Physiological Elements Required by Dancers

Alexandros MALKOGEORGOS¹ • Eleni ZAGGELIDOU¹
Georgios ZAGGELIDIS¹ • Galazoulas CHRISTOS¹

Dancing is an excellent alternative exercise for improving health related physical fitness elements. Dance performance requires support from enhanced physiological requirements necessary for dancers including cardiovascular fitness, muscle flexibility, muscular strength/power. A reduction in muscular strength associate with injury risk and many dancers succumb to problems such as the overtraining syndrome. Improvement in lower body muscular strength appears to have positive effects on aspects of dance performance and injury prevention. The qualities and benefits offered by dancing depend on the dance forms concerned but as a general rule, it improves physical health by developing strength, suppleness, coordination and balance in varying amounts. This literature study showed differences in fitness levels exist between in different dance forms but also in levels of dancers. As in most sports, dancing is a demanding exercise form for all styles dancers, taxing both aerobic and anaerobic processes and develops high levels of muscle tension. Joint mobility and body composition are also important parts of dance fitness. Dance training consists of technique and style training with an aim to increase the skill level of dancers. Furthermore, it needs more investigation whether improved physical fitness has positive effect on dance performance.

Keywords: dance, aerobic/anaerobic fitness, strength, flexibility, body composition

¹ Department of Physical Education and Sport Sciences, Aristotle University of Thessaloniki, Greece
Introduction

Dancing is an excellent way to improve physical fitness, a set of attributes that are either health or skill-related (Caspersen, Powell, & Christenson, 1985) and develop social skills, thereby improving mental health, and is something that can be taken up early in life and still provide plenty of entertainment well after retirement (Caldwell, 2005; Burkhardt, & Brennan, 2012). The best kinds of dancing to encourage people to take up are those which develop cooperation, either with a partner or within a set. Although each type has its own qualities and makes its own demands, there should be something suitable for almost everyone regardless of location (Bremer, 2007).

It is suggested that in older persons dancing has physical, psychological and social benefits, and should be promoted as a form of leisure activity (Hui, Tsan-keung, Chui, & Woo, 2009). Similar it has been reported that folkloric dance (specific to countries), Turkish or Greek dances based exercise program produce both physical and mental benefits for elderly individuals (Eyigor, Karaplot, Durmaz, Ibisoglu & Cakir, 2009; Mavrovouniotis, Argiriadou, & Papaioannou, 2010).

Dance is a healthy activity also an excellent alternative exercise form for children that would participate with pleasure improving health related physical fitness elements, (a) cardiorespiratory endurance, (b) muscular endurance, (c) muscular strength, (d) body composition, and (e) flexibility (McIllroy, Roundy, & Jacobson, 1989; Kremenitzer, 1990; Ignico & Mahon, 1995; Bartholomew, & Miller, 2002) and contributes to children's cognitive and emotional development (Brodie, & Britwistle, 1990; Lobo & Winsler, 2006) as well as to the development of kinetic skills.

Because of quantify and score specific qualitative aspects of dance performance such as overall proficiency, full body involvement, articulation and skills (Krasnow, Chatfield, Barr, Jensen, & Dufek, 1997), has been suggested that dance performance requires support from enhanced physiological capabilities including flexibility, muscular strength, power and endurance (Chatfield, Byrnes, Lally, & Rowe, 1990). As in most sports, dance fitness depends on the individuals’ ability to work under aerobic (Cohen, Segal, Witril, & McArdle, 1982; Clarkson, Freedson, Keller, Carney, & Skrinar, 1985) and anaerobic conditions, and on their capacity to develop high levels of muscle tension, i.e. muscle strength (Fitt, 1982). Joint mobility/muscle flexibility and body composition (Claessens, Beunen, Nuyts, Lefevre, & Wellens, 1987; Hergenroeder, Brown, & Klish, 1993) are also important parts of dance fitness (Angioi, 2010).
Fitness training has started only recently to be considered as a complementary activity within the traditional dance setting, mainly because of the stereotype that dancers, as artists, do not follow the athletes’ steps in terms of physical preparation (Krasnow & Kabbani, 1999). Nevertheless, dancers are engaged in long hours of daily training, followed by rehearsals and performances (Wiesler, Monte-Hunter, Martin, Curl, & Hoen, 1996; Shah, Weiss, & Burchette, 2008) but, unlike athletes, they do not have a regular training schedule (Liederbach, 2000), putting themselves in injury risk and many dancers succumb to problems such as the overtraining syndrome (Koutedakis, 2000; Liederbach & Compagno, 2001). This may partly explain the high injury rates found in dance (Weigert, 2005; Weigert & Erickson, 2007).

