Metabolic Equivalents of Selected Dance Styles on Trained Female Dancers

by

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ABSTRACT

The purpose of this study was to determine if there are significant differences in metabolic equivalent (MET) or energy expenditure levels between ballet, modern, jazz, and tap dance utilizing heart rate (HR) monitoring, as well as accelerometry. A secondary purpose of this study was to evaluate the validity of an ActiGraph equation for predicting METs or energy expenditure as compared to the calculated METs from the HR data. The hypothesis was that the studied dance styles would have significantly different MET levels, therefore placing different physiological demands on the trained dancers. It was also expected that all dance styles would exceed previously published MET values. The participants were six college-aged female dancers all with at least five years of dance experience. Heart rate (HR) monitoring and accelerometry were used to examine average heart rate, average activity VO$_2$ (ml·kg$^{-1}$·min$^{-1}$), MET levels, caloric expenditure, and percent time spent in different physical activity levels. Statistical analyses revealed that the average MET level for all dance styles, as determined by the HR data, was significantly higher than that previously reported. This higher MET value now categorizes dance as hard-intensity physical activity. Additional analyses implied the reliance on different energy systems between the individual dance styles. Accelerometers were found to underestimate caloric expenditure by 48%. It was concluded that supplemental physical training, in addition to skill training, needs to be tailored to the specific dance style being performed. Training needs to be planned and managed to the same extent as rehearsals are, as to allow dancers to peak for each performance period without increasing injury rate and occurrence of overtraining. Additionally, physiologists, clinicians and practitioners should use the information gathered in this study to properly prescribe dance-based physical activity for exercise.
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CHAPTER 1

INTRODUCTION

Dance can be defined as a human movement that is distinguished by aesthetic qualities such as grace, elegance, and beauty, to the accompaniment of music or other rhythmic sounds. Dance aims to create a visual performance by telling a story and/or communicating or expressing human emotions, themes, or ideas (Guidetti, Emerenziani, Gallotta, Da Silva, & Baldari, 2008). This is why for many centuries, dancers saw themselves as artists, not athletes. The acceptable dancer aesthetic forced those committed to the profession to maintain a ‘willowy’ or thin appearance. Koutedakis et al. (2007) noted that there was an unfounded fear, among sections of the profession, that increased levels of fitness would possibly undermine important aesthetic appearances. This is why there are surprisingly few published research studies on dance-related fitness. Physical conditioning was thought of only as supplemental when a dancer had to abstain from class participation and rehearsals due to injury or other medical condition. Additionally, most physical training undergone by a dancer was only a means to an end, that being the search for the perfect aesthetic (Wyon, Abt, Redding, Head, & Sharp, 2004).

Several researchers have concluded that dance classes typically fall below the work intensity required to elicit an aerobic training effect (Cohen, Segal, Witriol, & McArdle, 1981; Guidetti et al., 2008; Wyon & Redding, 2005). The nature of a dance class is to focus on movement vocabulary, technique, musicality, and development of creativity and expression. As the physical demands placed on today’s dancers continues to grow, their physiology and fitness becomes just as important as skill development. Dancers remain subject to the same unyielding physical laws as athletes (Koutedakis, Stavropoulos-
Kalinoglou, & Metsios, 2005). A recent trend seen in dance performance indicates that a more athletic approach to training dancers is being adopted, due to the physical nature of current choreography, but no existing research supports this fact.

There has been a lack of research in the dance world on topics outside of malnutrition, body composition, and the physiological profiles of ballet dancers. This is mainly because, until recently, dance has not been viewed from an athletic point of view, and therefore only certain physiological characteristics were seemingly important. Dance can still be an intense form of exercise, even though the artistic and aesthetic components supersede the athletic aspects of the activity (Yannakoulia, Keramopoulos, Tsakalakos, & Matalas, 2000). Analyzing and understanding the unique physiological demands of selected dance forms would be beneficial so that more specifically tailored training programs could be created.

**Statement of the Problem**

Dance can be an intense form of exercise and a significant source of caloric expenditure. However, literature has been inconsistent as to the exact level of intensity and physiological demands of dance due to the lack of physiological data.

Also, not all dance styles are similar and therefore they could elicit different physiological responses. It is unknown to what extent the differences are between the individual dance styles, and if certain ones are more demanding than others.

**Purpose of the Study**

The purpose of this study was to determine if there are significant differences in metabolic equivalent (MET) or energy expenditure levels between ballet, modern, jazz, and tap dance utilizing heart rate (HR) monitoring, as well as accelerometry. A secondary purpose
of this study was to evaluate the validity of an ActiGraph equation for predicting METs or energy expenditure based on activity counts as compared to the calculated METs from the HR data.

**Significance of the Study**

Many dancers have a history of low percent body fat, low caloric intake and high incidences of injuries related to fatigue and overtraining (Koutedakis & Jamurtas, 2004; Koutedakis et al., 1999; Mayers, Judelson, & Bronner, 2003; Yannakoulia et al., 2000). It would be beneficial to compare the energy demands of the selected dance styles to explore what type of supplemental training is necessary for dancers of different styles.

Minimal research has been done regarding dance and the science behind it. Some previous studies have looked at differences within specific populations of dancers such as experience level or seniority of company members (Guidetti et al., 2008; Wyon, Head, Sharp, & Redding, 2002). Additionally, most research has been aimed at ballet and contemporary dance (Schantz & Astrand, 1984; Wyon et al., 2004) while aspects of other dance styles have rarely been looked into.

This investigation intends to comparatively study ballet, modern, jazz and tap dance in terms of metabolic equivalents. To my knowledge, no correlational data exist surrounding these different dance forms.

**Hypothesis**

It is expected that the selected dance forms (ballet, modern, jazz and tap) will have significantly different MET levels, therefore placing different physiological demands on the trained female dancers. It is also expected that all dance forms will exceed the previously reported MET value of 4.8 by Ainsworth et al. (2000).
In addition, is it expected that each dance style will spend significantly different amounts of time in physical activity levels based on accelerometer activity cut-off points.

**Delimitations**

The following delimitations were made to narrow the scope of the study.

1. Participants for the study were women who participated in different dance clubs at SUNY Cortland. This limited the experimental group to college-aged students.
2. The female students involved were not professional dancers and were not involved in a strict dance-training program.
3. This study employed the use of heart rate as a determinant factor of VO\(_2\), and therefore METs. The HR/VO\(_2\) relationship is not as reliable in dance as it is for steady-state exercise (Redding, Wyon, Sherman & Doggart, 2004).
4. The accelerometers employed in this study were two-Dimensional and therefore unable to capture all movement created by the dancers. The ActiGraph GT1M is unable to capture movement in the frontal plane.
5. Specific dance routines were created for each style incorporating the 20 most common moves as determined by a panel of experts.
6. The testing sessions for each dance style were structured after a typical dance class. It has been shown that the energy requirements of a dance class significantly differ from that of a dance rehearsal and performance (Wyon et al., 2002; Wyon et al., 2004; Wyon et al., 2007; Wyon & Redding, 2005).

**Limitations**

The limitations of this study included:

1. The main researcher responsible for this study instructed all of the dance testing sessions
involved. This could provide bias on the instructor’s part if she believes one dance form to be more challenging than others. In an attempt to control for this, all dance movements and music tempos were planned out ahead of time. Movements and tempos were both based on previous literature that outlined typical class movements and tempos, as well as the surveys completed by a panel of experts in which the movements that would represent each style were chosen based on their knowledge and experience in dance instruction.

2. Participants involved were not directly measured to obtain their maximal exercise values. Instead, all participants underwent the sub-maximal YMCA cycle ergometer test to predict their maximal exercise values. Although this is an indirect measurement, it is shown that parameters such as heart rate and VO₂ measured at less than maximal load could be considered to be more reliable indicators of fitness level than maximal oxygen intake in dancers (Baldari & Guidetti, 2001).

3. Due to proximity of participants during the testing sessions, there could have been interference between the coded heart rate monitors and receivers.

4. Each dance style dictates a traditional style of music, which can vary in tempo. Modern dance had an average tempo of 67 bpm ±7, tap dance had an average tempo of 115 bpm ±7, ballet had an average tempo of 73 bpm ±38, and jazz dance had an average tempo of 85 bpm ±20.

Assumptions

Several assumptions were made in regard to the behavior of the participants during the course of the study.

1. It was inferred that the participants were cooperative with the teacher’s instructions and factors such as how they felt that day, or their feelings toward the class and instructor did
not affect their performance and are therefore negligible.

2. It was assumed that all participants answered all questions honestly and performed fitness tests to their maximum ability.

3. It was assumed that the heart rate monitor is a valid and reliable instrument for obtaining heart rate (HR).

4. It was assumed that an accelerometer is a valid and reliable instrument for obtaining ‘activity counts’ during physical activity.

5. It was assumed that the calculation for determining energy expenditure (METS) from HR as defined by Strath et al., (2000) is a valid and reliable calculation ($r = 0.87$).

6. It was assumed that the calculations for determining energy expenditure ($\text{kcal min}^{-1}$) and METs from activity counts as defined by Freedson, Melanson and Siard (1998) are valid and reliable equations ($r^2 = 0.82$).

7. It was assumed that on all testing days, participants followed testing instructions and abstained from caffeine, alcohol, and other drugs for 24 hours prior to the study.

8. It was assumed that participants made no drastic changes to their diet or engaged in an amount of exercise that would alter their fitness level over the course of the study.

**Definition of Terms**

1. Ballet: A theatrical art form using dancing, music, and scenery to convey a story, theme, or atmosphere; dancing in which conventional poses and steps are combined with light flowing figures (e.g., leaps and turns; Merriam-Webster Dictionary, 2010).

2. Contemporary/Modern: Contemporary dance emerged at the beginning of the 20th century as a breakaway from the rigid constraints of classical ballet (Angioi, Metsios, Koutedakis & Wyon, 2009). Contemporary dance draws on both modern and postmodern dance as a
source of inspiration. Modern dance today is much more sophisticated in technique and technology than when modern dance was founded (Wikipedia, 2010).

3. Dance: a human movement that is formalized with qualities such as grace, elegance, and beauty, to the accompaniment of music or other rhythmic sounds, for the purpose of telling a story and/or for the purpose of communicating or expressing human emotions, themes, or ideas (Guidetti et al., 2008).

4. Energy Systems: Anaerobic and aerobic systems. The anaerobic system refers to the breakdown of glucose to lactic acid in the production of ATP, in the absence of oxygen. The aerobic energy system refers to the process of utilizing oxygen to produce energy; long-term oxidative glycolysis (Wilmore, Costill, & Kenney, 2008).

