Medicina Sportiva
Med Sport 16 (1): 1-5, 2012
DOI: 10.5604/17342260.987830

EFFECTS OF A DANCE SEASON ON THE PHYSIOLOGICAL PROFILE OF COLLEGIATE FEMALE MODERN DANCERS

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Abstract

Introduction: A collegiate modern dancer is a unique athlete because in addition to the physical demands of dance, she also has the artistic demands of creating and performing for a season of showcases, or in some cases, multiple showcases. In preparing for her dance season in addition to her academic schedule, a collegiate modern dancer's training includes rigorous daily technique classes and rehearsals which may alter her fitness level across time.

Objective: To determine the effects of a dance season on the physiological profile of collegiate female modern dancers.

Methods: Eighteen collegiate female modern dancers were measured for relative anaerobic power, fatigue index, upper body and lower body strength, aerobic capacity and body composition at both pre and post dance season.

Results: At post season, there were significant improvements in relative anaerobic power (pre 7.43 $\pm$ 1.01 W/kg, post 8.00 $\pm$ 0.78 W/kg), body weight (pre 57.80 $\pm$ 5.10, post 58.72 $\pm$ 5.08), and body composition (pre 18.60 $\pm$ 2.03%, post 17.78 $\pm$ 2.49 %), and a significant increase in fatigue index (pre 33.38 $\pm$ 9.72%, post 38.91 $\pm$ 7.49%). There were no significant changes in relative upper and lower body strength or aerobic capacity.

Conclusion: The demands of a collegiate dance season resulted in improved power and lean mass but greater anaerobic fatigue in these female modern dancers.

***Key words**: aerobic capacity, anaerobic power, strength*

Introduction

Physiological data have been collected to describe ballet dancers [1] and understand their physical capacity, however, even though collegiate modern dancers participate in rigorous training, there is less physiological data available on this population. Previous research includes both qualitative and quantitative studies of dancers; however, they primarily focused on ballet, specifically professional dancers [2-7]. A few investigators have included modern dancers in their studies [8-10], but aerobic measurements including $\dot{V}O_2$max, heart rate, and blood lactate levels were the primary focus. There is little information regarding anaerobic measurements of power or strength in dancers in general.

Within technique class, dancers perform short bursts of activity that primarily utilize the phosphocreatine and anaerobic glycolytic systems [5,10-12]. Movement sequences lasting longer than a couple of minutes are also performed in class but not frequently enough to qualify dance as an endurance activity. Based on findings regarding the aerobic capacity of ballet dancers [2,3,5,7,8,10,12], they are classified as non-endurance athletes [13], however, modern dance does contain a large aerobic component [9,10].

Cardiorespiratory fitness is associated with performing large muscle, dynamic, moderate/high intensity exercise for extended periods of time [13]. Dance is complex in that different techniques and dance forms contain varying degrees of aerobic, anaerobic, power and strength components [14,15]. For example, a specific ballet technique may incorporate more of an anaerobic component coupled with isometric actions, while a modern dance technique may incorporate a more aerobic component coupled with dynamic explosive power movements.

Few studies have been conducted that include collegiate modern dancers, there is a lack of physiological data to describe and fully understand this population. Therefore, the first purpose of this study was to gather physiological data to describe female university modern dancers. The second purpose was to observe the physiological effects of their dance training across a dance season.

Materials and methods

Participants

Eighteen female collegiate modern dancers (mean $\pm$ SD age 21.33 $\pm$ 2.54, mass 57.82 $\pm$ 5.1 kg, height 162.54 $\pm$ 5.81cm) performed physiological tests pre and post season, with each testing session conducted over the course of two days. Each participant read and signed an informed consent form approved by the University Institutional Review Board prior to testing.

Procedures

The pretest was administered ten to twelve weeks prior to their dance performance while the posttest was administered one to two weeks post dance performance. The pretest and posttest included measuring body composition, maximal oxygen uptake, anaerobic power, strength, and vertical jump. The tests were administered over a two-day period to allow for sufficient recovery. The first day of tests included body composition, 1RM for upper body strength, vertical jump, and maximal oxygen uptake ($\dot{V}O_2max$). The second day included 1RM for leg strength and the Wingate anaerobic power test. Between pre and post testing, the dancers continued their training by participating in daily technique classes and rehearsals to prepare for their performance. The time commitment averaged 8 to 18 hours of dance per week.

Instrumentation

Body Composition

A seven-site skinfold test was used to determine the body composition of each participant. The sites included: abdominal, triceps, chest, midaxillary, subscapular, suprailiac, and thigh. Harpenden calipers were used to measure the site and Jackson and Pollock equations were used to formulate body fat composition [13].

