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The Effects of Three Months of Aerobic and Strength Training on Selected Performance- and Fitness-Related Parameters in Modern Dance Students

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Abstract. Koutedakis, Y., H. Hukam, G. Metsios, A. Nevill, G. Giakas, A. Jamurtas, and L. Myszkewycz. The effects of three months of aerobic and strength training on selected performance- and fitness-related parameters in modern dance students. *J. Strength Cond. Res. 21(3):808–812. 2007.*—The purpose of the present study was to assess the effects of a 12-week aerobic and muscular strength training program on selected dance performance and fitness-related parameters in modern dance students. The sample consisted of 32 men and women (age 19 ± 2.2 years) who were randomly assigned into exercise ($n = 19$) and control ($n = 13$) groups. Anthropometric and flexibility assessments, treadmill ergometry, strength measurements, and—on a separate day—a dance technique test were conducted pre- and postexercise training in both groups. After the end of the program, the exercise group revealed significant increases in dance ($p < 0.02$), $\dot{V}O_2max$ ($p < 0.04$), flexibility ($p < 0.01$), and leg strength ($p < 0.001$) tests compared to controls. It is concluded that in modern dance students (a) a 3-month aerobic and strength training program has positive effects on selected dance performance and fitness-related parameters, (b) aerobic capacity and leg strength improvements do not hinder dance performance as studied herein, and (c) the dance-only approach does not provide enough scope for physical fitness enhancements.

Key Words. dance test, muscular strength, aerobic power, flexibility, men, women

Introduction

Modern dance emerged at the beginning of the 20th century as a breakaway from the rigid constraints of classical ballet, which itself started as a performance art in the French courts in the 16th and 17th centuries. Shedding classical ballet technique, costume, and shoes, early modern dance pioneers practiced free dance based on movements expressive of feelings. Their main aim of the dancers was to raise consciousness by dramatizing the economic, social, ethnic, and political crises of their time.

A common characteristic of both modern dance and classical ballet is that both dance forms place great emphasis on quality, execution, and vocabulary of movement. However, because of its physical nature and as a result of an increased cross-fertilization between sport and modern dance (24), a far more athletic approach has been adopted by choreographers of this dance form. As a result, adequate physical fitness levels in modern dancers can be as important as skill development.

In dance, fitness incorporates elements of body composition (14), cardiorespiratory efficiency (4, 5), and muscular strength (7). However, there are surprisingly few published data on dance-related fitness (22). This partly reflects the fact that dancers are often see fitness as merely the absence of injury and other medical conditions. It also reflects an unfounded fear among sections of the profession that increased levels of fitness would possibly undermine important aesthetic appearances. Nevertheless, published data indicate that appropriate exercise training is not detrimental to either the dancers' aesthetics (25) or the dance performance (20) and that fitness parameters have the same functional characteristics in most active individuals, including dancers (19). It has also been established that exercise training results in positive adaptations of key parameters associated with aerobic fitness (6, 18) and muscular strength (26, 35) in physically active as well as nonactive individuals. Yet it is not entirely clear whether such adaptations will be accompanied by concomitant increases in technical elements of dance performance.

The physiological (12, 22) and technical (11, 32) aspects of performing dance have been examined primarily in the context of classical ballet. In view of the limited literature on modern dance, the aim of this study was to assess the effects of a 12-week aerobic and muscular strength training program on dance performance and fitness-related parameters in students of this dance form.

Methods

Experimental Approach to the Problem

The purpose of the present study was to assess the effects of a 12-week aerobic and muscular strength training program on dance performance and fitness-related parameters in modern dance students. The sample consisted of men and women students of a modern dance school, who were randomly assigned into exercise and control groups. The adopted instruments included anthropometry (height, body mass, and sum of skinfolds), flexibility test, treadmill ergometry, leg strength assessments, and a modern dance routine designed to evaluate technique levels. Prior to and just after the 12-week strength training period, during which subjects maintained their usual nutritional and lifestyle habits, all volunteers were subjected to the aforementioned assessments. Given the status of the subjects, this investigation was designed to be brief and relevant to the study purpose.

