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Acute Responses and Chronic Adaptations of Cardiorespiratory Systemin Dance

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***Abstract*—In ancient Greece people believed that dance, the combination of rhythm and harmony, was given to humans as a gift from Gods. Dance plays a significant role in humans' lives, as only humans among the creatures on earth perceive and enjoy the rhythm and harmony and need them in every manifestation of their lives in order to honor the Gods or rest from daily labors and entertain themselves. Dance, as an activity of body and spirit, gathers and combines characteristics of exercise and sports, entertainment and fun, art and spiritual test, constituting at the same time education and training. Dance also may be treated as a physical activity, because it includes a big variety of whole-body movements.From reviewing the literature, it became clear that the participation in most of dance species induce cardiorespiratory fitness benefits. The induced cardiorespiratory fitness benefits are very important for the participants in dance because they don't lead only in resistance to fatigue and to fewer injuries, but also result to general health benefits. Consequently, the wide variety of dance species, concerning mode, technique, rhythm, and duration, allows the design of sessions with a variety of dances mild to intense, aiming for the best possible benefits in cardiorespiratory fitness.**

***Index Terms*—ballet, modern dance, traditional dance, social dance, aerobic capacity, cardiorespiratory fitness.**

I. INTRODUCTION

The cardiovascular system is responsible for the supply of oxygen as well as for the transport and exchange of substances in the body's cells. The cardiovascular system is very important in the body, as its main role is the distribution of oxygen to the tissues, through the blood, the transport of metabolic waste, i.e., carbon dioxide, the transport and distribution of water and other nutrients to the tissues, the retention of homeostasis in the body and thermoregulation-heat transfer [1].

The respiratory system is responsible for taking in air from the environment, introducing it into the lungs, receiving oxygen from it, and releasing carbon dioxide into the air through breathing. The respiratory system is a small laboratory that constantly measures the density of carbon dioxide in the blood and, whenever necessary, increases and decreases the number of respiratory movements, according to the needs of the organism. The usual number of respiratory movements at rest is about 24 movements per minute.

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The number of respiratory movements is not constant, because breathing is not a completely automatic function (that is, we can control it to a certain extent with our will), any effort increases the need for oxygen and thus respiratory movements also increase (e.g., shortness of breath) and certain body functions, various activities but also certain mental states (e.g., digestion, exercise, stress, etc.) increase the respiratory rate[2].

Exercise improves the function of the cardiorespiratory system. With exercise, the heart muscle becomes stronger, and an increase in the size of the myocardium is observed, resulting in more blood being pumped with each pulse [3]. It is very important to emphasize that people who exercise regularly have a lower resting heart rate compared to people who do not exercise.Types of aerobic exercise, such as walking, running, cycling, swimming, dancing, etc. are the most effective forms of exercise for improving the function of the cardiorespiratory system since they increase cardiac output and pulse volume, reduce heart rate and the subjective perception of fatigue during submaximal exercise, bring about better blood pressure control and improve pulmonary ventilation[4], [5]. Cardiorespiratory fitness is very important, as increased cardiorespiratory fitness levels have been linked not only to general health benefits, but also to fatigue resistance and therefore a decreased risk of injury due to distraction of focus, or inability to maintain correct technique for dancers [6], [7], for exercisers, as well as athletes of various sports.

II. DANCING

Dance, the combination of rhythm and harmony, i.e., the order in movements and the order in voice, was given to humans as a divine gift with "*co-dancers and sponsors*", Apollo, the Muses and Dionysus [8].Only humans among the creatures on earth perceive and enjoy, as a divine gift, rhythm and harmony and need them in every manifestation of their lives in order to honor the Gods or rest from daily labors and entertain themselves[9].

Through the art of dance, humans succeed in creating an aesthetic space, giving form to amorphous matter, as they make a psychosomatic effort to "produce" a purely aesthetic and human result. They achieve this by imposing discipline on their body parts, thus giving breath to their movements and the space in which they take place [10]. The human body is the instrument that dance uses to express itself, it is the vehicle to move from nature to culture [11].