5. Intensity: For men and women below the age of 60, the minimal or lower-limit target (threshold) heart rate stimulus for cardiovascular improvement ranges between 60% and 70% of HR\text{max}. The upper-limit target heart rate equals about 90% of HR\text{max} (American College of Sports Medicine [ACSM], 2006).

6. Jazz: Jazz dance is a contemporary form of movement whose origins rest in African dance, modern dance and ballet (Galanti et al., 1993). Faster movements set to up-tempo rhythms, using more free-style movement, normally characterize this style of dance.

7. MET: Metabolic equivalent. A simplified system for classifying activities where one MET is equal to the resting oxygen consumption, which is approximately 3.5 milliliters of oxygen per kilogram of body weight per minute (3.5 ml·kg\textsuperscript{-1}·min\textsuperscript{-1}) (American Council on Exercise, 2010).

8. Physiological Adaptations: The sum of all individual improvements, (metabolic, cardiovascular, muscular and respiratory) made to the body due to the physical stresses
placed upon it (McArdle, Katch, & Katch, 2006).

9. Tap: A dance in which the rhythm or rhythmical variation is audibly tapped out with the toe or heel by a dancer wearing shoes with special hard soles or with taps. The essence of tapping is similar to that of Irish dancing or clogging, in that the emphasis is on percussive footwork (Mayers, Judelson & Bronner, 2003).
CHAPTER 2
REVIEW OF LITERATURE

A review of current literature on the physiological aspects of dance is presented in this chapter. In particular, the aerobic and anaerobic demands of dance will be comparatively discussed. This chapter will also review fitness level, body composition and nutrition among dancers. Furthermore, commonly seen injuries related to all dance forms will be investigated. The effects of dance training (class and rehearsal) will be evaluated relative to a dancer’s overall fitness level. In addition, this section will investigate if supplemental conditioning is necessary for dancers, based on the intensity of dance training. The chapter concludes with a review of current research methods in dance science as well as research concerning the validity of testing procedures.

Dance Class

The nature of a dance class is to focus on movement vocabulary, technique, musicality, and the development of creativity and expression (Wyon et al., 2004). This traditional class structure focuses on the mastery of the art form. Research has shown that the exercises in which dancers engage in (i.e. dance classes and rehearsals) place little stimulus on their cardiovascular system (Wyon et al., 2007). Derka and Lehotsky (2007) state that a typical ballet class begins with warm-up exercises at the ‘barre’, which is used to provide balance. The exercises consist of plies, tendus, port de bras and battements. This time is used to increase whole-body and muscle temperature, increase joint articulation, and improve limb alignment (Wyon et al., 2004). The time spent dancing during ‘barre’ exercises is more continuous, although the intensity is low.

The second part of a dance class contains the ‘centre’ work. The exercises done in
‘centre’ are a combination of movements involving unsupported traveling steps similar to those seen on stage and require quick movements, with jumps and leaps designed to attain maximum elevation. The emphasis here is on speed and power for short durations (Cohen, Segal, Witroil, & McArdle, 1981). This phase is typically at a higher intensity although the actual exercise periods are shorter (30-45 seconds) with longer recovery periods (Wyon, et al., 2002). Wyon et al. (2004) determined that the ‘centre’ section typically has lower mean values for both oxygen requirement (VO$_2$) and heart rate (HR) because of the length of the rest periods. The majority of the class was spent in the lower end of the dancer’s theoretical aerobic training zone, which would not place enough stress on the system to elicit an aerobic training effect (Wyon et al., 2004). While these two sections of a dance class differ in exercise intensity (Wyon et al., 2002), the ‘centre’ section more closely resembles the physiological cost of a typical dance performance.

**Dance Rehearsal and Performance**

The rehearsal period is often a lengthy and complex period where the emphasis is on learning sequences rather than physiological preparation. Wyon and Redding (2005), analyzed if the cardiorespiratory demands of individual classes, rehearsals and performances, validated the predicted cardiorespiratory changes in contemporary dancers over an extended period of time. The time frame for this study encompassed twelve weeks of normal daily company routine (class or class with rehearsal) followed by eight weeks of performance. There were no significant changes in heart rate or lactate parameters during the rehearsal period. However, significant decreases in both parameters were seen during the performance period. The researchers stated that work intensity and exercise-to-rest ratio noted during the performance period were at a level to cause these adaptations. The results from the study
were reinforced from the dancers, who commented that they felt it took two weeks of performing before they felt physically capable of “performing fully”, concluding that aerobic fitness adaptations are taking place in the performance period only.

Conversely, Galanti et al., (1993), found that after ten weeks of jazz dance rehearsals (4 days a week for 60 to 120 minutes per session) participants saw a 15% increase in VO$_{2peak}$ and a 9.6% increase in treadmill time to reach VO$_{2peak}$. Possible explanations for the increases seen in this study, as opposed to others, were in the design of the rehearsal sessions, which were modeled after The American College of Sports Medicine (ACSM) guidelines. The subjects of the study were determined to be within the recommended heart rate range of 60-90% of maximum heart rate, while the rest intervals between dances were limited to less than two minutes. This further emphasizes the need to study diverse styles of dance, as the physiological responses are different for each, resulting in different adaptations.

Wyon et al. (2004), found significant differences in oxygen uptake between class (17.42 ml·kg$^{-1}$·min$^{-1}$), rehearsal (10.17 ml·kg$^{-1}$·min$^{-1}$), and performance (23.34 ml·kg$^{-1}$·min$^{-1}$) for female contemporary dancers. The percentage of ‘work time’ (work-to-rest ratio) suggests a greater reliance on the aerobic and anaerobic glycolytic systems during an actual performance than are elicited during dance classes (Wyon et al., 2004). In a separate study on contemporary dancers, Wyon and Redding (2005) highlighted the differences in energy system utilization during rehearsal and performance. It was found that no change in aerobic fitness occurred during the rehearsal period, but a significant increase during the performance period was seen. From these studies, conclusions were made that class and rehearsal did not prepare the dancers adequately for their performance period. Supplemental cardiorespiratory training needs to be planned and managed to the same extent as the rehearsal schedule to
allow dancers to peak for each performance period physically as well as technically (Wyon & Redding, 2005).

**Physiological Aspects of Dancers**

Researchers have concluded that male and female dancers of all different styles and levels have aerobic fitness levels similar to that of non-endurance athletes (Wyon et al., 2007; Koutedakis & Jamurtas, 2004). Maximal oxygen uptake levels for male and female elite ballet dancers were shown to be 51.9 ml·kg⁻¹·min⁻¹ and 50.1 ml·kg⁻¹·min⁻¹, respectively (Cohen et al. 1981). Schantz and Astrand (1984), found levels reaching 57 ml·kg⁻¹·min⁻¹ and 51 ml·kg⁻¹·min⁻¹ for male and female dancers. Dahlstrom, Inasio, Jansson & Kaijser (1996), reported similar values (54 ml·kg⁻¹·min⁻¹) in 88 female dance students, trained in four different styles, after 3 years of intense training. However, in the dance community, modern dancers have been shown to have higher VO₂max levels than their ballet counterparts (Koutedakis et al. 2007; Angioi, Metsios, Koutedakis, & Wyon, 2009).

These aerobic fitness levels indicate that unlike most athletes, whose aerobic fitness and performance levels increase in parallel during their careers, dancers develop these two parameters independently (Koutedakis & Jamurtas, 2004). The dance-only training system currently in use by most university and professional dance schools may account for this. As previously mentioned, there is a significant difference in the demands of dance classes versus rehearsals and performances. During dance class, the intensity of the ‘barre’ work is too low to stimulate cardiovascular adaptations. Whereas the 'centre' portion offers some periods of cardiovascular stress but is plagued with longer rest periods (Redding & Wyon, 2003). Schantz and Astrand (1984) determined the average oxygen uptake during a ballet class was about 40% of VO₂max. They continued on to say that the motional intensity during 'centre'
floor exercises was frequently very high, but the exercise periods were too short to evoke any high and prolonged strain on the circulatory system. Koutedakis et al. (2007) noted that fairly strenuous exercise intensities (for at least 20 minutes) are required to bring about increases in VO\textsubscript{2max}. It can be surmised from these studies that dance training (i.e. class and rehearsal) in general, does not provide the adequate stimuli for aerobic adaptations.

Dance performances have consistently been shown to elicit the highest responses in a dancer’s VO\textsubscript{2} and blood lactate (BLa) values compared to dance classes and rehearsals (Schantz & Astrand, 1984; Wyon et al., 2004). It is interesting to note that while a normal ballet class elicited a mean lactic acid blood level of 3 mmol/L in women, a choreographed solo part raised it to 10 mmol/L (Schantz & Astrand, 1984). This is the same value seen in top-class football, squash, and hockey players during an event (Koutedakis & Jamurtas, 2004). This emphasizes the variation in energy system utilization during the different aspects of a dancer’s training. Research suggests in these circumstances that all the energy systems are being utilized to meet the muscular demands for adenosine tri-phosphate (ATP), though short-term high-intensity exercise is often referred to as anaerobic exercise (Wyon, 2005). The percentage of contribution from each energy system is determined by the rate of demand for ATP by the muscle cell.

According to Wyon (2005), the availability of oxygen at the cellular level determines which pathway of two possibilities actually occurs. Generally, ATP is developed aerobically (oxidatively) via the mitochondria, but as the rate of energy demand increases, this system becomes increasingly inadequate as a means to provide the ATP. To help meet those demands, the anaerobic system (glycogenolysis) produces ever-increasing quantities of ATP. For sudden bursts of increased work, as in large jumps or fast articulate footwork, the muscle
cell has limited stores of ATP that can provide energy for only 5 to 10 seconds. When further powered by glycolysis, the anaerobic system can sustain high power outputs for 30 to 60 seconds; for example, during a series of adagios or an allegro jump combination (Koutedakis & Jamurtas, 2004).

The limitation of each system is the rate at which it can reach homeostasis after being depleted. Pascoe and Glassen (1996) found that phosphagen restoration was 70% recovered in the 30 seconds following exercise and completely restored in three to five minutes. Factors affecting creatine phosphate (CrP) restoration are the concentrations of ATP, ADP, and Creatine (Cr), along with the concentration of Hydrogen Ions (H\(^+\)). H\(^+\) increases create a low cell pH, which inhibits creatine kinase, thereby impairing the resynthesis of CrP (Pascoe & Glassen, 1996). This suggests that a 30-second recovery phase is long enough to allow sufficient replenishment of the CrP stores to cope with maximal-intensity short-duration exercise (Wyon, 2005). Therefore, the fact that dance is defined as an intermittent type of exercise means that in choreographed dances, exercise can be very demanding energetically, even if they only last a few minutes each. Conversely, it is shown that during the dancer’s basic training sessions the energy expenditure is lower (Schantz & Astrand, 1984), requiring the integration of all the energy systems.