Subjects

Thirty-two dance students (women = 27, men = 5; mean age: 19 ± 2.2 years) from the same institution volun-

TABLE 1. Anthropometric characteristics of all subjects. Values represent mean (± *SD*).

	Age (y)	Height (cm)	Weight (kg)
Exercise group ($n = 19$)	20.1 (±2.7)	165.6 (±8.0)	56.4 (±5.3)
Control group ($n = 13$)	19.4 (±2.1)	163.7 (±9.8)	56.0 (±6.5)
t-test	NS*	NS	NS

* NS = nonsignificant ($p > 0.05$).

teered to participate in this study, which was conducted during the last 3 months (final term) of their first of 3 years in training to become professional dancers. They were randomly assigned into an "exercise" group ($n = 19$), which refers to individuals who undertook a specifically designed exercise training program in addition to their dancing commitments, and a "control" group ($n = 13$), which consisted of dancers who performed no extra physical exercise apart from that included in their school curriculum. The project was approved by the Wolverhampton University Review Board. Prior to and just after the end of the 12-week exercise training period all volunteers were subjected to anthropometric and flexibility assessments, treadmill ergometry, strength measurements, and—on a separate day—a dance technique test. All tests were conducted following 15–20 minutes of customized warm-up routines. Anthropometric data of all subjects appear on Table 1.

Anthropometry

Age (accurate to within 1 month) was recorded. Standing height was measured to the nearest 0.5 cm using a Seca Stadiometer 208 (Hamburg, Germany), with the subject's shoes off and his/her head at the Frankfort horizontal plane. Body mass was assessed to the nearest 0.5 kg (Seca Beam Balance 710). Using a Harpenden (John Bull, St. Albans, UK) caliper, the sum of 4 skinfold thicknesses (i.e., suprailiac, subscapular, triceps, and biceps; mean of 2 measurements) was also recorded.

Flexibility Test

Hamstring flexibility has been linked to injury (37) and, anecdotally, is thought to be a fair representative of whole-body flexibility. This parameter was assessed from a maximum passive straight right leg raise while a Leighton Flexometer (Leighton Flexometer, Inc., Spokane, WA) (28) was attached to the subjects' leg. The participant began the assessment while lying in the supine position on the floor. The use of the instrument allows flexibility of the joints and musculature involved to be recorded as degrees of range of motion. Maximal flexibility was defined as the point at which the examiner began to feel tension develop in the muscle. The mean of 3 readings was recorded, while shoulders, hips, and heel of the nonmeasurement leg remained in contact with the floor throughout the test.

Treadmill Ergometry

Procedures previously used in dancers have been adopted for the purpose of this study. The test protocol consisted of warming up with 5 minutes of steady-state running at 9 $km \cdot h^{-1}$ on the treadmill, followed by progressive 1-minute speed increments of 0.5 $km \cdot h^{-1}$ until exhaustion. Maximal oxygen intake ($\dot{V}O_2max$) was among the breathing parameters determined using the open-circuit method. An automated gas analyzer (Quinton, Q-Plex; Quinton Instruments, Seattle, WA) was used to record respiratory parameters every 30 seconds during testing while subjects inspired room air through a low-resistance 2-way Rudolph valve (Hans Rudolph, Inc., Kansas City, MO). The gas analyzers were calibrated with standard gasses previously checked by microtechniques. Spot checks were made on the calibration of the pneumotachograph for volume flows up to 200 $L \cdot min^{-1}$. Treadmill inclination throughout testing remained at 0° while $\dot{V}O_2max$ was confirmed via established procedures (8). A 2-minute walking warm-down period was allowed on the treadmill after the test was terminated.