As in other sports, dance performance depends on a large number of technical, medical, psychological, nutritional, economic, environmental and physiological elements. For these reason, researchers have concentrated on selected fitness attributes of dancers including: aerobic and anaerobic capacities (Chmelar, Schultz, & Ruhling, 1988; Chatfield et al., 1990; Padfield, Eisenman, Luetkemeier, & Fitt, 1993); muscular strength (Harley et al., 2002); anthropometric attributes (Berlet et al., 2002; Yannakoulia, Keramopoulos, & Matalas, 2004); physiological demands of dance (Wyon, Head, Sharp, & Redding, 2002; Wyon, Abt, Redding, Head, & Sharp, 2004; Wyon & Redding, 2005) types of injury and their occurrence (Weigert & Erickson, 2007).

An improvement in lower body muscular strength and power appears to have positive effects on aspects of dance performance (Brown, Wells, Schade, Smith, & Fehling, 2007; Koutedakis et al., 2007). It has been suggested that professional dancers must be experts in the aesthetic and technical side of the art, psychological prepared to handle the stress of critical situations and be free from injury and most importantly they must be physically prepared. The physiological requirements necessary for dancers is a large reserve of power, required for explosive jumps and high elevation or during the act of a lift, and muscular endurance which occurs when a relatively high power output is maintained (ex. in a dance sequence during training) (Koutedakis & Jamurtas, 2004).

According to Wyon and Redding (2005), dance is an intermittent type of exercise, seen to be equal to walking as physical activities in terms of calorific output (Ribeiro -Nunes, Irene-Monte, Ferreira-Emygdio, & Knackfuss, 2007), and similar to soccer or tennis where explosive bursts of action are followed by moments requiring precision and skill, dancers would further benefit from a good aerobic foundation (Allen & Wyon, 2008). However, although dance involves several hours of daily practice, published data reveal that female dancers have less aerobic fitness levels compared to athletes from other sports, such as...
gymnasts (Baldari & Guidetti, 2001), but their results are based on data deriving mainly from ballet (Kirkendall & Calabrese 1983; Koutedakis & Jamurtas, 2004). Since performing and recreational dancers in several dance forms demonstrate differences in fitness, as well as non-professional and professional athletes have also significant differences in fitness levels, which in turn, have significant implication in performance (Angioi, 2010).

In general, ballet dancers have been consistently found to demonstrate reduced fitness levels than other athletic populations (Cohen et al., 1982; Bennel, Khan, Matthews, & Singleton, 1999). The qualities and benefits offered by dancing depend on the form concerned but as a general rule, it improves physical health by developing strength, suppleness, coordination and balance in varying amounts. Furthermore, it remains unclear whether improved physical fitness affects aspects of dance performance in student and professional dancers. This literature study examines the differences in fitness levels exist between in different dance forms but also in levels of dancers.

Methods

Considering regarding the effects of dance practice it is relevant to gain more insight in health related physical fitness elements benefits of dance by reviewing the existing research on this topic. Literature data were primarily collected through computer and manual searches of primary sources (e.g., journal articles, theses and dissertations). The databases (e.g., Sport Discus, Google scholar, PubMed…) were searched to identify publications in English regarding fitness components of dancers using keywords such as: physical, fitness, exercise, strength, aerobic, anaerobic, performance, training, body composition, fat-free mass, in combination with “dance” and “dancers”.

The results of this literature study will be described in the present review, and the possible effects of dance practice on participants’ physical fitness will be discussed. Finally, a conclusion is presented and recommendations are provided for further investigation.

Dance and Aerobic Fitness. The aerobic (cardiorespiratory) system is the most economical and long-lasting but the least powerful. Aerobic fitness declares the ability for muscular work under aerobic conditions and it includes all aspects of uptake, transport and consumption of oxygen to liberate energy from muscle fuels. A number of authors have investigated aerobic fitness levels of dancers in different levels and different dance forms. Even if the most taxed metabolism of dance exercise was the aerobic source, its percentage of utilization was related to the fitness level of the performer. A higher percentage
allows a better performance, since the anaerobic lactic metabolism is less utilized (Guidetti, Emerenziani, Gallotta, Da Silva, & Baldari, 2008).

Latest research has shown that the maximal oxygen consumption ($\text{VO}_2^{\text{max}}$) of elite dancesport dancers for male and female dancers averages (59.2-60.9 ml.kg$^{-1}$.min$^{-1}$ and 46.3-53.7 ml.kg$^{-1}$.min$^{-1}$), respectively (Jensen, Jørgensen, & Johansen, 2002; Bria et al., 2011; Klonova, Klonovs, Giovanardi, & Cicchella, 2011). In their study Chmelar et al. (1988) found that professional contemporary dancers exhibited significant higher values of (49.1±5.9 ml.kg$^{-1}$.min$^{-1}$) than professional ballet (42.2±2.9 ml.kg$^{-1}$.min$^{-1}$), in contrast to the ballet and contemporary dance students which did not demonstrate significant differences in cardiorespiratory fitness (47.0±2.1 & 47.5±3.1 ml.kg$^{-1}$.min$^{-1}$, respectively). Similar in White, Philpot, Green, and Bemben, (2004) study ballet and contemporary dance students did not demonstrate significant differences in $\text{VO}_2^{\text{max}}$ (Ballet: 40.8±1.6 ml.kg$^{-1}$.min$^{-1}$ and contemporary: 39.2±1.9 ml.kg$^{-1}$.min$^{-1}$).