During the process of dancing with the simultaneous accompaniment of music, an aesthetic image is created that gives the false impression that the dancer's body strains very little during the effort to perform each dance sequence. The comfort with which a dancer moves gives the impression of ease, but the road to perfection is difficult and

the fatigue is great. The agility of the body acquired through absolute discipline is what distinguishes the dancer. In this way, the dancer can self-control his body, and after achieving this, they can then feel liberated [12] to move and "interpret" the notes and the music.

The movements and actions that take place during the performance of the motor skill of dance are the results (of cooperation) of various mental (and neuromuscular) processes. The movements of the body in the dance process are organized into sequences and forms of message and meaning. The dancers' main characteristics are foot virtuosity, facial expression, hand movement, trunk posture, and spinal control. These motor activities are an expression of individual needs, feelings, goals, and aspirations. The body in this case functions both as an object and as a subject, but also as a means (organ) of movements [13]. Dance, as an activity of body and spirit, gathers and combines characteristics of exercise and sports, entertainment and fun, art and spiritual test, constituting at the same time education and training [11].

The fundamental component of dance is movement, in the form of kinetic form and sequence. Dance is characterized by complexity, mainly in combinations of movements of the lower limbs, such as simple and complex steps, foot skips, arsis, single or double jumps, dynamic supports on the whole foot or on half a foot, slides, single or double swings, lifts, lower limbs scissors, jumps, turns and a multitude of other movements of the lower limbs that are combined with movements of the upper limbs and the hand, and also with the movement and posture of the whole body, a variety of simple kinetic patterns performed with appropriate intervals and frequent rhythm alternations[14]. Thus, dance may be treated as a physical activity, because it includes a big variety of whole-body movements.

III. DANCE AND CARDIORESPIRATORY SYSTEM

Dancing, like any physical activity, requires energy to perform. During the performance of the dance, the neuromuscular system is activated, and the metabolism increases with a corresponding increase in the activation of the cardio-respiratory system, in order to receive the oxygen necessary to produce the required energy. This energy is then used by the muscles to perform the dance movements [15].

Dancing constitutes a type of continuous physical activity, of rhythmic and aerobic form, with intensity at 30%-75% of VO_2max, in which large muscle groups participate. Thus, dancing as a physical activity meets the criteria of cardiovascular exercise [16] (American College of Sports Medicine, 2006).Additionally, as a physical activity of moderate intensity, of approximately 3-5 METs, dancing may result in a calorie loss from 300-360 kcal/h, at a low-intensity pace, to 420-480 kcal/h, at a more intense pace. It could be said that dance constitutes a physical activity that may contribute to the improvement of physical fitness [14], [17]-[20].

Participating in dance has been shown to lead to improvements incardiorespiratory endurance and aerobic capacity, as well as strength of the lower limbs, balance, flexibility, and agility of the body, and of body composition [21]-[24]. It is worth mentioning that dance induces similar effects in cardiorespiratory fitness and in calorie output levels not only with uncompetitive physical activities such as walking, running but also with non-competitive forms of various sports such as football or tennis[25].

Concerning ballet physiologic responses, [26] examined 7 men and 8 women elite professional ballet dancers from American Ballet Theatre, aged 20-30 yr. During barre exercise, mean VO_2 for men was 18.5 $ml \cdot min^{-1} \cdot kg^{-1}$ (38% VO_2max) and for women 16.5 $ml \cdot min^{-1} \cdot kg^{-1}$ (38% VO_2max). During center floor exercisemean VO_2 for men was 26.3 $ml \cdot min^{-1} \cdot kg^{-1}$ (55% VO_2max) and for women 20.1 $ml \cdot min^{-1} \cdot kg^{-1}$ (46% VO_2max). During the barre exercise, HR was below the training-sensitive zone (70% HR max) for significant periods of time. During allegro center floor exercise, HRmax for men was 178 $beats \cdot min^{-1}$ (92% HRmax), and for women 158 $beats \cdot min^{-1}$ (85% HRmax), whichwere maintained for only brief durations like sprint or burst activities. These physiologic data obtained during ballet class represent only a relatively modest stimulus for augmenting aerobic VO_2max [26].