**Body Composition and Nutrition**

Another physiological element that affects a dancer’s physical fitness is their typically low body weight/mass. The professional dancer’s body type is easily identifiable by their long necks, shorter torsos, as well as their long, thin and lean legs. They also present with external rotation of the legs, along with slight knee hyperextension (Derka & Lehotsky, 2007). Typical percent body fat for a ballerina ranges from 16%-18% (Koutedakis &
Modern dance encompasses a more athletic dance technique allowing these dancers to maintain a slightly higher lean body mass than classical ballerinas (Yannakoulia et al., 2000). Extreme body weight restrictions adopted by dancers, especially professional ballerinas, appears to limit increases in lean body mass (Koutedakis & Jamurtas, 2004). Increases in lean body mass could be beneficial in improving dance performances. Body weight targets are normally met by low caloric intake. Female dance students and professional ballerinas reported consuming below 70% and 80% of the recommended daily allowance of energy intake (Koutedakis & Jamurtas, 2004). Koutedakis and Jamurtas (2004) reported that only a small percentage of dancers receive dietary advice from qualified specialists, despite the fact that relevant reports have stressed that optimal dietary habits can positively affect dance performance.

Due to their lifestyle, the female ‘triad’ (disordered eating, amenorrhea and osteoporosis) is now well recognized and commonly seen in dancers (Koutedakis & Jamurtas, 2004). This is a result of intense training coupled with an energy-restricted diet, as well as imbalances in hormones, such as luteinizing hormone and estrogen (Keay, Fogelman, & Blake, 1997). Women with exercise-induced amenorrhea frequently present with osteopenia, which is defined as having bone mineral density (BMD) lower than normal, but not low enough to be classified as osteoporosis (Shangold & Sherman, 1998). This may result from reduced bone accretion in adolescence or premature bone loss (Warren et al., 2003). Since amenorrheic dancers have been known to have reduced levels of bone mineral, it is important to determine to what extreme this detriment is, and if this places them at a high risk for osteoporosis later on in life.

Keay et al. (1997) determined that a dancer’s lifestyle of intense training in
combination with caloric restriction, in turn, outweighs the benefits that dance has as a weight bearing exercise (which would normally increase BMD). This places dancers at an immediate risk of fracture and also for developing early osteoporosis. The model constructed from their results quantifies the important environmental factors of delayed menarche, and low body weight on BMD. The researchers concluded that dancers need to be vigilant about any prolonged periods of amenorrhea, in an attempt to avoid early decreases in BMD (Keay et al., 1997).

**Dance-Related Injuries**

Previous literature has assessed various health factors in elite dancers including nutritional status, body composition, risk factors, and injuries that occurred (Guidetti et al., 2008). Koutedakis and Jamurtas (2004) reported that over a 12-month period almost 50% of a large sample of dancers reported 1-6 days off due to musculoskeletal injury. These injuries are most commonly from fatigue, overuse, unsuitable floors, difficult choreography and insufficient warm-up (Koutedakis & Jamurtas, 2004). A recent survey reported an 80% injury occurrence for dance professionals in the UK, with the main perceived cause of injury being fatigue (Wyon et al. 2007). As previously stated, it has been suggested that supplemental training and an increase in the overall fitness of dancers might circumvent such problems. According to Wyon (2005), by increasing a dancer’s VO$_2$max, it allows them to carry out the same exercise at a lower relative workload, thereby delaying the effect of fatigue. Stacey (2004) recommends dancers participate in body conditioning classes during adolescence to promote proximal growth and prevent unnecessary stress to the epiphyseal joints during development.

Most research on dance injuries has been contained to populations of ballet dancers,
who seem to experience the highest amount of time off due to injury. This may be due to the fact that the injury recovery process takes longer in dancers with reduced muscular strength. Ballet dancers have been shown to have the lowest body mass of all dancer populations, possibly leading to their increased injury rates. The prolonging of recovery time may be due to the fact that with reduced muscular strength, joints are surrounded by weaker soft tissue and are subject to more strain when overexerted (Angioi et al., 2009). Additionally, when connective tissue of a muscle is weak, it is more likely to become damaged due to overstretches, or sudden, powerful muscular contractions (Koutedakis et al., 2005). Strengthening the muscles bound by the connective tissue can reduce the likelihood of such an injury and reduce time off due to injury.

In the first study of its kind, Mayers, Judelson, and Bronner (2003) determined the injury rates and patterns of experienced tap dancers. The difference between tap dance and other forms of dance and athletics is the percussive footwork. Their results showed lower injury rates for tap dancers than were reported for other dance styles, with a range of .26 to .42 injuries per 1000 hours of dance exposure.

**Supplemental Physical Training**

The majority of a dance class is spent between 10 and 25 ml·kg⁻¹·min⁻¹ (Guidetti et al., 2008; Koutedakis & Jamurtas 2004; Koutedakis et al., 2007), which is equal to 20%-50% of typical VO₂max levels in dancers. In a typical stage performance, intensities can reach 70-80% of VO₂max (Koutedakis & Jamurtas, 2004), showing again that dance class alone is not sufficient enough in preparing dancers for performance level stresses. Wyon and Redding (2005) suggest an enhancement of the aerobic system, most likely at the pre-rehearsal stage, to allow the dancer to build up their physiological capability to cope with the stresses during
a performance. The benefits of supplemental physical training alongside skill training have been widely acknowledged within athletics, but it is a relatively new concept in dance and especially ballet (Wyon et al., 2007). Wyon & Redding (2005) suggest the use of a ‘training impulse’ within an interval-based program as a means of monitoring the training effect of dance-based activity. This training needs to be planned and managed to the same extent as rehearsals are, to allow dancers to peak for each performance period (Wyon & Redding, 2005).

In a study by Koutedakis et al. (2007), a supplemental aerobic and strength training program was incorporated into modern dancer’s weekly routines. Similar with other studies of its kind (Wyon et al., 2007), their findings showed significant improvements in the key fitness parameters of aerobic capacity, muscular strength, and flexibility following a training program. Furthermore, it was shown that even supplemental, self-administered exercise regimens brought about increases in VO2max (Koutedakis & Jamurtas, 2004). Since these parameters are linked to better oxygen transport mechanisms and enhanced neuromuscular functions, Koutedakis et al. (2007) inferred that the supplemental training would, in turn, affect key elements of physical performance through reduced fatigue and injury rates. Even so, the proven benefits of supplemental training are not enough for some dancers to include it into their routine training schedule.

It is widely believed that strength training and muscular strength development would diminish a dancer’s aesthetic appearance, but data on male and female dancers proves otherwise. It has been shown that supplemental resistance training for the hamstrings and quadriceps muscle groups could lead to improvements in strength, without interfering with key artistic and physical performance requirements (Koutedakis & Sharp, 2004). It was also
shown that during two separate three-month studies (both on the effects of strength training for dancers) that appropriate exercise training was found not to be detrimental to the dancer’s aesthetics, or their performance (Koutedakis et al., 2007; Koutedakis & Sharp, 2004). The participants in these studies actually felt that their physical appearance was enhanced in conjunction with their dance performance. This research disproves the popular myth and demonstrates that an increase in muscle strength does not alter selected aesthetic components.

If supplemental training is to be included in a dancer’s schedule then the specificity of cardiorespiratory development should be met within the actual rehearsal process, ideally with a periodized training process consisting of three stages as suggested by Wyon (2005). The first stage develops an aerobic foundation (intensity between 60% and 80% of VO\(_{2}\text{max}\), 70% to 90% HR\(_{\text{max}}\), or 14-17 RPE). The second stage facilitates maximal aerobic power (increasing a dancer’s VO\(_{2}\text{max}\) through interval training to delay the effects of fatigue). The last stage would be to develop the 'fast' glycolytic system.

In addition to technique training, conditioning classes should be included or supplemented into the dancer’s training regimen. Conditioning class could, and ideally should, utilize dance movements to elicit a training effect by lengthening the dance periods during 'centre' work and reducing the rest time (Wyon, 2005). The emphasis would need to be on the training effect rather than movement accuracy, although this brings up concerns of causing a deterioration of skill. Wyon (2005) suggested that the substitution of one to two dance classes a week with physical conditioning would be enough to stimulate physiologic adaptations without interfering with technique, although this is yet to be proven.

Frequency of supplemental training needs to be addressed with caution as to not
increase the injury rate and occurrence of overtraining. Koutedakis et al. (1999) showed that six weeks of summer vacation, following a year of professional dance, resulted in significant increases in selected physiological parameters associated with physical fitness and conditioning. This is in contrast to previous literature that suggests de-conditioning occurs when formal exercise stops. They concluded that the findings support the hypothesis of a “burnout” phenomenon at the end of a professional dance season, which negatively affects the mechanisms of fitness and conditioning. Additionally, overtraining can lead to a compromise of the immune system (Koutedakis & Jamurtas, 2004), only increasing a dancer’s chance for fatigue and injury.

These reasons demonstrate why more physiological research is necessary regarding dance. There is an importance in testing dancers and dance movements so that more effective and appropriate training programs can be prescribed. Therefore, creating better athletic performers who are better able to cope with the new demands of dance choreography (Redding & Wyon, 2003).

**Research Methods in Dance Science**

Dancers as a population have been overlooked in the realm of research, especially in the field of sports medicine and science. In the *Compendium of Physical Activities* by Ainsworth et al. (2000), the dance styles of ballet, jazz, tap, modern, twist and jitterbug were all “coded” or grouped together to have the same metabolic equivalent (MET) level. This is an upgrade from the original 1993 version, which included only ballet and modern dance styles. It is interesting to note that the dance forms mentioned are “coded” together as one cohesive group, when there are 10 separate forms of “inactivity” in the same report. Another interesting point to make is these dance styles were reported to have a MET level of 4.8
According to the report, this is the same amount of METs used in hunting, maple syruping, finishing cabinetry, weeding, and orange grove work (Ainsworth et al., 2000). Additionally, these levels were obtained from some previously published data as well as through a 365-day physical activity recall questionnaire. Meaning that some of the MET values obtained were not derived from indirect calorimetry, and are just estimates. This demonstrates again why more research into the physiological demands and energy expenditure of dance is necessary.

Collecting data on dancers is not always easy, and this may explain why there is so little research done in this field. The transitory and intermittent nature of dance has made it difficult to accurately measure the physical parameters of energy requirements and training development within a dance-specific setting (Redding & Wyon, 2003). If more professional dancers and educators were made aware of the positive adaptations to dance training, it might enhance attitudes toward the importance of testing dancers and dance movements so that more effective and appropriate training programs can be prescribed.