Among different levels of dance students was found no significant differences in $\text{VO}_2^{\text{max}}$ existed, beginners (40.4±4.9 ml.kg$^{-1}$.min$^{-1}$), intermediate (42.5±4.3 ml.kg$^{-1}$.min$^{-1}$), professional (43.6±2.3 ml.kg$^{-1}$.min$^{-1}$) but all dance students demonstrate significant differences in $\text{VO}_2^{\text{max}}$ compared with non-dancers (36.4±4.8 ml.kg$^{-1}$.min$^{-1}$), (Chatfield et al., 1990). Between professional and dance students in ballet and contemporary dance they did not also found significant differences in $\text{VO}_2^{\text{max}}$ (Wyon et al., 2002). Similar results found between in performing (45.6±4.8 ml.kg$^{-1}$.min$^{-1}$) and recreational adolescent dancers (46.3±6.0 ml.kg$^{-1}$.min$^{-1}$), (Padfield et al, 1993).

In contrast, Guidetti et al. (2008) found significant differences in $\text{VO}_2^{\text{max}}$, among low technical ability dancers and high technical ability dancers (38.1±1.9 & 46.2±2.1 ml kg$^{-1}$ min$^{-1}$, respectively). Both high and low technical level dancers in this study had maximal oxygen uptake values below the average for other athletes (Koutedakis & Jamurtas, 2004). Also significant differences in $\text{VO}_2^{\text{max}}$ were found among prepubertal and pubertal ballet dancers boys (47±6 & 56±4 ml kg$^{-1}$ min$^{-1}$, respectively) (Pekkarinen, Litmanen, & Mahlamaki, 1989).

Between different dance forms were found that ballet and contemporary dance students demonstrate significant differences in $\text{VO}_2^{\text{max}}$ (51.2±11.4 ml kg$^{-1}$ min$^{-1}$) compared to contemporary and jazz (45.8±8.7 ml kg$^{-1}$ min$^{-1}$) and contemporary and character dance student (46.6±12.2 ml kg$^{-1}$ min$^{-1}$) (Dahlstrom, Inasio, & Kaijser, 1996). Novak, Magill, and Schutte, (1978) found significantly higher mean in $\text{VO}_2^{\text{max}}$ between female dancers (41.5±6.7 ml.kg$^{-1}$.min$^{-1}$) and sedentary females (41.5±6.7) of a similar age. Also, they reported that
Physiological Elements Required by Dancers

dancers in performance had a significantly greater physiological demand than rehearsal (Wyon et al., 2004). Finally, in Koutedakis et al. (2007) study found that supplementary aerobic exercise training increases $\text{VO}_{2\text{max}}$ (before intervention $50.7 \pm 7.5 \text{ ml.kg}^{-1}.\text{min}^{-1}$ and after intervention $56.6 \pm 9.3 \text{ ml.kg}^{-1}.\text{min}^{-1}$) and aspects of dance performance in contemporary dance students.

As alternative exercise forms, dancing and walking were found to be similar in cardiorespiratory fitness benefits and they had significant correlation between calorie output levels (Ribeiro-Nunes et al., 2007). Consequently in another study, senior citizens followed a 12 weeks dance program had significant improved in resting heart rate, and 6-min timed walking test (Hui et al., 2009). Furthermore in his study Wanke, 2001 assessed the effect of an integrated endurance training program for ballet dancers ($n=16$) across a ballet season and found positive results.

**Anaerobic Fitness and Dance.** However, as mentioned previously, dance is intermittent and will demand an ever-changing combination of both systems for its energy. Dancers are rarely pushed to their maximum aerobic capacity during class; it can be sometimes assumed that more emphasis should be placed on the anaerobic system. Anaerobic fitness or local muscular endurance operates in the absence of oxygen and involves two high energy sources: phosphocreatine (PCr), muscular action lasts for just a few seconds and glycolysis (the breakdown of glucose), high power outputs must be sustained for about 30–60 seconds. Unlike aerobic fitness, its characteristic is to provide high levels of power but over short time duration, thus anaerobic fitness is necessary for fast and explosive dance movements (Wilmore & Costill, 1999; Angioi, 2010). Individual anaerobic threshold (IAT) was 55 and 60% of $\text{VO}_{2\text{max}}$ for high and low technical level dancers, respectively (Guidetti et al., 2008).

Blood lactate (BL), known as lactic acid, is used as the body’s natural indicator of muscle fatigue and is partly responsible for the burning sensation felt within the muscle towards the end of an exercise. A rise in (BL) beyond 4 mM.L$^{-1}$ is an indicator that the demand for ATP cannot be met solely by the aerobic glycolysis, and that the proportion of energy derived from anaerobic pathways has increased (Redding et al., 2009). In female adolescents ballet dancers lactate peak occurred 3 min after exercise, values were 4.5 ± 0.4 and 2.5 ± 0.3 mmol. L$^{-1}$ in low technical level dancers and high technical level dancers, respectively, $p<0.01$. Previous research in a study of classical ballet solo choreography in women, has noted BL values of 10 mM.L$^{-1}$ (Schantz & Astrand, 1984).