In addition, [27] studied the aerobic and anaerobic energy yield during professional training sessions ("classes") of classical ballet as well as during rehearsed and performed ballets on 6 men (28±6 years old), and 7 women (25±8 years old), elite professional ballet dancers from the Royal Swedish Ballet in Stockholm, who danced 5-6 days/week for 15 years.The results showed that the measured oxygen uptake during six different normal classes at the theatre averaged about 35-45% of the maximal oxygen uptake. and the blood lactate concentration averaged 3 mM. During 10 different solo parts of the choreographed dance, with a median length of 1.8 min, representative of moderately to very strenuous dance, an average oxygen uptake (measured during the last minute) of 80% of maximum, and blood lactate concentration of 10 mM was measured. Maximal oxygen uptake amounted to, on average,56 $ml \cdot min^{-1} \cdot kg^{-1}$in men and 51 $ml \cdot min^{-1} \cdot kg^{-1}$in women. The researchers concluded that classical ballet is a predominantly intermittent type of exercise. In choreographed dance, each exercise period usually lasts only a few minutes but can be very demanding energetically, while during the dancers' basic training sessions, the energy yield is low [27]. In agreement, [28] and[29] reported that the cardiorespiratory fitness of ballet and contemporary dancers is relatively low. However, contemporary dancers demonstrate higher maximal oxygen uptake and higher scores in muscular endurance than ballet dancers at a professional level [28]. Moreover, other researchers suggest that the lower recorded intensity of dance class, as well as its discontinuous nature, is rather inadequate to derive an aerobic training response [30], [31].

Concerning aerobic dance, in[32] study, 10 female students, 22.9±2.6 years old, were randomly assigned to low-impact and high-impact aerobic dance sessions. The sessions consisted of 20 min of aerobic exercise followed by 5 min of local muscular endurance exercise and 5 min of flexibility exercises. The mean intensity of the low-impact and high-impact aerobic dance sessions was 51.6% and 64.7% VO_2max, respectively. The mean %HRmax for the low-impact and high-impact aerobic dance sessions was 71.4% and 76.7%, respectively. On average, the rating of perceived exertion for the high-impactaerobic dance session was 12.1 and for the low-impact aerobic dance was 11.1 degrees. The researchers concluded that high-impact aerobic dance has the potential to maintain or/and improve the aerobic fitness of the participants.

Moreover, [33] examined the effect of aerobic dance exercises on cardiorespiratory endurance of 30 female students who were randomly assigned to the intervention group (N=15) that participated in a program of aerobic dance exercises of 45 minx3/week for 12 weeks, and the control group (N=15).The sessions included a 10-min warm-up, 25 min of aerobic dance exercises, and 10 min of recovery. Every 3 weeks of the program, the load intensity was increased by 5%, and ranged from 65% to 80%.The researchers indicateda significant improvement in cardiorespiratory endurance performance due to the impact of the aerobic dance training program.

The results of [33] research confirm the results of [34] who similarly examined 16 college-aged women and found a significant increase in VO_2max from 38.3 $ml \cdot kg^{-1} \cdot min^{-1}$to 41.3 $ml \cdot kg^{-1} \cdot min^{-1}$ and a significant decrease in body fat from 25±6.8% to 21±6.3% with no post-training change in body weight. In conclusion, the researchers stated that a relatively low-impact aerobic dance is as effective as other endurance training programs in improving cardiovascular fitness and decreasing body fat.

Concerning a combination of aerobic dance and other forms of alternative physical activities, [35] examined the effect of zumbaand aerobic dance exercises on physical fitness variables of 30 female students 18-24 years, who were randomly assigned toan intervention group (N=15) that participated in a program with zumba and aerobic dance exercises of 60 minx5/week for 12 weeks, and a control group (N=15).The sessions included zumba, zumba and exercises on specific body parts, floor aerobics, hi-low impact aerobics, and step aerobics. After the 12-week training program, there was a significant improvement in the cardiovascular endurance and skinfold measurement of the young women who participated.