Leg Strength Assessments

A strength measurement device (Electronics Co., Leeds, UK) was used to assess maximal isometric strength of both dominant and nondominant knee extensors in a random order. Following individual warm-up procedures, subjects were asked to sit on a specially designed chair, without shoes and with hip and knees flexed at 80° and 65°, respectively. Following 4–5 familiarization submaximal attempts, the mean of 3 maximal readings per leg was recorded. Rest periods of 1–2 minutes were allowed between tests. We found the test-retest reliability coefficient to range from $r = 0.89$ to $r = 0.96$.

Dance Test

Although the concept of technique as a sequence of movements appears to be well established in the literature of human movement, the concept of technique assessment is less well developed. The methods of technique analyses have been divided into predictive, qualitative, and quantitative. The latter is ideal for observation of some parts of a dance technique, such as turnout (9), but is less suitable for establishing the characteristics of the whole skill. For a critical review on technique analysis, see Lees (27).

For the purpose of this study, a specially designed test was utilized. Two pairs of concentric circles (60 and 70 cm and 55 and 65 cm in diameter for boys and girls, respectively) drawn on the studio's floor and a specially choreographed modern dance sequence were the key components of this test. Dancers were required to perform with reference to the circles' center (starting point), traveling away from them followed by the reverse movement (i.e., return toward the center of the circles). Failure to follow this process was penalized with point deduction.

Specifically, the dance sequence consisted of 2 parallel sideways jumps, away from the center of the circles (starting position), from 2 legs landing to 1, with arms held at the chest level (elbows were at the same level, opposite to each other, facing the frond of the body). These jumps were then immediately repeated in the opposite direction toward the starting position at the center of the two circles. Volunteers were instructed to discontinue exercise when they felt that technical elements of their dance had begun to deteriorate as a result of somatic fatigue.

Adopting the marking procedures used in sports such as gymnastics and ice skating, 2 teachers and former professional dancers assessed overall performances. These performances resulted in individual scores obtained from the number of complete repetitions and the technical/artistic competence. The latter consisted of 5 separate technical elements, namely posture and alignment, use and articulation of upper body and arms, lower body and feet, total body coordination, and presentation of movement. A

TABLE 2. Dance test performance and fitness-related parameters in the exercise ($n = 19$) and control ($n = 13$) groups before and after a 3-month exercise training program. Values are mean (± *SD*).*

	Dance test (points)	$\dot{V}O_2max$ (ml·kg^{-1}·min^{-1})	Skinfolds (mm)	Flexibility (°)	Strength left and right leg (kg)
Exercise group (before)	73.9 (± 16.2)	50.7 (± 7.5)	39.4 (± 10.5)	125.5 (± 24.6)	90.6 (± 16.0)
Exercise group (after)	109.2 (± 21.3)	56.6 (± 9.3)	35.7 (± 9.3)	140.0 (± 23.4)	102.0 (± 17.4)
Difference (before/after)	35.3 (± 9.1)	5.9 (± 2.8)	−3.6 (± 1.2)	14.7 (± 3.6)	11.4 (± 4.1)
Effect size	2.2	0.79	−0.34	0.60	0.71
Control group (before)	76.0 (± 19.4)	49.2 (± 5.5)	40.9 (± 11.7)	123.2 (± 17.8)	94.1 (± 15.8)
Control group (after)	81.5 (± 11.8)	48.5 (± 5.4)	44.6 (± 13.3)	129.3 (± 17.2)	83.1 (± 11.2)
Difference(before/after)	5.8 (± 4.6)	−1.3 (± 2.8)	3.6 (± 10.3)	6.6 (± 5.2)	−11.2 (± 3.9)
Effect size	0.30	0.51	0.88	0.29	0.25
ANOVA (p value)	0.02	0.04	NS	0.01	0.001

* ANOVA = analysis of variance; NS = nonsignificant ($p > 0.05$).

maximum of 2 and a minimum of 0 marks were achievable for each of these 5 technical elements. Finally, points were deducted for spatial inaccuracy. When the dancer returned to the starting position of the sequence (i.e., close to the center of the 2 circles), no points were deducted. However, when the dancer returned only within the outer concentric circle, 1 point was deducted, while failure to return within the circumference of both circles was penalized with 2 points. Individual scores were estimated from the following equation: Score = Number of complete repetitions × 2 + (Judge1 + Judge2)/2 × 5 − Inaccuracy (deducted points). We calculated a test-retest reliability coefficient of 0.89.