Direct measurement of the physiological cost of dance has, until recently, proven problematic as many forms of gas collection and analysis have lead to potential movement restrictions (Redding & Wyon, 2003). Other studies have employed the use of heart rate monitors, which overcame the movement restrictions but did not take into account potential variations in the heart rate-oxygen relationship between dance and steady-state exercise (Redding, Wyon, Shearman, & Doggart, 2004). They assessed the validity of estimating VO₂ during modern dance from the HR/VO₂ relationship, established from an incremental treadmill test. Findings indicated there could be a difference of 31 bpm at 10 ml·kg⁻¹·min⁻¹ and 49 bpm at 60 ml·kg⁻¹·min⁻¹ during a modern dance class. Results from Redding et al.
(2004) also suggest that an individual with a heart rate of 200 bpm could possibly have values anywhere between 151 and 249 bpm if the same dance class was repeated, due to measurement error.

During dance exercise, the relationship between heart rate and oxygen consumption is weaker \((r = 0.68)\) thus making it more difficult to estimate oxygen demands from heart rate values with accuracy (Redding et al. 2004). A possible reasoning behind this low correlation is that heart rate, although well correlated with direct measures of aerobic demand \((\text{VO}_{2\text{max}})\) for steady-state exercise, can over-estimate aerobic demand for dancers by as much as 40% (Welsh, 2003). This is due to the inclusion of isometric work, bursts of high-energy activity, and movements where the arms are held higher than the heart. However, the relationship between heart rate and oxygen uptake is still widely accepted (Astrand & Rhyming, 1954; Astrand & Saltin, 1961; Wyndham et al., 1958) and utilized by many researchers for studies on non steady-state exercise (Bot & Hollander, 2000; Lothian & Farrally, 1995; Strath et al., 2000). Baladari and Guidetti (2001), who compared fitness levels of gymnasts and dancers, actually concluded that parameters such as heart rate and \(\text{VO}_2\) measured at less than maximal load could be considered to be more reliable indicators of fitness level than maximal oxygen intake. Heart rate has also been utilized in dance testing as a valid predictor of cardiac demands (Guidetti, Gallotta, Emerenziani, & Baldari, 2007; Maxfield & Brouha, 1961).

Resting heart rate is variable among individuals with heart rate being dependent on age, cardiovascular endurance, time of day, gender, as well as food and beverage intake. Resting heart rate alone is not used to assess cardiovascular functioning, but is essential for establishing a baseline for assessing heart rate response to exercise. Heart rate monitors have been consistently used in testing dancers and dance movements due to their widely accepted
validity (Moore, Lee, Greenisen, & Bishop, 1997; Rixon, Rehor, & Bemben, 2006). The use of relatively inexpensive heart rate monitors can reduce a significant source of error during a test. Testing of commercially available heart rate monitors has validated the use of this tool to determine exercise intensity in the laboratory, in field settings, on children and adults, as well as at rest and during exercise (Treiber, et al., 1989; Welk & Corbin, 1995).

Despite advances in technology, which have allowed for better physiological monitoring during dance activities, dancers still pose a special challenge for those wishing to measure their maximal aerobic capacities since the training and movement demands faced by dancers make some traditional tests of physical capacities difficult (Welsh, 2003). It has been noted that dancers experience mechanical problems when running and walking due to highly developed eversion and limited dorsiflexion capabilities of the ankle, therefore making traditional field testing unsuitable for this population (Wyon, Redding, Abt, Head & Sharp, 2003). Creating a field test for a specific population of dancers would provide the ability to measure base fitness levels and training adaptations, ensuring dancers obtain necessary levels of fitness. However, due to the fact that dance science is a relatively new research area, an appropriate and specific field test for dancers has only recently been validated. Wyon et al. (2003) aimed to produce a continuous incremental five-stage aerobic fitness test that used dance specific movement. Each one of the five stages would correspond to the mean oxygen requirements of dance classes as well as dance performances. Overall, the test was shown to be a valid and reliable field test capable of measuring a dancer’s physiologic ability to handle the sub-maximal aerobic demands of class and performance.

Although field-testing allows those without access to laboratory equipment the ability to monitor fitness levels and predict maximal exercise values, directly measuring maximal
aerobic capacities is the most accurate method, but still proves problematic in dancers. Redding et al. (2009) aimed to develop an intermittent high-intensity dance-specific fitness test. Results showed that four of the five dancers involved were found to be working above their determined \( VO_{2\text{max}} \) during a dance performance, showing that the dancers pushed themselves harder while dancing than during an incremental treadmill test. This conclusion further substantiates the need for dance-specific methods of measuring physiological parameters. This new dance-specific fitness test requires further research for cross-validation.

As mentioned earlier, the most accurate assessment of one’s \( VO_{2\text{max}} \) should be obtained in a laboratory using appropriate metabolic analyzers, but this is not always feasible with the population and activity being measured, as it provides many restrictions. Both single-stage and multistage submaximal exercise tests are available to predict \( VO_{2\text{max}} \) from simple heart rate measurements. The Astrand and Rhyming (1954) single stage method lasts six minutes where work rate is based on gender and fitness level. In contrast, Martiz et al. (1961) measured HR during a series of stages and extrapolated the response to the subject's age-predicted maximal heart rate. This protocol, best known as the YMCA bike test, has become one of the most popular assessment techniques to estimate \( VO_{2\text{max}} \) and has been validated against other fitness assessment methods (Beekley, et al., 2004).

To additionally assess physical activity in a field setting, many researchers have turned to accelerometers. These 'activity monitors' use dual- or tri-axial accelerometers to measure human motion against the force of gravity. This technology was first developed in the early 1990s by the U.S. military to measure the performance levels of troops. In the following years, the applications for the science of accelerometry have grown to include physical activity research, sleep diagnostics, rehabilitation monitoring, obesity and diabetes
prevention, and sports medicine. Accelerometers are capable of determining individual activity levels as well as energy/caloric expenditure, duration/intensity of sustained activity, daily activity profile, limb/extremity movements, and steps taken during a designated time frame. (Actigraph, 2010).

Studies have validated the use of Actigraph accelerometers to determine moderate to vigorous activity, as well as VO\(_2\) and METS (Mattocks et al., 2007). A study by Mattocks et al. (2007) found that Actigraph 'activity counts', when adjusted for age and fitness, could correctly predict energy expenditure across a wide range of activities. This study was also able to determine VO\(_2\) from the activity counts obtained during 'free-living activity'. From that data, researchers were capable of validating moderate to vigorous activity cut-off points to be employed when using Actigraph accelerometers. This knowledge can be beneficial for future studies on dancers as accelerometers are compact and easily worn for longer durations without interference on daily living. To the knowledge of this researcher, no data exist on utilizing accelerometers to compare energy expenditure between the dance styles of the current study.

The assessment of body composition of dancers has been widely studied, as dancers are a unique population of performing athletes, presenting with typically low percent body fat. Body composition is a critical component in the determination of one's overall health as an excess can lead to a multitude of diseases. Basic body composition can be expressed as the relative percentage of body mass that is fat and fat-free tissue (ACSM, 2006). Body composition can be estimated through a variety of laboratory and field techniques. Measurements of height, weight, circumferences, skinfolds, bioelectrical impedance, and hydrostatic weighing are all methods used to estimate body composition. Although skinfold
measurements are more difficult than other anthropometric procedures, they provide a better
estimate of body fat if accurately taken. Estimation of body fat percent utilizing skinfold
measurements is more intrusive on the subjects than other methods and yields an error on ±
3.5%, as it is highly sensitive to human error (ACSM, 2006).

The bioelectrical impedance (BIA) method is a more recent technique developed to
measure body fat percentage. The BIA method utilizes a low-level current that flows through
the mass of the body. The current flows more rapidly through hydrated fat-free mass
compared to fat or bone tissue because of greater electrolyte content (McArdle, Katch, &
Katch, 2006). Generally, the accuracy of BIA is similar to that of skinfolds, as long as the
correct protocol is followed for the population being tested. It has been found that the BIA
method can accurately estimate the body composition of female dancers ($r^2 = 0.83$)
(Yannakoulia, et al., 2000).

For this investigation the aforementioned instruments and techniques are the most
appropriate and reliable. Being that this study surrounds a special population, certain
instruments and techniques can prove unreliable and problematic. Implementing the
previously discussed techniques will aid in the validity of this investigation.

**Summary**

Studies have concluded that dance classes typically fall below the work intensity
required to elicit an aerobic training effect. On the other hand, dance performances have been
shown to place greater demands on the energy systems than both classes and rehearsals.
Previous research has also shown that supplemental exercise training does in fact
significantly increase aspects of dance performance, with concomitant increases in selected
fitness-related parameters. Additionally, the research discussed demonstrates differences
between dancers of different styles as well as the dance styles themselves. These studies all suggest that further physiological research in regards to dance is necessary.
CHAPTER 3

METHODS AND PROCEDURES

The purpose of this study was to determine if there are significant differences in metabolic equivalent (MET) or energy expenditure levels between ballet, modern, jazz and tap dance utilizing heart rate (HR) monitoring, as well as accelerometry. A secondary purpose of this study was to evaluate the validity of an ActiGraph equation for predicting METs or energy expenditure as compared to the calculated METs from the HR data. This chapter includes description of the subjects, the pre-testing procedures as well as testing protocols, and the statistical treatment of the data.

Participants

Trained dancers from the State University of New York (SUNY) College at Cortland were used as participants in this study. During the Fall 2010 semester, participants were recruited from two SUNY Cortland dance clubs, “The Cortland Dance Company” and “Danceworks”. A total of approximately 50 subjects were verbally invited to take part in the study. However, the goal of the lead researcher was to utilize between ten and fifteen trained dancers. This exceeds the required number of subjects necessary for statistical power (set at 0.8). Based on a pooled standard deviation, an estimated effect size was calculated (0.98) and input into G*Power software version 3.1.2 to calculate sample size (Faul, Erdfelder, Buchner, & Lang, 2009). According to G*Power software, the number of subjects necessary for statistical power in a study of this nature was estimated to be three. Because the outcome of interest for this study was reported as energy expenditure or METs, the investigations by Cohen et al. (1981) and Noble and Howley (1979) were utilized in determination of sample size.
When recruiting participants, the lead researcher informed the students as to what
their participation would include, as well as the risks and benefits involved with the study.
Potential participants were required to be experienced dancers with at least five years of
dance training. Students interested in participating were asked to contact the lead researcher.
Those who were interested in participating were asked to complete a survey to determine
dance experience. This survey also asked for participant contact information (phone number
and/or email address) (Appendix A). In addition to the survey, each participant completed a
health readiness questionnaire, which included a Physical Activity Readiness Questionnaire
(PAR-Q) (Appendix B). The lead researcher collected all completed forms.

Participants were chosen based on their availability, current health status and overall
experience with the dance styles studied in this investigation. A total of seven students who
met technical and physical activity requirements were invited to participate via email.
However, one participant failed to attend any of the testing sessions other than pre-testing
and therefore her data was omitted.