Similarly, [36] examined the effect of aerobic dance and pranayama on variables of the cardio-respiratory system on 60 male students, aged 18 to 20 years, who were randomly divided into two experimental groups: aerobic dance group and pranayama group that participated in a training program of 45 minx6/week for 6 weeks, and a control group. Aerobic dance sessions included warm-up, full-body aerobic dance exercises, and recovery. The Pranayama sessions, whichare a type of yoga breathing exercise, included Pranava, Nadishuddi, and Savitri Pranayama.Post-training tests showed significant differences in pulse rate, forced vital capacity, forced expiratory volume in the first second, and pulse rate and peak expiratory flow rate in both the aerobic dance group and pranayama group. The researchers concluded that aerobic dance and pranayama exercise programs may be implemented to delay the onset of fatigue and improve the mechanical efficiency of the lung and heart.

According to traditional dance, [15] determined the heart rate and oxygen consumption of eight males aged: 46.5±4.4 years and eight females aged 45.1±3.4 years, who have been dancing for the last 5 years, and performed in random order 24 traditional dances from eight regions of Greece.Of the 24 dances examined, some dances (specifically Pogonisios, Berati of Epirus, Sta tria, Berati of Thessaly, Tsakonikos, Tik, and Dipat)were characterized as mild, based on their intensity (30-43% VO_2max and 55-63% HRmax) and can be paralleled with classical ballet exercises performed on the barre at an intensity of 38% VO_2max and 63% HRmax [26] or 35-45% VO_2max [27]. The intensity of these dances, apart from Tik dance, is not considered sufficient [16] to improve the cardiorespiratory function of healthy individuals.According to the classification of physical activity based on the number of calories consumed for its performance, the above dances, requiring 5.29 kcal/min from men and 4.0 kcal/min from women, are classified as moderate and not mild physical activities [37], burdening the body of individuals to an extent equivalent to archery, billiards, “bowling”, golf, and sailing [38].

Moreover, some dances of the 24 dances examined (specifically Zonaradikos, Zagorisios, Aidoni-Tasia, ZervosKarpathou, Gaida, Kalamatianos, Tsamikos, and Chaniotikos), with an intensity of 46-59% VO_2max and 64-69% HRmax can be paralleled with classical ballet exercises [26], and with low-impact aerobic dance programs [32].Oxygen consumption in these dances averaged at 1.09 l/min while heart rate ranged from 117 to 126 beats per minute. The above values, appear proportional to the corresponding oxygen consumption values of a 40-minute low-impact aerobic dance program (1.06 l/min). Additionally, some dances of the 24 dances examined (specifically Baidouska, SirtosSygathistos, Ikariotikos, Trehatos-Raikos, Enteka, Kotsari, Pentozalis, and Susta of Crete), with an intensity of 61-75% of VO_2max and 74-86% of HRmax are included in the entertainment activities, whose intensity is characterized as very strong for women, while for men from strong to very strong [37]. In addition, these dances can be compared to other types of recreational activities such as walking, running, water skiing, horse riding, swimming, table tennis, tennis, canoeing, rowing, aerobic dance, modern dance, ballroom dancing, cricket, equally contributing to improving cardiorespiratory function[38].

In addition, [39] examined the effect of traditional dances on cardiorespiratory fitness of 40 sedentary healthy adults, 23 women and 17 men, aged 35-55 years, who were randomly divided intoan experimental group that participated in a Greek traditional dance program of 60 minx3/week for 24 weeks, and a control group.Post-training with Greek traditional dances, the VO_2max of the experimental group increased significantly from 35.95±4.3 $ml \cdot min^{-1} \cdot kg^{-1}$to 38.91±3.7 $ml \cdot min^{-1} \cdot kg^{-1}$, and favorable changes in DBP and SBP were found. The researchers concluded that Greek traditional dances may be used as an alternative and, also, effective form of physical activity that may help in improving aerobic capacity and may bring favorable changes in the cardiorespiratory status of adult people.Similar results ended up in researches of [40] concerning the participation of postmenopausal women and [41] concerning elderly women’s participation in Greek traditional dance programs.