Aerobic and Strength Training Program

Most of the training took place at the volunteers' school premises, which were appropriately equipped with the necessary facilities. For the entire intervention period, both programs were supervised by one of the present coauthors, who was also one of the school's teachers during the data collection period. Prior to start of the programs, each volunteer was given an individualized exercise plan based on their baseline data.

Aerobic training consisted of 20–40 minutes of swimming, jogging, or cycling, 2–3 times a week and for a period of about 12 weeks in duration. During sessions, the work intensity was equivalent to 70–75% of the age-related maximal heart rate (age-related maximal heart rate = 220 − age). It was expected that aerobic training would mainly affect $\dot{V}O_2max$ levels.

A strength training program already used in men (20) and women (25) dancers was adopted for the purposes of this study. The program lasted for approximately 12 weeks, with up to three 50-minute sessions per week using free-weight exercises for both upper and lower body. During the first 2 weeks, exercises comprised low-resistance lifts (<70% of 1 repetition maximum [1RM]), but with high repetitions. The principle of high resistance (>70% of 1RM) with a low number of repetitions was adopted for the remaining period, during which resistance increased by 15–20%. For this period, a typical session consisted of 5–6 sets of 3–4 exercises each, with up to 8 repetitions in each exercise. A rest period of about 4 minutes was allowed between exercises in each test and between sets. It was anticipated that the adopted strength training regime would mainly affect leg strength levels.

Statistical Analyses

Preliminary evaluation of the variables using a Kolmogorov-Smirnov test of normality revealed that none of the studied parameters required logarithmic transformation in order to reach normality. Mean (± *SD*) was calculated for all parameters. Differences (i.e., delta values) between pre- and postexercise training program for both groups (experimental vs. controls) were assessed using a 2-way analysis of variance, with 'group' and 'sex' as fixed factors, using the SPSS (version 10; SPSS, Inc., Chicago, IL). Statistical power as well as effect sizes and intraclass reliability for all dependent measures were also calculated. The criterion for significance was set at $p \leq 0.05$.

RESULTS

No statistical differences were found between the two groups at baseline level in any of the studied parameters. The compliance with the exercise training program was 84%. After the end of the program, the exercise group revealed significant increases in dance ($p < 0.02$), $\dot{V}O_2max$ ($p < 0.04$), flexibility ($p < 0.01$), and leg strength ($p < 0.001$) tests compared to controls (Table 2). However, the 12-week exercise training regime brought about no alterations in the sum of the skinfold thicknesses ($p > 0.05$). The factor 'sex' had no significant effect on any of the reported changes.

Statistical power was found to be 0.9, and intraclass reliability measures for the dance test, $\dot{V}O_2max$, skinfolds, flexibility, and strength were 0.90, 0.93, 0.96, 0.92, and 0.94, respectively.

DISCUSSION

It has been suggested that elite dancers must be experts in the aesthetic and technical side of their art, psychologically prepared to handle the stress of critical situations and free from injury; they must also be physically fit (24). The present data partly confirm this view. The main finding was that supplementary exercise training significantly increased aspects of dance performance, with concomitant increases in selected fitness-related parameters, in modern dance students.

To our knowledge, there are no published data for direct comparisons. The data presented in the multitude of publications in dance are in sharp contrast with the limited data regarding associations between technical/artistic components of dance and fitness exercise training. However, given that the present training program revealed significant improvements in the key fitness parameters of aerobic capacity, muscular strength, and flexibility, and given that such improvements have been previously linked to better oxygen transport facilities (1) and enhanced neuromuscular functions (15), which, in turn, affect qualitative elements of physical performance through reduced fatigue (31, 34) and injury (17, 21) rates, it is tempting to suggest a possible association between technical/artistic components of dance and fitness exercise training in dance students.