Prior to testing all procedures were approved by the SUNY Cortland Institutional
Review Board (Appendix C). The standards of the board were followed to ensure the safe
and ethical treatment of all subjects. In addition, confidentiality was maintained by removal
of all identifying characteristics from finalized data. Prior to the pre-testing session the lead
researcher offered to read aloud the informed consent form (Appendix D). The participants
then had the opportunity to read and sign it if in agreement.

Instrumentation

Weight was measured by using an electronic scale. A stadiometer was used to
measure height. Body fat percentage was measured using the bioelectrical impedance (BIA)
method (Omron HBF-306C). Appropriate BIA testing procedures were followed according to the American College of Sports Medicine (ACSM, 2006). Resting HR was measured using a heart rate monitor (Polar E600, Finland), in which the receiver was worn around the chest with a matching and coded display unit on the wrist. Resting oxygen consumption (VO$_2$) was measured using a MedGraphics VO2000 portable analyzer (St. Paul, Minnesota) with BreezeSuite 6.4.1 software.

An accelerometer (Actigraph GT1M, Pensacola, FL) was utilized to determine ‘activity counts per unit of time.’ The GT1M accelerometer is a compact dual-axis device that measures and records activity counts and steps taken. These data are then used to determine individual METs and energy expenditure. The GT1M features a direct USB connection, a rechargeable battery, one MB of memory and requires no field calibration (Actigraph, 2010).

A submaximal YMCA cycle ergometer test (Martiz et al., 1961) was performed to predict maximal oxygen consumption using a Monark (Ergomedic 828 E) ergometer. A metronome, stopwatch, and a HR monitor were all used for the cycle test.

**Pre-Testing**

Pre-testing sessions were held prior to the start of the study. All participants met with the lead researcher for approximately 45 minutes at a time convenient for them. All participants were e-mailed testing procedures at least 72 hours prior to their session (Appendix E). The instructions asked the participants to abstain from alcohol, caffeine, and other drugs 24 hours before testing began. Subjects were also asked to eat the same diet on all testing days and wear the same clothes to all testing sessions. Participants were asked not to engage in moderate to vigorous exercise within 12 hours prior to testing.
The pre-testing session consisted of obtaining anthropometric data from the dancers such as height, weight, age and percent body fat (%BF). It has been found that BIA can accurately be used for the estimation of the body composition in female dancers (Yannakoulia, et al., 2000). From these data, fat-free mass was calculated (Body mass - fat mass).

Additionally, during the pre-testing session, resting HR and VO\(_2\) were obtained. These were measured by having the dancers remain seated in a quiet area for 20 minutes of rest. Each participant was assigned and equipped with a coded heart rate monitor to determine resting HR values. After the 20 minutes, resting HR values were recorded for all subjects. It has been previously determined that heart rate recording is valid in both the laboratory (Treibet et al., 1989) and field settings (Moore, Lee, Greenisen, & Bishop, 1997). The participants were also individually measured for their resting oxygen consumption (ml·kg\(^{-1}\)·min\(^{-1}\)) using open-circuit spirometry. Subjects breathed through a low-resistance valve while pulmonary ventilation and expired fractions of O\(_2\) and CO\(_2\) were measured using a portable VO\(_2\) analyzer. The system was calibrated before each test using room air (21\% O\(_2\), 0.03\% CO\(_2\)). VO\(_2\) data was continuously measured using breath-by-breath analysis for the entire resting period. After the 20 minutes was completed, a resting VO\(_2\) value was recorded. At the time of testing, equipment was malfunctioning; therefore a standard value of 3.5 ml·kg\(^{-1}\)·min\(^{-1}\) was used for all participant’s resting VO\(_2\) value (McArdle, Katch, & Katch, 2006).

After resting measurements were determined, each participant completed a submaximal cycle ergometer test, using the YMCA protocol, to predict their maximal VO\(_2\) (ACSM, 2006). To begin the submaximal cycle ergometer test, the seat of the cycle
ergometer was adjusted for comfort and proper fit. The protocol for the submaximal test (ACSM, 2006) consisted of two to four three-minute stages of continuous exercise (50 revolutions per minute [rpm]) at which the participant’s heart rate was monitored until a steady-state heart rate (within five beats per minute [bpm] of the previous minute) was reached. This multistage protocol involved a progressive increase in workload based on the subject’s heart rate response during exercise. The heart rate was measured during the last minute of each steady-state stage until the participant had completed two stages above 110 bpm and below 85% of HR_max. From this, the participant’s estimated maximal exercise values were calculated using the formulas from the Canadian Society for Exercise Physiology (2010).

The slope of the line based on the HR response to the last two workloads:

\[
\text{Slope (b)} = \frac{\text{SM}_1 - \text{SM}_2}{\text{HR}_2 - \text{HR}_1}.
\]

\[
\text{VO}_2\text{max} = \text{SM}_2 + [b \times (\text{HR}_{\text{max}} - \text{HR}_2)].
\]

Where \(\text{SM}_1\) is equal to the \(\text{VO}_2\) at the second to last workload, \(\text{SM}_2\) is equal to the \(\text{VO}_2\) at the last workload, \(\text{HR}_1\) is the heart rate at the second to last workload, and \(\text{HR}_2\) is the heart rate at the last workload. To find the \(\text{VO}_2\) (ml·kg\(^{-1}\)·min\(^{-1}\)) at the different workloads the following formula was used:

\[
\text{VO}_2 = (\text{workload} / \text{body mass} \times 10.8) + 3.5 + 3.5.
\]

Where workload was measured in Watts (W) and body mass in kilograms (kg). All pre-testing information was recorded on individual data sheets by the lead researcher (Appendix F). Participant characteristics are displayed in Appendix G.

**Testing Protocol**

Testing sessions took place once a week for five consecutive weeks, including one
make-up session. All testing sessions took place at the same time of day. Testing sessions lasted approximately 60 minutes and each session tested a different dance style (jazz, tap, ballet, & modern). The dance style tested during each session was chosen at random by an unbiased colleague by picking a coded number from a cup prior to the start of testing. Order of completion was determined to be modern, tap, ballet, and then jazz.

On testing days, the participants were fitted with their assigned heart rate transmitter (Polar Team 2, Finland) as well as their assigned accelerometer. The ActiGraph accelerometer was placed in a nylon pouch and attached to a flexible elastic belt that was fastened snugly around the waist of the participant. The accelerometer was positioned on the right midaxilla line at the level of the iliac crest (Trost, Way & Okely, 2005). The heart rate monitor was fitted to the subject and positioned at the level of the xyphoid process. The participants did not wear the coded, or matching, wrist display unit as to avoid bias.

The same instructor taught all of the testing sessions. The protocol for each testing session began with a six-minute warm-up. This warm-up consisted of three minutes of light free jogging, where the intensity ranged from 25-35% of the participants heart rate reserve (HRR). This was followed by three minutes of dynamic stretching (10-20% HRR). Thereafter, the subjects executed 20-30 minutes of dancing in the specific style, followed by a five-minute cool-down (Appendix H). It is shown that it takes two to three minutes for heart rate to rise to the level representative of the activity (Strath et al., 2000). A minimum of 20 minutes of dance is employed here to determine an average MET level for the movements indicative of each style, as well as to be representative of a typical dance class format. The movements performed for each dance style were determined from a survey conducted on a panel of dance experts in order to avoid bias by the lead researcher conducting the dance
testing sessions (Appendix I). The tempo utilized for each session was the traditional tempo representative of the movements performed for each style (Appendix J). Tempos ranged from 40 bpm to 126 bpm across all styles, with an average of 83 bpm.

**Calculations**

Heart rate data was stored and downloaded to a computer program through the coded HR transmitter using the Polar Team 2 software. To calculate MET levels for each of the dance styles individual activity heart rates were utilized. For all participants, recorded mean HR values for each dance style were transformed to %HRR values utilizing the Karvonen (or heart rate reserve) method (Karvonen, Chwalbinska-Moneta, & Saynajakangas, 1984):

\[
%HRR = \left( \frac{\text{activity HR} - \text{resting HR}}{\text{estimated HR}_{\text{max}} - \text{resting HR}} \right) \times 100\%.
\] (4)

Where HR\(_{\text{max}}\) was assumed to equal 220-age (years) (Karvonen, Kertala & Mustala, 1957).

The relative intensity of the exercise bout was determined by %VO\(_2\)\(_{\text{reserve}}\), rather than %VO\(_2\)\(_{\text{max}}\), as it has recently been shown to more accurately reflect %HRR (Swain & Leutholtz, 1996; Swain, Leutholtz, King, Haas & Branch, 1998). Therefore, based on this research, %HRR would equal %VO\(_2\)\(_R\) for each dance style. Percent %VO\(_2\)\(_R\) was then transformed into relative oxygen consumption (ml·kg\(^{-1}\)·min\(^{-1}\)) using the following formula:

\[
%\text{VO}_2\text{R} = \left[ \frac{\text{activity VO}_2 - \text{resting VO}_2}{\text{estimated VO}_2\text{max} - \text{resting VO}_2} \right] \times 100\%.
\] (5)

Where activity VO\(_2\) was solved for using predicted VO\(_2\)\(_{\text{max}}\) from the submaximal cycle ergometer test, and the standard resting VO\(_2\) value of 3.5 ml·kg\(^{-1}\)·min\(^{-1}\) (ACSM, 2006). VO\(_2\) (ml·kg\(^{-1}\)·min\(^{-1}\)) was converted to METs by dividing by 3.5. After adjusting for age and fitness level, heart rate was shown to be a strong predictor (r = 0.87) of energy expenditure using the previous formulas according to Strath and colleagues (2000).

Accelerometer data were stored in the memory of the device and directly downloaded
to a computer via the USB connection. Individual activity counts were recorded for each subject by the accelerometer at a rate of 32 hertz. To calculate energy expenditure and METs from individual activity counts, two prediction equations by Freedson, Melanson, and Sirad (1998) were employed, respectively:

\[
\text{kcal min}^{-1} = (0.00094 \times \text{counts per minute}^{-1}) + (0.1346 \times \text{body mass in kg}) - 7.37418. 
\]

(6)

\[
\text{MET} = 1.439008 + (0.00079 \times \text{counts per minute}^{-1}). 
\]

(7)

**Statistical Analysis**

Minute-by-minute values were obtained for accelerometry during each test session while HR data were recorded in five-second intervals for each session. For each subject, the mean HR (bpm) and accelerometry data (activity counts) were computed for the minutes spent performing the dance style during each session (the time after the warm-up and before the cool-down). Average MET values were calculated from the HR and accelerometry data as per the equations from Strath et al., (2000) and Freedson, et al. (1998), respectively. It is these MET values that were used for comparison and statistical analysis between styles. All calculations for %HRR and %VO_{2\text{reserve}} were corrected for age and fitness level (ACSM, 2006).