Strength

Upper and lower body strength were measured using a 1RM test. Because the participants were not familiar with a 1RM protocol, the tests were performed on Cybex isotonic weight machines instead of free weights. The upper body test was performed on a Cybex chest press and the lower body test was performed on a Cybex leg press. Both upper and lower body tests followed the same protocol [16]. The participant performed five warm-up reps at 70% of her estimated maximum, followed by a set of 3 reps at 80% of her estimated maximum with two minutes rest. Thereafter the weight was increased 10-15 pounds for each trial of one repetition until the participant could not lift anymore. All lifts were done under the supervision of a spotter.

Vertical Jump

The vertical jump test was performed using a Vertec apparatus. The participant reached up with the dominant hand with heels remaining on the ground. The reach height was recorded. The participant then stood sideways to the apparatus in a comfortable jumping position. The participants made one countermovement dip of the legs and hips and jumped up as high as possible and touched the highest vane possible. The participant jumped five times with 30s rest. The trial with the maximum jump was recorded. The difference between the standing reach and jump reach determined the jump height [16,17].

Aerobic Capacity

Maximum oxygen uptake ($\dot{V}O_2max$) was measured by a graded treadmill test using a Parvomedics metabolic cart calibrated according to the manufacturer's directions. The protocol for the test followed the Bruce protocol [18]. Participants walked without holding the handrails on a treadmill for the first nine minutes followed by a steady run. The participants were encouraged to run until they could no longer continue. The dancers' maximum aerobic capacity was met when her heart rate reached predicted max, she reached a respiratory exchange ratio of 1.1 or she stopped the test voluntarily.

Anaerobic Power

Participants performed the Wingate anaerobic test using a Monark cycle ergometer. The force settings were determined by calculating 0.075kp per kg of body weight. Prior to the start of the test the participants warmed up on the cycle by pedaling at a comfortable cadence. The participants were also told to perform short ten second sprints until the participant was warm enough to perform the test. The participants were asked to pedal at maximum speed. When maximum speed was met the administrator gave a signal to start the test and the weight was dropped on the bike wheel, at which point the participant pedaled as fast as possible for thirty seconds against the preset force setting. At the completion of the test, the participant cooled down. Peak power and fatigue Index were recorded using software that accompanies the cycle [19,20].

Statistical Analysis

Alpha was set a-priori at 0.05. A repeated measures ANOVA was used to determine differences between pre and posttest scores.

Results

Significant improvements between pre and posttests were observed in body weight, body composition, absolute upper body strength, absolute lower body strength, and absolute and relative peak power. There was a significant increase in fatigue index (Table 1). Non-significant differences were observed in vertical jump, relative upper body strength, relative lower body strength and aerobic capacity (Table 1).

Table 1. *Physiological characteristics (mean ± SD) pre and post concert*

	Pre	Post
Body weight (kg)	57.80 ± 5.10	58.72 ± 5.08*
Percent body fat (%)	18.60 ± 2.03	17.78 ± 2.49*
Absolute Upper body strength (kg)	41.54 ± 10.18	43.93 ± 19.33*
Relative Upper body strength (kg/bw)	0.71 ± 0.15	0.70 ± 0.15
Absolute Lower body strength (kg)	113.25 ± 16.44	123.48 ± 24.00*
Relative Lower body strength (kg/bw)	1.90 ± 0.30	2.12 ± 0.47
VO2max (ml/kg•min-1)	42.66 ± 4.33	42.55 ± 4.26
Vertical jump (cm)	35.83 ± 5.61	33.22 ± 8.10
Absolute peak power (Watts)	430.08 ± 61.24	463.92 ± 58.95*
Relative peak power (Watts/kg)	7.43 ± 1.01	8.00 ± 0.78*
Fatigue index (%)	33.38 ± 9.72	38.91 ± 7.49*

* Significantly different than Pre

Discussion

The first purpose of this study was to develop a physiological profile of female collegiate modern dancers. These dancers were above average for most physiological variables with the exception of anaerobic power and upper body strength. Compared to norms of the American College of Sports Medicine [13] and university females [17], the female collegiate modern dancers were above average for relative lower body strength, body composition, and $\dot{V}O_2$max (90th, 90th, 80th, and 80th percentiles respectively). Compared to Division III female collegiate basketball players with a vertical jump of ~40cm [21,22], our dancers' vertical jump was ~36cm. Compared to physically active college aged females, relative upper body strength was average falling into the 60th [13] percentile. When compared to similar age female norms for absolute peak power pre and posttest, the dancers scored in the 35th and 55th percentiles [20]; for relative peak power they scored at the 45th and 55th percentiles [20].