Maximal aerobic capacity, adjusted for body size and composition, is an integrated measure of cardiorespiratory and neuromusculo-skeletal function, oxygen transport, and delivery. High levels of aerobic capacity, maintained through heavy daily exercise, have probably been a necessary requirement for survival in the earlier history of humans. In modern, industrialized countries the demand for physical activity to sustain life is declining, leading to as many health problems as smoking does (6).

Both dance students (2) and professional dancers (24) demonstrate lower $\dot{V}O_2$max values than do other athletes of comparable age. Given that fairly strenuous exercise intensities (for at least 20 minutes) are required to bring about $\dot{V}O_2$max increases, it is probable that dance activities in general do not provide adequate stimuli for such adaptations. This notion may be further supported by the fact that dance students demonstrated no cardiac structure and cardiac function changes as a result of their activities, compared to matched controls (36), and by the fact that cardiorespiratory responses to modern dance classes revealed no differences between university, graduate, and professional dancers (39), thus highlighting the need for supplementary aerobic fitness training (38, 40).

The latter has been confirmed by the present study, whereby the dance-only training system adopted by the control subjects failed to show any significant $\dot{V}O_2$max changes at the end of the 12-week monitoring period. It has also been demonstrated that cardiovascular adaptations to training are intensity dependent. A close correlation between $\dot{V}O_2$max, cardiomyocyte dimensions, and contractile capacity indicates significantly higher benefit with higher exercise intensities (16). It should be stressed here that in the dance profession, which is characterized by a high incidence of osteoporosis due to reduced bone mineral density (24), somatic exercises of high strain rates and high peak forces are more effective in bone formation than is training at low intensities (13).

The potential benefits of resistance training with regard to health and performance are numerous; resistance training has been shown to reduce body fat; increase basal metabolic rate; decrease blood pressure and the cardiovascular demands to exercise; improve blood lipid profiles, glucose tolerance, and insulin sensitivity; increase muscle and connective tissue cross-sectional area; improve functional capacity; and relieve low back pain (26). Improvements in the muscle's ability to generate force also seem to provide a way for dancers to enhance their performance (24). Soloist ballerinas are characterized—inter alia—by increased muscular strength (30). However, although many research articles have been published on muscular strength, relatively few data exist that are directly relevant to dance. This partly reflects a fear that strength and strength training would be detrimental to dancers' artistic prospects. The present data do not support this fear, as improvements in leg strength levels were followed by concomitant increases in the dance-test performance.

Another prominent finding of the present study was that control dancers, although they met all dance duties described in the school's curriculum, showed no differences in muscular strength after the 12-week monitoring period. Again, the design of the present study does not permit a clear understanding of the factors involved. However, it has been suggested that suboptimal loading of the neuromuscular system may result in muscular strength decreases in both men and women (10) and that young women dancers do demonstrate lower hip muscle strength than their control subjects (3). It could, therefore, be argued that dance-studio exercises alone do not provide enough stimuli to promote enhancement of this fitness and performance attribute.

In line with other fitness parameters, flexibility demonstrates noticeable variations. Aspects related to exercise training, detraining, or even overtraining may account for these variations (23). The present results are in line with published data advocating that supervised strength training does not adversely affect flexibility in young men and women (29, 33). Whether the same applies to professional dancers or other elite sportsmen and women remains to be confirmed.

PRACTICAL APPLICATIONS

The present data have shown that (a) a 3-month aerobic and strength training program has positive effects on selected dance performance and fitness-related parameters in modern dance students, (b) aerobic capacity and leg strength improvements do not hinder the development of dance performance as studied herein, and (c) the dance-only approach does not provide enough scope for developing aspects of physical fitness. More research is required on the effects of systematic off-studio physical fitness training on dance performance.

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