Statistical analyses were run using PASW (SPSS) versions 18 & 19 for Windows. An alpha value of 0.05 was set to determine statistical significance. A one-way within-subjects repeated measures analysis of variance (ANOVA) was utilized to determine any significant differences between the four dance styles in terms of MET levels utilizing the HR data. A t-test was run to determine a significant difference between the mean MET value obtained in this current study for all dance styles versus previously reported values. A linear regression
analysis was also performed to examine the relationship between the METs obtained from
HR monitoring and accelerometry. Lastly, a 4x4 two-way within-subjects repeated-measure
ANOVA was run to determine significant differences in percent time spent in light, moderate,
hard, and very hard physical activity between all dance styles based on the activity count cut-
off points.
CHAPTER 4

RESULTS AND DISCUSSION

The purpose of this study was to determine if there are significant differences in metabolic equivalent (MET) or energy expenditure levels between ballet, modern, jazz, and tap dance utilizing heart rate (HR) monitoring, as well as accelerometry. A secondary purpose of this study was to evaluate the validity of an ActiGraph equation for predicting METs or energy expenditure as compared to the calculated METs from the HR data. Participants took part in four separate dance classes, one for each style tested. Heart rate and accelerometer data were recorded during all testing sessions.

Results

A one-way within-subjects repeated measures analysis of variance (ANOVA) was run to determine any significant differences between the four dance styles in terms of MET level utilizing the HR data. There was no significant effect on the style of dance, $F(3,9) = .546, p = .663$, partial $\eta^2 = .15$. This means that the four styles of dance did not differ significantly from one another in terms of MET level. However, when the average MET value from this study was compared to the 4.8 MET value reported by Ainsworth et al. (2000) in the *Compendium for Physical Activities* using a t-test, a significant difference was found, $t = 6.270$, df = 18, $p < .0005$, two-tailed. Meaning that the average of all four independent variables (ballet, jazz, tap, and modern), $M = 6.3$, was found to be significantly higher than the previously value of 4.8 METs. Average MET levels for all four dance styles based on the HR data are displayed in Table 1. Data for all participants are displayed in Appendices K and L.
Table 1

*Average MET Values for Dance Style Using Heart Rate Data*

<table>
<thead>
<tr>
<th>Dance Style (MET)</th>
<th>Modern</th>
<th>Tap</th>
<th>Ballet</th>
<th>Jazz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>6.44</td>
<td>5.91</td>
<td>6.2</td>
<td>6.63</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>0.933</td>
<td>1.07</td>
<td>0.365</td>
<td>1.73</td>
</tr>
</tbody>
</table>

Using data obtained from the accelerometers, and the calculations from Freedson, Melanson, & Sirad (1998), average MET level for each dance style was determined and is displayed in Table 2. After visually inspecting the data it could be observed that the average MET values obtained using activity counts versus heart rate data varied greatly in this study. Figure 1 shows the variation in MET values obtained in this study by comparing the values from the HR data and those from the accelerometer data.

Table 2

*Average MET Values for Dance Style Using Accelerometer Data*

<table>
<thead>
<tr>
<th>Dance Style (MET)</th>
<th>Modern</th>
<th>Tap</th>
<th>Ballet</th>
<th>Jazz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>3.36</td>
<td>2.8</td>
<td>2.78</td>
<td>2.77</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>0.227</td>
<td>0.443</td>
<td>1.03</td>
<td>0.254</td>
</tr>
</tbody>
</table>
A 4x4 two-way within-subjects repeated-measures ANOVA was run to determine if there was a significant difference in percent time spent in light, moderate, hard, and very hard physical activity between all dance styles based on the activity count cut-off points. The cut-off points utilized in this study were those published by Freedson et al. (1998), and are presented in Table 3. The main effect of activity level was significant, $F(3,9) = 160.336, p < .0005$, partial $\eta^2 = 9.82$. The main effect of dance style was not significant, $F(3,9) = 1.00, p = .436$, partial $\eta^2 = .250$. There was a significant interaction between activity level and dance style, $F(9,27) = 13.441, p < .0005$, partial $\eta^2 = .818$. The percent time spent in all activity levels for all dance styles are shown in Figures 2 through 5 below. These figures show that the most percentage of time was spent in light and moderate physical activity for all dance styles according to the accelerometer activity count cut-offs. Data for all participants are displayed in Appendix M.
Table 3

*Activity Cut-Off According to MET Level*

<table>
<thead>
<tr>
<th>Activity Intensity</th>
<th>MET Range</th>
<th>Activity Counts (cnts\cdot min^{-1})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light</td>
<td>&lt; 3.00</td>
<td>&lt; 1952</td>
</tr>
<tr>
<td>Moderate</td>
<td>3.00-5.99</td>
<td>1952-5724</td>
</tr>
<tr>
<td>Hard</td>
<td>6.00-8.99</td>
<td>5725-9498</td>
</tr>
<tr>
<td>Very Hard</td>
<td>&gt; 8.99</td>
<td>&gt;9498</td>
</tr>
</tbody>
</table>


*Figure 2.* Percent time spent in light, moderate, hard, and very hard physical activity during modern dance.

*Figure 3.* Percent time spent in light, moderate, hard, and very hard physical activity during tap dance.
Figure 4. Percent time spent in light, moderate, hard, and very hard physical activity for ballet.

Figure 5. Percent time spent in light, moderate, hard, and very hard physical activity for jazz dance.

Since the accelerometer and heart rate data clearly varied in terms of their calculated MET levels, a linear regression was run to show the proportion of variance accounted for between the two variables. Although a significant model emerged, $F(1,17) = 5.003, p < .05$, the model explains less than 20% of the variance (Adjusted $R^2 = .182$). This demonstrates that accelerometers are not a reliable predictor for MET levels based on HR data, and vice versa (Figure 6).
Figure 6. A linear regression of MET levels based on accelerometer and HR data. The regression line indicates a weak explanation of the variance between the two variables, $Y = 0.1804x + 1.799$, $R^2 = 0.23$.

Previous research has demonstrated that accelerometers used during dance-based exercise have underestimated caloric expenditure by as much as 41% to 52% depending on the particular dance-based exercise style (O’Malia, Schardd-Olson, & Williford, 2002). In order to examine if the accelerometers underestimated energy expenditure in this current study, heart rate and accelerometer data were compared for individual participants during the different dance styles. Figures 7 (participant three) and 8 (participant six) demonstrate that both the heart rate data and accelerometer data responded similarly to changes in movement and intensity during the time the participant was performing the dance style. However, it is clear that the accelerometer underestimated the actual energy expended by the dancer, and therefore their MET level.
Figure 7. A comparison of activity counts from the accelerometer and heart rate for participant three during modern dance.

Figure 8. A comparison of activity counts from the accelerometer and heart rate for participant six during modern dance.
To compare energy expended between all dance styles, caloric expenditure per minute was calculated. Caloric expenditure was calculated from Activity VO\(_2\) (ml·kg\(^{-1}\)·min\(^{-1}\)) as follows:

\[
\text{Caloric expenditure} = \left\{ \left( \frac{\text{Activity VO}_2}{1000} \right) \times \text{Body mass} \right\} \times 5 \text{ kcal/L of O}_2 \text{ consumed} \times \text{Minutes spent dancing}\}.
\]

Since the dance classes ranged in total minutes, total caloric expenditure was divided by total minutes spent dancing to find kilocalories (kcal) per minute (Table 4). Kcals per minute were then multiplied by 20 to find caloric expenditure over a 20-minute period. This value was used to comparatively study the dance styles to one another and to previously published results.

Table 4

*Average Caloric Expenditure per Minute of Dancing Based on Heart Rate Data*

<table>
<thead>
<tr>
<th>Dance Style (kcal per min)</th>
<th>Modern</th>
<th>Tap</th>
<th>Ballet</th>
<th>Jazz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>7.4</td>
<td>6.1</td>
<td>7.5</td>
<td>5.15</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>0.8</td>
<td>0.96</td>
<td>0.18</td>
<td>1.1</td>
</tr>
</tbody>
</table>

To further examine the relationship between the dance styles, average heart rate for each style was compared for each participant. By examining the participant’s average heart rate and their corresponding standard deviations, it can be noted that some styles of dance fluctuated in terms of heart across the time spent dancing, while others remained relatively stable (Figures 9 and 10).
Figure 9. Average heart rate values for participant three during four dance styles.

Figure 10. Heart rate response for participant three during ballet and tap dance.

The fluctuation in HR, or large range in HR, for certain dance styles across the time spent dancing implies that these styles are more interval, or intermittent, in nature. These dance styles appear to have short bursts of high-energy followed by longer rest periods. The other styles that did not fluctuate as much across the time period can be said to be less intermittent, having less rest periods, but staying at a consistently lower intensity throughout.
The differences between dance styles (in terms of heart rate variation within a dance class) are consistent with previous published research (Wyon et al., 2002), as well as with pilot study data performed by the same lead researcher from the current study (Appendix N). More research would need to be conducted to examine the work-to-rest ratios during dance classes to make conclusions about the individual differences between the dance styles.

Discussion

The results of the current study were limited by a relatively small sample size and the accuracy of self-report (for dance experience and food/caffeine intake). Resting oxygen consumption was not directly measured. A known standard value for resting oxygen consumption of 3.5 ml·kg\(^{-1}\)·min\(^{-1}\) was used for all participants (McArdle, Katch, & Katch, 2006). The mean values and standard deviations of all physiological variables measured for all participants during the pre-testing session are displayed in Appendix J, along with their current hours of dance training per week and years of training experience.

The results of this study indicated that in the population sampled, the dance styles did not differ significantly from one another. However, they were shown to be significantly higher from the previously reported MET level of 4.8 by Ainsworth et al. (2000). The current MET levels found in this study had an average of 6.3 METs (± 1.0) across all dance styles. These findings demonstrate that dance can be used as a significant source of energy expenditure. The previously reported value of 4.8 METs was equivalent to hunting, orange grove work, and weeding. The new value of approximately 6.3 METs (± 1.0) found in this study, is the equivalent MET level for weight lifting with vigorous effort, chopping or splitting wood, playing recreation basketball, and boxing with a punching bag (Ainsworth et al., 2000).
Additionally, this new value of 6.3 METs crosses the threshold into “hard” physical activity. MET values between 3.0 and 5.99 are of “moderate” intensity, while those ranging from 6.0 to 8.99 are of “hard” intensity according to Freedson et al. (1998) (r = .88). These values can be found again in Table 3. In a landmark paper, Pate et al. (1995) presented the recommendations of the Centers for Disease Control and Prevention (CDC) and the ACSM for adult physical activity. This paper recommends that adults accumulate at least 30 minutes of regular, moderate-intensity physical activity on most days of the week. This recommendation has become a standard used by researchers, clinicians, and practitioners. If dance is to be used as a form of physical activity it is important to have an understanding of the level of intensity it requires. Also, those clinicians using MET levels to prescribe exercise to clients, especially those rehabbing from a cardiac episode, should understand the level of intensity dance requires.