In agreement, traditional dances from other countries, such as Tai Chi-a Chinese traditional form of dance, Turkish traditional dances, Korean traditional dances, as well as a Sardinian traditional dance have been proven that they may improve cardiovascular system function, fitness, and aerobic capacity [42]-[47].

Concerning ballroom dance, [48] examined heart rate and estimated energy expenditure in ten competitive ballroom dance couples, with an average age of 23.2 years for men and 21.8 years for women, that presented competitive sequences of modern and Latin American dance.Overall mean heart rate values for the Modern dance sequence were

170 beats·min^{-1} and 173 beats·min^{-1} for males and females respectively. During the Latin American sequence,the overall mean heart rate for males was 168 beats·min^{-1} and 177 beats·min^{-1} for females. Overall mean heart rate as a percentage of maximal heart rate was 86±5% for the male and 88±6% for the female dancers concerning modern dance and 85±7% for the male and 91±6% for the female dancers concerning Latin American dance. Predicted mean gross values of oxygen consumption for the males were 42.8±5.7 ml.kg^{-1}·min^{-1} and 42.8±6.9 ml·kg^{-1}·min^{-1} for the Modern and Latin American sequences respectively. Corresponding gross estimates of oxygen consumption for the females were 34.7±3.8 ml·kg^{-1}·min^{-1} and 36.1±4.1 ml·kg^{-1}·min^{-1}. Males were estimated to expand 54.1±8.1 kJ.min^{-1} of energy during the Modern sequence and 54.0±9.6 kJ·min^{-1} during the Latin American sequence, while predicted energy expenditure for females was 34.7±3.8 kJ·min^{-1} and 36.1±4.1 kJ·min^{-1} for Modern and Latin American dance respectively. The results led to the suggestion that both males and females were dancing at greater than 80% of their maximum oxygen consumption. Consequently, mean gross energy expenditures in kJ·min^{-1} show that competitive ballroom dance is as demanding as other sports activities such as basketball (35.83 kJ·min^{-1}), squash (42.70 kJ·min^{-1}), and cross-country running (44.37 kJ·min^{-1})[48]. Traditional and ballroom dances are social dance kinds, have many similarities and, has been found to result to similar benefits regarding the cardiorespiratory fitness, probably due to their properties as an aerobic exercise mode [40].

Consequently, most of dance species constitute a physical activity incorporating both aerobic properties, through repetitive multidirectional movement, various standings on the feet, turning around, and co-ordinated arm movements, and socialization under the accompaniment of music. The induced cardiorespiratory fitness benefits are very important for the participants in dance because they lead in resistance to fatigue, fewer injuries, as well as to general health benefits.

IV. CONCLUSIONS

Fromreviewing the literature, it is evident that dancers of zumba, jazz, aerobic, contemporary, modern, ballroom, and traditional dance, men or/and women, beginners or/and advanced, demonstrate significantly higher values in VO_2max compared to pre-program values and compared to sedentary individuals [7], [35], [39], [48]-[54].

In accordance with the classification of exercise according to oxygen intake, dancing at a HR above 80% of HRmax can produce training effects for the participants [55]. Thus, exercise intensity elicited by low-impact aerobic dance may have a limited training effect, and for some individuals may result in detraining. However, low-impact aerobic dance may be an appropriate mode of exercise for overweight and unfit individuals, as well as the elderly. Therefore, low-impact activity programs may serve as a moderate-intensity exercise mode to increase health benefits for a segment of the population and may offer a considerable health gain to the least fit [32],[56]-[57].

Summing up, participation in dance requires an appropriate level of physical effort and may lead the cardiorespiratory variables to changes in the desirable direction. In this way, dancers may approach an appropriate level of fitness. The wide variety of dance species, concerning mode, technique, rhythm, and duration, allows the design of sessions with a variety of dances mild to intense, aiming for the best possible benefits in cardiorespiratory fitness.So, let's dance!

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