The highest values for (BL) after the competition of elite dancesport dancers for male and female dancers have been found (Klonova et al., 2011)
around (BL: 9.6 and 8.9 mM.L\(^{-1}\) respectively). Between contemporary and ballet dance students they didn’t found any difference in post exercise (BL) levels. Chmelar et al. (1988) in their study reported that in post exercise (BL) levels contemporary professional dancers exhibited higher values than their ballet professional dancers (BL: 9.7±1.4 & 6.0±1.5 mM.L\(^{-1}\), respectively). In Ribeiro da Mota et al. (2011) study, the absolute values of BL reported here immediately after a specific street dance (SD) competitive choreography was (8.2 ± 2.4 pre and 10 ± 2 mM.L\(^{-1}\) post training respectively).

In an anaerobic power study, determined by the Wingate test between different levels of dance students (beginners, intermediate, professional), they didn’t found significant differences in anaerobic capacity mean values (from 907.5±140.7 to 922.5±195.4 Kgm.30 sec\(^{-1}\)), but all dance students demonstrate relatively higher anaerobic capacity mean values (but not significantly) compared to non-dancers (828.38±161.2 Kgm.30 sec\(^{-1}\)) (Chatfield et al., 1990). No significant differences were also detected in anaerobic mean power between adolescent performing dance students and recreational dancers (6.6±0.7 & 6.2±0.9 Watts Kg\(^{-1}\), respectively) and also they didn’t found any difference in anaerobic mean power compared to non-dancers (Padfield et al., 1993).

Male and female dancesport dancers present relatively high values for aerobic and anaerobic capacity (Liiv et al., 2012) compared to the other dance styles like ballet (Cohen, Segal, Wittriol, & MacArdle, 1982; Schantz & Astrand, 1984; Oreb et al., 2006; Wyon et al., 2007), modern dance (Chmelar, Schultz, & Ruhling, 1988), flamenco (Pedersen, Wilmerting, Kuhn, & Encinias-Sandoval, 2001) and folk dance (Oreb et al., 2006). Furthermore, they appear to be performing at relatively high energy-demanding (both aerobic and anaerobic) phases during their competitive dance routines (Bria et al., 2011).

Muscular Strength and Dance. Strength is the ability to exert maximal force an increasing importance has been given of athletes to the ability to exert force at specified speeds for performance purposes. Dancers often support each other’s body weight, perform flips, and do many forms of cartwheels and gymnastic-like movements. Dance especially ballet and contemporary also demands sufficient muscle strength. Dancers utilize their muscular strength to perform movements such as lifts and floorwork—using gravity to pull them down to the floor (Phillips 1999; Koutedakis, Stavropoulos-Kalinoglou, & Metsios, 2005). Dance training contributes to strength development in children (Walker, Nordin-Bates, & Redding, 2011). After a 12-month period, significant increases in hip muscle strength were observed in all participants (53 young female novice dancers and controls), but the dancers’ strength increases were greater than the controls’ in three out of the five muscle groups tested (Bennell et al. 2001).
Physiological Elements Required by Dancers

Lower extremity strength is not only essential for the performance of explosive manoeuvres, such as leaps and jumps, but is vital for the balance and postural control in various balletic positions, such as arabesque and attitude (Bennell et al., 1999). Despite requiring muscle strength for jumps and balance on one leg, dancers are reported to have limb strength that is lower than in physically active participants in other sports (Kirkendall & Calabrese, 1983), better balance control than physically fit individuals according to Schmit, Regis, & Riley (2005). The women engaged in a dance-based program demonstrated greater values of explosive force than the sedentary ones (Pereira, Schettino, & Machado, 2010). In support of this, ballet professionals have been found to be stronger than ballet students (Chmelar, Schultz, & Ruhling, 1988), suggesting that muscular strength is associated with dance training.

Between different levels of dance students (beginners, intermediate, professional), they didn’t found significant differences in muscular strength and power of knee and ankle and also has been found to be not significantly different when compared to sedentary individuals (Chatfield et al., 1990). No significant differences were found in the quadriceps and hamstring peak torque between professional ballet dancers and professional contemporary dancers and similar results were observed between ballet and contemporary dance students (Chmelar et al., 1988). Also, in comparison to ballet, contemporary and folk dancers reported higher scores in muscular endurance (Thomas, 2003).