In previous studies, ballet dancers' percent body fat was between 19 and 21% [6,21,23]. Chmelar et al. [8] found that female collegiate modern dancers had a percent body fat of ~15% and female collegiate ballet dancers had ~14%, both of which were lower than our present findings (~18%). The present study illustrates that collegiate modern dancers are within a healthy body composition. Their percent body fat significantly decreased as a result of their training season while their total body weight significantly increased resulting in an increase in lean muscle mass.

According to ACSM guidelines [13], the dancers had adequate lower body strength, however, they were deficient in upper body strength which is essential in partnering and performing floor work. Nonetheless, their absolute upper body strength and lower body strength significantly increased as a result of the training season. Although their absolute strength significantly increased it was not sufficient to increase relative strength in either the upper or lower body. No change in their relative strength may be explained by their classes, rehearsals, and performance not emphasizing enough strength training to bring about a significant improvement or by their increase in bodyweight. Many techniques of modern dance do not focus on developing strength possibly because there is an underlying belief that strength will be developed as a result of class, rehearsal, and performances. Furthermore, because modern dance has an aesthetic component there is a fear that dancers will develop a "bulky" physique as a result of resistance training. Nonetheless, Koutedakis and Sharp [24] found that ballet dancers who participated in strength training of the quads and hamstrings did not develop a bulky physique and felt their performance was enhanced. This suggests that alternative approaches to training dancers may be beneficial to increasing the level of their performance. Whether an increase in strength will enhance a modern dancer's performance is yet to be determined.

When comparing aerobic capacity, the dancers scored comparable to previous findings on female collegiate modern dancers. Chmelar et al. [8] found that female collegiate modern dancers had a $\dot{V}O_2$max of ~47ml·kg^{-1}·min^{-1} while Wyon et al. [10] found that female collegiate modern dancers had a $\dot{V}O_2$max of ~40ml·kg^{-1}·min^{-1}. Our present study, showing a $\dot{V}O_2$max of ~43ml·kg^{-1}·min^{-1} supports these findings in that modern dance is best classified as a non-endurance activity [13].

We expected that the participants, being anaerobic athletes, would have scored above average on the

Wingate anaerobic power test. Although the participants in this study scored higher in absolute peak power than female ballet dancers for pre and posttests [25], their scores were below average according to the norms established by Maud and Schultz [20]. Koutedakis et al. [25] found that ballet dancers had peak power of between 350 and 400 Watts while the modern dancers in our present study had peak power of between 430 and 465 Watts for pre and posttests respectively. Similar to their strength measurements, they significantly increased both absolute and relative peak power. In addition, their fatigue index was greater in the posttest which indicates that although they increased their peak power output, they were unable to maintain it throughout the course of the test. This might be explained through their dance training which elicited an increase in their relative and absolute anaerobic peak power, thereby decreasing their ability to maintain it over time. However, their overall Wingate values indicate that collegiate modern dancers lack explosive power. Their absolute leg strength values revealed that they had the strength but were not trained to use it in an explosive manner.

The anaerobic power and upper body strength values could be related to the timing and nature of the evaluation. The dancers were tested at the beginning of the semester after a long winter break and therefore were not at their peak physical condition; therefore, training alone could have induced physiological improvements. In addition, since they were unfamiliar with the test protocols administered, improvements in posttesting may have been related to familiarity of testing. Lastly, any aerobic capacity improvements may been masked due to concurrent anaerobic and aerobic training in class [26].

In conclusion, this sample of female collegiate modern dancers was in very good physical condition, but should improve their upper body strength and anaerobic power to possibly increase their athleticism and enhance their performance. Secondly, significant physiological changes occurred as a result of their dance-training season. However, their training did not bring about enough of a change in strength and power to classify them above average. Further research needs to be conducted to determine what variables are most important to modern dancers, an upper body strength training intervention and its effects on body size and perceived performance, the anaerobic requirements of technique class, rehearsal, and performance, how to include supplemental strength and power training into technique class, and the physiological changes from freshman to senior year over the course of their collegiate dancing career.

Declaration of interest

The author reports no conflicts of interest.