The findings of this current study indicate that dance can be considered hard-intensity physical activity. Wyon et al. (2002) found certain styles of dance to be higher in intensity than others, with the actual exercise periods being short (30-45 seconds), and the recovery periods being longer. The variation in heart rate, and therefore activity VO$_2$, found in this current study is consistent with the previous research by Wyon et al. (2002) and indicates that the styles themselves place different physiological demands on the body. This further emphasizes the need to study diverse styles of dance in terms of intensity and energy system utilization. This also demonstrates that for pre-professional and professional dancers, training the body to be physically prepared for their specific activity is extremely important in order to maintain health and avoid injuries.

These results also support the findings of previous research by Koutedakis and
Jamurtas (2004) who found that the majority of a dance class was spent between 10 and 25 ml·kg⁻¹·min⁻¹, or 20% to 50% of typical dancer VO₂max levels. The average VO₂ for all dance styles during this study was 22 ml·kg⁻¹·min⁻¹, with a standard deviation of ± 3.5 ml·kg⁻¹·min⁻¹. While this is consistent with other research findings, it has been shown that VO₂ values during rehearsal and performance far surpass those values seen in dance class (Wyon et al., 2004). This places further emphasis on the need for a more structured training program for dancers, in order to fully prepare the body for the rigorous demands of dance performance.

This current study also aimed to evaluate the validity of an ActiGraph equation for predicting METs or energy expenditure from activity counts. Research conducted by O’Mailia et al. (2002) showed that accelerometers underestimated the caloric expenditure of dance. Using open-circuit spirometry, O’Mailia et al. (2002) demonstrated that all dance-based exercise forms yielded a 150 kcal energy requirement over approximately 20 minutes. The accelerometers used in the O’Mailia et al. (2002) study underestimated energy expenditure by 41% to 52%. The findings of this current study showed an average estimated caloric expenditure of 130 kcals over approximately 20 minutes of dance, based on the HR data and calculations previously explained. Meanwhile, the accelerometers estimated caloric expenditure to be just 62.6 kcals over 20 minutes, an underestimation of 48%, consistent with the results of O’Mailia et al. (2002) who compared both a one-dimensional and three-dimensional accelerometer in their research.

The inaccuracy of the accelerometers is likely based on the limitation of a dual-axis device. The ActiGraph accelerometer used in this current study does not measure movement in the frontal plane and therefore may not be specific enough for dance-based activity styles that involve movement in all three planes (frontal, sagittal, transverse). Additionally, all
dance styles involve a significant amount of upper body movement and arm choreography. The additive energy expenditure produced by the upper body and arm choreography cannot be adequately accounted for with this type of accelerometer since it is designed to predict energy cost largely in terms of the movement in the lower extremities. These inaccuracies are also a determinant factor in the weak correlation between HR and accelerometry shown from the linear regression, where less than 20% of the variance was explained.

The results show that the dance styles studied in this research have significantly higher MET levels than previously reported and can be categorized as hard-intensity physical activity. Data implies the reliance on different energy systems for the diverse styles of dance. This is indicated by the differences in the ranges, or standard deviations, for heart rate between the individual dance styles. Further research would be needed to determine actual energy system utilization. Caloric expenditure and activity VO$_2$ were found to be consistent with other findings on dance class, however this study included dance styles not previously researched in these terms. Accelerometers were shown to underestimate the MET levels and energy expenditure for all dance styles. All of the results discussed here are consistent with the most current published research regarding the physiological demands of dance.
CHAPTER 5

SUMMARY, CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS

Summary

The purpose of this study was to determine if there are significant differences in metabolic equivalent (MET) or energy expenditure levels between ballet, modern, jazz, and tap dance utilizing heart rate (HR) monitoring, as well as accelerometry. A secondary purpose of this study was to evaluate the validity of an ActiGraph equation for predicting METs or energy expenditure as compared to the calculated METs from the HR data. The hypothesis was that the studied dance styles would have significantly different MET levels, therefore placing different physiological demands on the trained dancers. It was also expected that all dance styles would exceed previously published MET values. The participants were six college-aged female dancers all with at least five years of dance experience. Heart rate (HR) monitoring and accelerometry were used to examine average heart rate, average activity \( VO_2 \) (ml·kg\(^{-1}\)·min\(^{-1}\)), MET levels, caloric expenditure, and percent time spent in different physical activity levels. Statistical analyses revealed that the average MET level for all dance styles, as determined by the HR data, was significantly higher than that previously reported. Additional analyses implied the utilization of different energy systems between the individual dance styles. Accelerometers were found to underestimate caloric expenditure by 48%.

Conclusions

It was concluded from this study that:

1. Using the participants HR data, the selected dance styles had a significantly higher average MET value than the previously reported MET value of 4.8.

2. That the new MET value of 6.3 for the dance styles studied can be considered hard-
intensity in terms of physical activity.

3. Based on the accelerometer data obtained in this study, the ActiGraph equations used during this research appear to lack specificity in accurately predicting the energy expenditure and MET levels during all of the studied dance styles.

**Implications**

Results of this study are relevant to professionals who work with pre-professional and professional dancers. Supplemental physical training, in addition to skill training, needs to be tailored to the specific dance style being performed. Training needs to be planned and managed to the same extent as rehearsals are, as to allow dancers to peak for each performance period without increasing injury rate and occurrence of overtraining. The benefits of supplemental physical training alongside skill training have been widely acknowledged within athletics, but it is a relatively new concept in dance. Specifically, those professionals who work within one dance style and are responsible for conducting dance classes, rehearsals and choreographing performances, should use the information presented on the physiological demands of the dance style to better train their dancers.

Additionally, researchers, physiologists, clinicians, and practitioners should update their records to reflect this increased MET value of 6.3 (±1.0). This increase in MET level crosses the threshold into the category of hard-intensity physical activity and should be prescribed as such.

Lastly, those in the field of dance science can use the results of this study to conclude that accelerometers do not make reliable tools for measuring dance, whereas the heart rate monitors and subsequent equations by Strath et al. (2000) were able to more accurately predict energy expenditure and MET levels for the participants and dance styles utilized in
this study.

**Recommendations**

In terms of future research, a comparative analysis of different dance styles, in terms of respiratory exchange ratio (RER), blood lactate response, muscle fiber type, and other physiological parameters would be beneficial. Future studies should also aim to measure adaptations to fitness related parameters following different training programs, and the individual effects they have on aesthetics and technique. This type of research could determine if supplementing a technique class with a session that emphasizes specific physiological parameters would be detrimental to the development of the dancer’s aesthetics and technique (Wyon et al. 2004).

Additionally, future research can be done using different accelerometer placement (hip, wrist, or both) as well as implementing different prediction equations for energy expenditure. This would be beneficial in determining a reliable and valid method of using accelerometers for dance-based physical activity research. Accelerometers do not seem to interfere with dance movement where some research equipment, such as portable oxygen analyzers, can disrupt movement economy. Being able to conduct reliable research using accelerometers would be beneficial as they do not appear to disrupt movement, are easy to use, are relatively cheap in terms of research equipment and are therefore more readily available to researchers.

Lastly, replicating this current study utilizing a larger sample size could increase the validity and reliability of the results. Also, recruitment of dancers who are currently taking part in a more rigorous skill-training program (such as a pre-professional college dance program) would also be beneficial for further testing the validity and reliability.
REFERENCES


Methods, 41, 1149-1160.


APPENDIX A

Dance Experience Survey

Please complete all parts of the questionnaire to the best of your ability. If you do not know the answer to a question please write “Do not know”. If you wish to not answer a question, just leave the question blank. Your responses will be treated in a confidential manner.

Name: (Last) ___________________  (First) __________________
Age: ________ (must be at least 18 years of age to participate in the study)
Date of Birth: _____/______/______
Undergraduate level (as of Fall 2010): (freshman, sophmore, etc.)

Email: ________________________________@ _______________________
Contact Phone Number: (______)_______-____________

These first 9 questions will pertain to your background and experience in dance. Please answer them to the best of your knowledge.

1) How many years have you been dancing under trained supervision? (studio, classes, college, etc.)

2) What styles of dance have you been trained in? (Circle all that apply)
   Ballet  Pointe  Jazz/Lyrical  Tap  Modern/Contemporary  Hip-Hop  Latin Inspired
   Other: __________________________________________

3) Have you participated in collegiate level dance classes?

4) If you answered yes to question #3, Are you currently enrolled or participating in college level dance classes? And how many hours per week do you spend in these college level dance classes? If you answered no to question #3, please place an “X” below and move on to the next question.

5) How many hours per week do you spend training with your dance club?
6) Do you participate in dance classes outside of those offered here at SUNY Cortland or with your dance club?

7) *If you answered yes* to question 7, How often do you participate in these extra-curricular dance classes (hours/week)? *If you answered no* to question #7, please place an “X” below and move on to the next question.

8) Any other information on your dance training or background that you wish to share with me, or think would be important to the study?

The following question pertains to your availability to participate in the study.

9) Please list times in which it would be convenient for you to participant in this study on the following days.

   Sunday:

   Monday:

   Tuesday:

   Wednesday:

   Thursday:

   Friday:

   Saturday:

Thank you for completing this survey. If you are chosen to participate you will be notified via e-mail within the next 48 hours.
APPENDIX B

Health Readiness Questionnaire

Name: (Last) _________________  (First) _________________
Today's Date: _____/_____/______

Please complete all parts of the questionnaire to the best of your ability. Should you have any questions, feel free to ask. Your responses will be treated in a confidential manner.

Physical Activity Readiness Questionnaire (PAR-Q)
Being active is very safe for most people. However, some people should check with their doctor before they start becoming much more active. Please read the questions below carefully and answer YES or NO for each of them.

Y  N  Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?

Y  N  Do you feel pain in your chest when you do physical activity?

Y  N  In the past month, have you had chest pain when you were not doing physical activity?

Y  N  Do you lose balance because of dizziness or do you ever lose consciousness?

Y  N  Do you have a bone or joint problem that could be made worse by change in your physical activity?

Y  N  Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?

Y  N  Do you know of any other reason why you should not do physical activity?

If you answered YES to one or more of the questions above, talk to your doctor by phone or in person before you start becoming more physically active or before you have a fitness appraisal. Tell your doctor about the PAR-Q and the questions to which you answered YES.