Pekkarinen et al. (1989) reported that young boys training in ballet improved their mechanical power and the ability in the flight times in static jumps. Training in ballet boys demonstrated higher mean values than adolescent schoolboys in flight times in static jumps and mechanical power (Bosco, Luhtanen, & Komi, 1983). In their study, the flight time in static jump and mechanical power in both prepubertal and pubertal dancer boys were slightly higher than in cross-country skier boys (Pekkarinen et al., 1989). Semi-professional dancers had significantly greater peak and mean force output in the 5 sec maximal voluntary isometric leg extension tests (p <0.01) compared to athletes but they do not demonstrated higher jumps than controls (37.6±5.5 cm and 35.9±3.9 cm, respectively) (Harley et al., 2002). Continuously performing and recreational adolescent dancers had no significant differences in jump height (26.7±3.5 cm and 25.1±6.6 cm, respectively) (Padfield et al., 1993).

In professional dancers, knee extensor and flexor low muscle strength levels have been associated with increased injury severity and the injury recovery process may take longer in dancers with reduced muscular strength (Weiss & Zlatkowsi, 1996). It has been suggested that the effect of supplementary strength training on dancers was a significant increase in muscular strength,
resulted in significant benefits for enhancing jump performance (Brown et al., 2007), overall performance competence and technique (Koutedakis et al., 2007). However, studies of dancers using structured strength training programs in addition to their traditional dance training technique classes report strength gains and improved performance (Vetter, & Dorgo, 2009).

**Muscle Flexibility and dance.** A successful career in dance demands that the dancer be both flexible and strong. Dancers were asked to perform a sideways leg extension the combined hip action of flexion, abduction and external rotation. The angular flexibility was measured through the goniometry (flexing, abduction and external rotation of the hip), which registers the amplitude of movement (ADM) in degrees (°), and the linear flexibility by the Box of Sitting and Reaching (the Back and leg flexibility test) of Wells and Dillon (1952), which values the flexibility of the muscular subsequent chain, in centimeters (cm). This protocol is suggested for both ballet and contemporary dancers, and it has been recommended to be used for the assessment of dance specific flexibility-related skills (Grossman & Wilmerding, 2000).

The essential movements (important aspect of flexibility) in classical ballet are plié (“bent”, a smooth and continuous bending of the knees), and external hip rotation (turnout). These movements are the foundation from which many other movements, such as leaps and jumps, occur. As for the rates of flexibility, the group of classical ballet presented superior values for all the evaluated movements; however significant difference was presented only for the ADM of abduction of the inferior members, making the practicing of classical ballet more flexible than those of contemporary dance (Silva, & Bonorino, 2008).

The flexibility of boy dancers seems to be better than the average in age 9 to 16 years. A high degree of flexibility was observed also in ballet girls studied by (Claessens, Beunen, Nuysts, Lefevre, & Wellens, 1987). It has been reported that in pre-professional female dancers mean value on turnout was 136°, mean unilateral passive hip external rotation was 49.4°, and mean femoral torsion was 18.4° (Hamilton et al., 2006). Very similar to the values of 133° and 136° reported by Negus, Hopper, and Briffa, (2005) and Watkins, Woodhull-McNeal, Clarkson and Ebbeling, (1989), respectively.

Dancers had less hip external rotation (ER) (p<0.05) and internal rotation (IR) (p<0.01) range than controls but greater ER/IR (Bennell et al., 1999). Although there was no difference in turnout between groups, the dancers had greater non-hip ER. Ballet dancers had greater range of ankle dorsiflexion (demi-plie) and maximum plantar flexion (en pointe) than controls (Russell, Wyon, Nevill, Koutedakis, & Kruse, 2010), measured in both centimeters (p<0.01) and
Physiological Elements Required by Dancers

degrees (p<0.05). Gupta et al. (2004) were found that ballet dancers have greater inner range, angle specific strength and inner range hip external rotation range of motion compared with non-dancers (Kadel, Gerberg, Donaldson-Fletcher, & Micheli, 2005). Professional and advanced student dancers have demonstrated significantly greater flexibility than beginner dancers; dancers also display significantly greater flexibility than controls (Khan et al. 1997; Gupta et al. 2004; Kadel et al. 2005, Walker, Nordin-Bates, & Redding, 2011).

In a 12 month longitudinal study young female novice ballet dancers participated in a range of weekly hours of ballet training from 1 to 10.3 hours compared to controls participated in less than two hours a week of extracurricular sporting activities (excluding swimming) and have done less than three months of balletic or gymnastic training changes in hip and ankle range of motion and hip muscle strength, dancers showed significant increases in internal rotation in range with an average of 12° (12.5±13.5) whereas controls did not change (0.5±13.9) and also in hip external increases in dancers 11.7±11.3° and controls 8.1 ±17.6°. Significant difference was found in total turnout were increased 12.0±16.7° in dancers and 2.2±20.0° in controls (Bennell, Khan, Matthews, & Singleton, 2001).

Body Composition and Dance. Dance, a highly stylized and artificial art form, also requires a very specific body type (Hamilton et al., 1992). When assessing the fitness levels of athletes/dancers, body composition is usually estimated. In addition, it is also important to know the body composition of dancers from a nutritional standpoint. Nutritional status is typically determined from the use of body mass index (BMI). However there are numerous cases where BMI may not accurately reflect the actual composition of the athlete (Nevill, Stewart, Olds, & Holder, 2006). Fat free mass index (FFMI) might offer a better representation, is an index to take into account the amount of muscle mass a person is carrying and relate that to their height. An actual estimate of body composition in the equation (Loenneke et al., 2012) FFMI=FFM (kg)/m² (fat-free mass/height squared) and FMI (fat mass/height squared).

