury risk in dancers (Welsh et al., 1998). Moreover, as some concerns may be raised about the effects of this kind of "strength training" on the cardiovascular system, we found instead a decrease in the basal heart rate and blood pressure that it is known to be related to positive outcomes of endurance training (Cornelissen et al., 2010).

It is important to note that the main focus of dance classes is skill and aesthetic acquisition. We recognize that jumping ability may not be critical and the most important variable to ballet and that such training may not necessarily improve other important factors, such as skill acquisition and movement quality. However, it is important to highlight that in our study, replacing part of the ballet class by explosive training with kettlebell exercises did not have a detrimental effect on dancing performance. Moreover, improving physical performance may help recreational dancers to improve their performance.

Our results suggest that KT may be included in training programs for ballet classical dancers. Altogether, these findings support the inclusion of KT exercises as complementary specific ballet training to improve performance in dancers. In conclusion, adding KT to the routines of classical ballet dancers may improve their conditioning, jump and balance performance.

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