References

1. Hamilton WG, Hamilton LH, Marshall P, et al. A profile of the musculoskeletal characteristics of elite professional ballet dancers. *Amer J Sports Med* 1992; 20: 267-73.
2. Baldari C, Guidetti L. $\dot{V}O_2$max, ventilatory and anaerobic thresholds in rhythmic gymnasts and young female dancers. *J Sports Med Phys Fit* 2001; 41: 177-82.
3. Cohen JL, Segal K, Witriol I, et al. Cardiorespiratory responses to ballet exercise and the $\dot{V}O_2$max of elite ballet dancers. *Med Sci Sport Exer* 1982; 14: 212-7.
4. Galanti MLA, Holland GJ, Shafranski P, et al. Physiological effects of training for a jazz dance performance. *J Strength Cond Res* 1993; 7: 206-10.
5. Mostardi RA, Porterfield JA, Greenberg B, et al. Musculoskeletal and cardiopulmonary characteristics of the professional ballet dancer. *Phys and Sports Med* 1983; 11: 53-61.
6. Novak LP, Magill LA, Schutte J E. Maximal oxygen uptake and body composition of female dancers. *Eur J Appl Phys* 1978; 39: 277-82.
7. Ramel E, Thorsson D, Wollmer P. Fitness training and its effect on musculoskeletal pain in professional ballet dancers. *Scand J Med Sci Sports* 1997; 7: 293-8.
8. Chmelar RD, Shultz BB, Ruhling RO, et al. A physiologic profile comparing levels and styles of female dancers. *Phys Sports Med* 1988; 16: 87-96.
9. Wyon M, Abt G, Redding E, et al. Oxygen uptake during modern class, rehearsal, and performance. *J Strength Cond Res* 2004; 18: 646-9.
10. Wyon M, Head H, Sharp C, et al. The cardiorespiratory responses to modern dance classes. Differences between university, graduate, and professional classes. *J Dance Med Sci* 2002; 6: 41-5.
11. Kirkendall D, Calabrese LH. Physiological aspects of dance. *Clin Sports Med* 1983; 2: 525-37.
12. Schantz P, Astrand P. Physiological characteristics of classical ballet. *Med Sci Sports Exer* 1984; 16: 472-6.
13. Balady GJ, Berra KA, Golding LA, et al. ACSM guidelines for exercise testing and prescription (6th ed). Philadelphia, PA: Lippincott Williams & Wilkins, 2000.
14. Koutedakis Y. "Burnout" in dance the physiological viewpoint. *J Dance Med Sci* 2000; 4: 122-7.
15. Koutedakis Y, Jamurtas A. The dancer as a performing athlete physiological considerations. *Sports Med* 2004; 34: 651-61.
16. Baechle TR, Earle RW. Essentials of strength training and conditioning (3rd ed.). Champaign, IL: Human Kinetics, 2005.
17. Ashley CD, Weiss LW. Vertical jump performance and selected physiological characteristics of women. *J Strength Cond Res* 1994; 8: 5-11.
18. Bruce RA. Methods of exercise testing. *Amer J Card* 1974; 33: 715-20.
19. Bar-Or O, Dotan R, Inbar O. A 30-second all out ergometric test- its reliability and validity for anaerobic capacity. *Israel J Med Sci* 1977; 13: 326.
20. Maud PJ, Schultz BB. Norms for the Wingate anaerobic test with comparison to another similar test. Res Quart Exer Sport 1989; 60:144-51.
21. Hergenroeder AC, Brown B, Klish WJ. Anthropometric measurements and estimating body composition in ballet dancers. *Med Sci Sports Exer* 1993; 25: 145-50.
22. Unick J, Kieffer HS, Cheesman W, et al. The acute effects of static and ballistic stretching on vertical jump performance in trained women. *J Strength Cond Res* 2005; 19: 206-12.
23. Eliakim A, Ish-Shalom S, Giladi A, et al. Assessment of body composition in ballet dancers: Correlation among anthropometric measurements, bio-electrical impedance analysis, and dual-energy x-ray absorptiometry. *Inter J Sports Med* 2000; 21: 598-601.

24. Koutedakis Y, Sharp NC. Thigh-muscle strength training, dance exercise, dynamometry, and anthropometry in professional ballerinas. *J Strength Cond Res* 2004; 18: 714-8.
25. Koutedakis Y, Myszkewycz L, Soulas D, et al. The effects of rest and subsequent training on selected physiological parameters in professional female classical dancers. *Inter J Sports Med* 1999; 20: 379-83.
26. Gravelle BL, Blessing DL. Physiological adaptation in women concurrently training for strength and endurance. *J Strength Cond Res* 2000; 14: 5-13.

Received: October 28, 2011
Accepted: March 15, 2012
Published: March 30, 2012

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A – Study Design
B – Data Collection
C – Statistical Analysis
D – Data Interpretation
E – Manuscript Preparation
F – Literature Search
G – Funds Collection