The skinfold caliper measurement test is one common method of determining a person’s body composition and body fat percentage. This test estimates the percentage of body fat by measuring skinfold thickness at specific locations on the body. The thickness of these folds is a measure of the fat under the skin, also called subcutaneous adipose tissue. Skinfold thickness results rely on formulas that convert these numbers into an estimate of a person’s percentage of body fat according to a person’s age and gender. Durakovic et al. (2001) found that soloist professional ballerinas are characterized by lower thickness of skinfolds than corps ballerinas.
Dual-energy X-ray absorptiometry it is a technique of measuring bone mineral density (BMD), DXA scans can also be used to measure total body composition and fat content. However, it has been suggested that, while very accurately measuring minerals and lean soft tissue (LST), DXA may provide skewed results as a result of its method of indirectly calculating fat mass by subtracting it from the LST and/or body cell mass (BCM) that DXA actually measures (Coin et al., 2008).

An investigation into body composition of female dancers revealed that, using the skinfolds method, percentage body fat (%BF) was found to range from 13.0% to 26.9%. In the same sample of participants, using dual energy x ray absorptiometry (DXA), values for %BF ranged from 10.3% to 30.4%. The fat-free mass (FFM), as determined by DXA, was 42.6±3.3kg (range 35.6-50.1) (Yannakoulia, Keramopoulos, Tsakalakos, & Matalas, 2000).

There were significant difference between group of Malaysian female dancers and control subjects in terms of percentage of fat (%BF) with Mean±SD = 19.07±4.979 for dancers and 27.51±3.871 for control (students in the same age). Besides that, percent of lean body weight also have mean significant difference with Mean±SD for dancer 80.09±4.144 and 72.84±4.700 for control subjects. Both of percent fat and lean body weight showed those dancers groups have low in body fat but high in free fat mass. However, although Body Mass Index (BMI), arm muscle area and body weight did not have significant mean difference, the dancers group still have low Mean±SD = 20.134±2.482 of BMI, high arm muscle area 22.661±5.584 and low body weight 48.24±4.875 (Hidayah & Syahrul Bariah, 2011).

Regarding different levels of dancers Chatfield et al. (1990) reported significant differences between non-dancers and intermediate dance students, non-dancers and professionals dance students in %BF (non-dancers: 27.8±4.4, Beginners: 23.7±4.8, Intermediate: 20.9±4.6, and Professional: 8.1±2.3). In addition, Padfield et al. (1993) in their study, has been found that performing and recreational adolescent dance students do not significantly differ in %BF (8.7±6.5 and 9.7±7.6, respectively).

In comparison, contemporary dance students with non-active females Whyte et al. (2003) found no significant differences in %BF and FFM. In contrast Novak et al. (1978) found to have a significantly lower %BF in female dance students than sedentary females in the same age (dancers 20.5±4.6, and controls 26.5±3.6). Between semi-professional female dancers and active females there also weren’t significant differences in %BF (21.4±2.8 and 25.6±3.7 respectively) and in FFM (42.2±3.7 kg and 42.2±6.6 kg respectively) (Harley et al., 2002).
Physiological Elements Required by Dancers

White, Philpot, Green, and Bemben, (2004) between ballet dance students and contemporary dance students they were found no significant differences exists in %BF (Ballet: 19.9±1.5 and Contemporary: 19.3 ±1.4) or in FFM (Ballet: 41.5±1.1 kg and Contemporary: 43.2±1.6 kg). Similar results found Chmelar et al. (1988) compared contemporary professional dancers (%BF: 12.2±2.1) with professional ballet dancers (%BF: 14.1±1.9) and contemporary dance students (%BF: 14.7.±3.4) with ballet students (%BF: 14.2.±3.2). Potter et al. (1996) found that the modern dancers had a higher body fat composition than the ballet dancers. Significant differences in %BF also were found by Berlet et al. (2002) between professional dancers and weight-matched controls. (Female dancers: 13.6±3.3, female controls: 9.7±2.5 and male dancers: 14.4.±4.8, male controls: 24.0±5.7).

Brown et al. (2007) and Koutedakis et al. (2007) in their studies reported that supplementary aerobic and or strength training does not elicit significant changes in %BF of dance students.

Discussion

Today, to meet the choreographic demands of many amateur or professional modern dance companies and college dance major programs, training must prepare dancers to meet the physical requirements necessary to accomplish artistic intent. Few sports can compare with dance in terms of the time and technical demands placed on the mind and body. Further, the dancer must seek optimal responses from the body to meet aesthetic demands (Berardi, 1994). According to Solomon, it should be “the main business of dance technique training to eliminate the tendencies which lead to inefficient and deleterious movement and get the dancers working in a more effective manner” (Solomon, 1987).

The dance training methods are essentials for maintaining and developing the dancers’ technique and coordination to perform an artistic form of movement. Dance technique training, by itself, does not always provide a sufficient conditioning program for the prevention of injuries or skeletal imbalances often associated with the performance and rehearsal (Ahearn, 2006), and since dance body movement expression is closely linked with a high physical performance (Schantz & Astrand, 1984), dancers need supplemental cardiovascular training to improve their fitness level, (Krasnow & Chatfield, 1996; Wyon, 2004; Guidetti, Gallotta, Emerenziani, & Baldari, 2007) especially in low technical level dancers (Guidetti et al, 2008).

Moreover, consistent with the mixed aerobic–anaerobic nature of dance (Schantz & Astrand, 1984), both high and low technical level dancers
demonstrate maximal oxygen uptake values below the average for other athletes (Koutedakis & Jamurtas, 2004). Dance consists of human movements involving qualities such as grace and style. However, current choreography places physical demands on dancers that make their physiologic and fitness development just as important as skill development (Redding & Wyon, 2003).

This literature study showed that differences in aerobic fitness levels exist between not only in different dance forms but also in levels of dancers (Chmelar et al., 1988; Chatfield et al., 1990) and dancers demonstrate values of $\text{VO}_{2\text{max}}$ between 38.1 ± 1.9 (Guidetti et al., 2008) to 51.2±11.4 ml kg$^{-1}$ min$^{-1}$ (Dahlstrom et al., 1996), lower values than do other athletes of comparable age but significantly greater than sedentary individuals.

Dancers in different dance forms demonstrate differences in fitness levels which in turn, have significant implication in performance (Angioi, 2010). In some cases, modern dance training improved aerobic and anaerobic capacity, and in other studies, there were no significant differences (Krasnow & Kabbani, 1999). It would be fair to suggest, therefore, that contemporary dancers need to be both aerobically and anaerobically fit in order to be prepared for the many different demands of the genre (Redding et al., 2009). Supplementary exercise training significantly increased aspects of dance performance, with concomitant increases in selected fitness-related parameters, in dances (Koutedakis et al., 2007).

Dance involves a strong static component in conjunction with a dynamic component consisting of bursts of high intensity, for brief duration. Dance training consists of technique and style training with an aim to increase the skill level of dancers. Even if the most taxed metabolism of dance exercise was the aerobic source, its percentage of utilization was related to the fitness level of the performer. A higher percentage allows a better performance (Guidetti et al., 2008).

As concerning the anaerobic mean power no significant differences were detected in between adolescent performing and recreational dancers and compared to non-dancers (Padfield et al., 1993; Chmelar et al., 1988). Between different levels of dancers (beginners, intermediate, professional), they didn’t demonstrated significant differences in anaerobic capacity mean values (Chatfield et al., 1990). Guidetti et al. (2008) reported that individual anaerobic threshold (IAT) was 55% and 60% of $\text{VO}_{2\text{max}}$ for high and low technical level dancers, respectively and suggested that dance intensity should not be defined only as a percentage of $\text{VO}_{2\text{max}}$ but it is preferable to define the individualized intensity in relation to the IAT.
In accordance with these Seip et al. (1991) reported that trained athletes have an individual anaerobic threshold at a higher percentage of their VO$_{2\text{max}}$. In a study regarding the effect of a warm up, commonly adopted by classical dancers prior to ballet exercises, showed that the warm up did not affect the overall energy cost, decreased the percentage contribution of the anaerobic source, and increased the aerobic sources contribution during the exercise (Guidetti, Emerenziani, Gallotta, & Baldari, 2007) and the lack of warm up before the performance increases the risk of injury (Malkogorgos, Argiriadou, Mavrovouniotis, & Zaggelidis, 2010).

Between different levels of dancers (beginners, intermediate, professional), no significant differences exist in muscular strength and power and also between different dance styles (Chmelar et al., 1988; Chatfield et al., 1990). Low muscle strength levels in professional dancers have been associated with increased injury risk and a reduced in muscular strength may extent the recovery time (Weiss & Zlatkowski, 1996). It has been suggested that supplementary strength training on dancers resulted in significant benefits for jump performance (Brown et al., 2007), as well as in overall performance competence and technique (Koutedakis et al., 2007).

Joint mobility/muscle flexibility and body composition are also important parts of dance fitness. The results indicate that dancers are in general moderately lean, and have a high degree of flexibility (Angioi, 2010). Dancers’ joint range of motion ROM does not improve or diminish with age but rather is preserved. The ability of dancers to retain joint flexibility with age is probably because of their exposure to extensive exercise, as ROM in non-dancers tends to deteriorate with age (Steinberg et al. 2006).

Kadel et al. (2005) reported that child dancers (age 8–13 years) are significantly leaner compared to age matched, non-dancer controls. In their study Steinberg et al. (2008), clearly shows that the extent of weight differences between dancers and non-dancers varied greatly with age. Ravaldi et al. (2003) reported a significantly lower BMI in non-elite ballet dancers (mean age 16.2 6 4.1 years) when compared with controls. Studies which investigated into body composition of dancers revealed that dancers in different levels or styles demonstrate significant lower values in body fat percentage (%BF), high and no significant differences in fat-free mass (FFM) compared with non-dancers (Novak et al., 1978; Chatfield et al., 1990; Harley et al., 2002; Berlet et al., 2002). Between different levels or styles they weren’t exists significant differences in %BF and FFM (Chmelar et al., 1988; Padfield et al., 1993; Mihajlovic and Mijatov, 2003; White et al., 2004). The findings showed that dancers have mean body weight, Body Mass Index (BMI) and percentage of fat less than control
subjects since they have to control body weight as required in order for them to be physically active in any dancing movement (Hidayah & Syahrul Bariah, 2011).

Štalec, Štalec, Katić, Podvorac, & Katović, (2007) in their study with female high school students aged 16–18 years (fit for attending physical education classes), following an experimental procedure, physical education including programmed components of dance structures and aerobics, was used with the experimental group throughout the academic year (66 periods). During the same time, control group attended standard physical education curriculum for high school students, also 66 periods in total. Of these, 6 periods were used for initial, transitory and final measurements (2 periods each). Study results indicated the program of physical education including dance, aerobics and rhythmic gymnastics influenced the relevant motor abilities of coordination (agility and coordination in rhythm), aerobic endurance, strength (repetitive and explosive) and flexibility as well as the morphological status in terms of excessive adipose tissue reduction.

In conclusion dance is an excellent alternative exercise form improving health related physical fitness elements. The development of the dancer’s physical fitness seems to be more a byproduct of skill acquisition than focused fitness training. As in most sports, dance fitness depends on the individuals’ ability to work under aerobic and anaerobic conditions, and develop high levels of muscle tension. Dance performance requires support from enhanced physiological requirements necessary for dancers including: joint mobility, muscular strength, cardiovascular fitness, body composition and suggested that supplementary aerobic and or strength exercise training may have significant benefits on performance. In fact, several studies had examined the physiological responses to dance modalities such as modern dance, ballet, and aerobic dance. The investigation into physiological and fitness components of dance and dancers has mainly concentrated on classical ballet dance and modern dance. Relatively little has been published in relation to other forms. More multidisciplinary scientific research is needed on the different forms of dance. Furthermore, it needs more investigation whether improved physical fitness has positive effect on dance performance.
References


Physiological Elements Required by Dancers


Physiological Elements Required by Dancers


Physiological Elements Required by Dancers


Physiological Elements Required by Dancers


Alexandros MALKOGEORGOS, MSc, is a member of the Special Teaching Staff of the Faculty of Physical Education & Sport Sciences, Aristotle University of Thessaloniki (Hellas). He received his Master degree in Human Performance and Health Sciences, from the Faculty of Physical Education & Sport Sciences, Aristotle University of Thessaloniki. He is Ph.D candidate in faculty in sport science in Pitesti University Romania. He is interested in sports and health and specialized in dance activities and has worked as dance teacher in traditional Greek dances for many years. E-mail address: malko@phed.auth.gr

Eleni ZAGGELIDOU, is graduate from the Faculty of Physical Education & Sport Sciences, Aristotle University of Thessaloniki (Hellas). She received also diploma in teaching classical and modern dance from professional dance school (Hellenic Ministry of Culture and Tourism). She is a post-graduate master’s degree student in Human Performance and Health Sciences, in the Faculty of Physical Education & Sport Sciences, Aristotle University of Thessaloniki. She is interesting in dance and she working as dance teacher and as trainer in rhythmic gymnastics. E-mail address: elenzang@phed.auth.gr
Georgios ZAGGELIDIS, Ph.D. is an Assistant Professor of the Faculty of Physical Education & Sport Sciences, Aristotle University of Thessaloniki (Hellas), is specialized in judo-karate. He received a Ph.D in Pedagogy (Sport), from University of Bucharest (Faculty of History-philosophy), Romania. His research interests involve Sport Pedagogy, coaching and combat sports. He has published as author or co-author numerous papers.

**Corresponding address:**
Georgios Zaggelidis  
Department of Physical Education and Sport Sciences, 
Aristotle University of Thessaloniki, 
57001 Thermi  
Thessaloniki, Greece  
Phone: +30 2310 992172 or mobile: +30 6977 022064  
E-mail: gzangel@phed.auth.gr

Galazoulas CHRISTOS, PhD is an Assistant Professor of the Faculty of Physical Education & Sport Sciences, Aristotle University of Thessaloniki (Hellas), is specialized in Basketball Coaching. He received a Ph.D in Sport Exercise and Health, from Aristotle University of Thessaloniki (Department of Physical Education & Sport Sciences), Greece. His research interests involve Strength training, Flexibility, Coaching and Developmental ages. He has published as author or co-author numerous papers. E-mail address: galazl@phed.auth.gr