If you answered NO to all PAR-Q questions, you can be reasonably sure that you can start becoming more physically active – begin slowly and build up gradually.
Medical/Health Status Questionnaire

On this portion of the questionnaire, a number of questions regarding your physical health are to be answered. Please answer every question as accurately as possible so that a correct assessment can be made. Please place a check in the space to the left of the question to answer “yes”. Leave the space blank if your answer is “no”.

Medical Screening

☐ Any personal history of diabetes or other metabolic disease (thyroid, renal, liver)?
☐ Do you have a known heart murmur?
☐ Are you a cigarette smoker?
☐ Are you pregnant?

Medications

- Please list the specific medications you currently take:
  __________________________________________________
  __________________________________________________
  __________________________________________________
  __________________________________________________
  __________________________________________________

Lifestyle

Please Rate Your Daily Stress Levels (select one):

☐ Low
☐ Moderate
☐ High: but I enjoy the challenge
☐ High: sometimes difficult to handle
☐ High: often difficult to handle

Other

- Please indicate any other medical conditions or activity restrictions that you may have. It is important that this information be as accurate and complete as possible.
  __________________________________________________
  __________________________________________________
  __________________________________________________
  __________________________________________________

Thank you for taking the time to complete this questionnaire!
APPENDIX C

Human Subjects Approval Form

MEMORANDUM

To: Jenna Domin, Kinesiology
Philip Buckenmeyer, Kinesiology
From: Jena Curtis, Primary Reviewer
Institutional Review Board
Date: 05-13-2010
RE: Institutional Review Board Approval

In accordance with SUNY Cortland's procedures for human research participant protections, the protocol referenced below has been approved for a period of one year:

Title of the study: Metabolic Equivalents of Selected Dance Styles on Trained Female Dancers
Level of review: Expedited
Protocol number: 091044
Project start date: Upon IRB approval
Approval expiration date*: 05-12-2011

* Note: Please include the protocol expiration date to the bottom of your consent form and recruitment materials. For more information about continuation policies and procedures, visit www.cortland.edu/irb/Applications/continuations.html

The federal Office for Research Protections (OHRP) emphasizes that investigators play a crucial role in protecting the rights and welfare of human subjects and are responsible for carrying out sound ethical research consistent with research plans approved by an IRB. Along with meeting the specific requirements of a particular research study, investigators are responsible for ongoing requirements in the conduct of approved research that include, in summary:

- obtaining and documenting informed consent from the participants and/or from a legally authorized representative prior to the individuals' participation in the research, unless these requirements have been waived by the IRB;
- obtaining prior approval from the IRB for any modifications of (or additions to) the previously approved research; this includes modifications to advertisements and other recruitment materials, changes to the informed consent or child assent, the study design and procedures, addition of research staff or student assistants, etc. (except those alterations necessary to eliminate apparent immediate hazards to subjects, which are then to be reported by email to irb@cortland.edu within three days);
- providing to the IRB prompt reports of any unanticipated problems involving risks to subjects or others;
- notifying the IRB of continued research under the approved protocol to keep the records active; and,
- maintaining records as required by the HHS regulations and NYS State law, for at least three years after completion of the study.
In the event that questions or concerns arise about research at SUNY Cortland, please contact the IRB by email irb@cortland.edu or by telephone at (607)753-2511. You may also contact a member of the IRB who possesses expertise in your discipline or methodology, visit [http://www.cortland.edu/irb/members.html](http://www.cortland.edu/irb/members.html) to obtain a current list of IRB members.

Sincerely,

Jena Curtis
IRB Primary Reviewer
School of Professional Studies
APPENDIX D

Informed Consent Form

The research in which you have been invited to participate is being conducted by graduate student Jenna Domin of the Kinesiology Department at SUNY Cortland. The researcher requests your informed consent to be a participant in the project described below. The purpose of this study is to determine if there are differences in energy expenditure levels between Ballet, Modern, Jazz, and Tap dance. Please feel free to ask about the project, its procedures, or objectives.

If you agree to participate, you will be asked to take part in a pre-testing session lasting around 45 minutes where height, weight, percent body fat, resting heart rate, resting oxygen consumption and predicted maximal oxygen consumption will be tested. Additionally, you will be asked to participate in four separate dance classes, one for each of the dance styles. These sessions will begin with a 6-minute warm-up, followed by a 20-minute dance class, and will end with a 5-minute cool-down. You will be asked to wear a heart rate monitor around your chest and an accelerometer around your waist. These sessions will last no more then 60 minutes in total with set-up and removal of equipment. Each session will be separated by at least 24 hours rest. You will be asked to abstain from caffeine, alcohol and other drugs 24 hours prior to each testing session. The opportunity to participate in this study will be made available to around 15 female dancers from SUNY Cortland.

The risks associated with your participation in this study are very minimal. However, there is always a risk associated with participating in physical activity. Only the researcher and her committee chair will have access to your data. Your pre-testing data will be kept in paper format. All data from the testing sessions will be saved on a flash drive containing your participant code #, and the day/time of your testing. All information will be kept confidential. This flash drive and all other data will be kept in a locked cabinet in the researchers office for no more then three years, upon which all data will be deleted and all paper documents will be shredded. At no time will your name be associated with the data results. Data will only be reported in group means, not as individual responses.

You are free to withdraw consent at any time without penalty. At any time, you may ask the researcher to destroy all data from the testing sessions, as well as any other data or information collected.

From participating in this study you may better understand the way in which research is conducted. Additionally, you will receive free dance training from a professionally trained dancer.

If you have any questions concerning the purpose or results of this study, you may contact Jenna Domin at (607) 624-5926 or at JennaBFit10@gmail.com. Additionally, you may contact Dr. Phil Buckenmeyer, Chair of the Kinesiology Department, at Cornish D132 or (607) 753-5558. If you have any questions about your rights and welfare as a participant in this research, or if you feel you have been placed at risk, you can contact Amy Henderson-Harr, Office of Sponsored Programs, SUNY Cortland at (607) 753-2511. In case of an injury, please contact the SUNY Cortland Health Center in room B-26 of Van Hoesen Hall at (607) 753-4811. SUNY Cortland EMS services can be contacted by calling (607) 753-4111.

I ______________________________ (print name) have read the description of the project for which this consent is requested, understand my rights, and I hereby consent to participate in this study.

Participant’s Signature: ______________________________

Date: ______/______/_____

This form was approved by the SUNY Cortland IRB on 05-13-2010 and is in effect until 05-12-2011.
APPENDIX E

Participant Testing Instructions

Location of Testing:

Day and Time of Testing:

1) Please arrive on time.
2) Wear clothes appropriate for dance. You will wear these same clothes for all testing sessions. Please bring all appropriate dance shoes necessary for ballet, jazz, tap and modern.
3) Do not consume caffeine 24 hours prior to the study. This includes but is not limited to, coffee, soda, red-bull or other energy drinks, and “5-hour energy shots” or other energy boosters.
4) Do not consume alcohol or other drugs 24 hours prior to testing.
5) Please keep the same diet on all testing days. Please keep a log of food and beverages consumed on testing days. The lead researcher will collect this log at the beginning of each testing session.
6) Do not engage in vigorous exercise within 12 hours prior to testing.

*****Please make me aware if you are unable to adhere to the above instructions.

If you are unable to come at your scheduled time please contact me as soon as possible.

Jenna Domin
(607) 624-5926
JennaBFit10@gmail.com
APPENDIX F

Participant Testing Information

HR Monitor Assignment: _________
Accelerometer Assignment: _________

DOB: ____/____/____
Age: ______
Predicted HR max: _________

Height: _______(in) ______ (m)
Weight/Mass: ______(lbs) ______(kg)
Body Fat Percentage: ____________
  Fat Mass: ______
  Fat-Free Mass: ______

Resting HR: ____________ (bpm)
Resting VO\textsubscript{2}; ____________ (ml\cdot kg\textsuperscript{-1} \cdot min\textsuperscript{-1})
Predicted VO\textsubscript{2max}; ____________ (ml\cdot kg\textsuperscript{-1} \cdot min\textsuperscript{-1})

Warm-Up HR Zone (25%-35% HRR): ____________ bpm
Stretching HR Zone (10%-20% HRR): ____________ bpm

Participant’s Age-Predicted HRmax: _________
Participant’s 85% HRmax: _________________

<table>
<thead>
<tr>
<th>STAGE</th>
<th>WORKLOAD</th>
<th>HR (bpm) at each min</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>1\textsuperscript{st} stage</td>
<td>150 kgm/min (0.5 kp)</td>
<td></td>
</tr>
<tr>
<td>2\textsuperscript{nd} stage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3\textsuperscript{rd} stage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4\textsuperscript{th} stage</td>
<td></td>
<td></td>
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</tbody>
</table>
APPENDIX G

Participant Characteristics with Means and Standard Deviations

<table>
<thead>
<tr>
<th>Subject</th>
<th>Age</th>
<th>Height (m)</th>
<th>Body Mass (kg)</th>
<th>Body Fat %</th>
<th>Resting HR (bpm)</th>
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<th>Years of dance experience</th>
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APPENDIX H

Testing Sessions Choreography/Movement and Repetitions

Warm-up Movements and Intensity

<table>
<thead>
<tr>
<th></th>
<th>Tempo/Intensity</th>
<th>Time (min:sec)</th>
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<tbody>
<tr>
<td>A.</td>
<td>Light, Free Jogging</td>
<td>20-25% HRR</td>
</tr>
<tr>
<td>B.</td>
<td>Figure 4 (10x ea)</td>
<td>10-20% HRR</td>
</tr>
<tr>
<td></td>
<td>Arm Circles (10x front and back)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Quad walk w/ lean (5x each)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Flexion/Extension at the hips 10x</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cross Over touch toes 10x ea</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Squat &amp; Stretch 5-8x</td>
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</tr>
<tr>
<td></td>
<td>Ankle Rolls 5x ea dirction</td>
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Note. This warm-up was utilized for all testing sessions.

Modern Dance Movements and Repetitions

<table>
<thead>
<tr>
<th></th>
<th>Center Floor Exercises</th>
<th>Repetitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>C.</td>
<td>Roll-downs in parallel w/ plie</td>
<td>2x ea position</td>
</tr>
<tr>
<td>D.</td>
<td>Isolations (fwd &amp; back/side-to-side)</td>
<td>8x ea</td>
</tr>
<tr>
<td>E.</td>
<td>Parallel tendus w/ plie</td>
<td>4x ea</td>
</tr>
<tr>
<td>F.</td>
<td>Contract/Release in 2nd position</td>
<td>4x ea</td>
</tr>
<tr>
<td>G.</td>
<td>Releases Fwd &amp; Back/Side to Side</td>
<td>4 sets/2x ea</td>
</tr>
<tr>
<td>H.</td>
<td>Releases with jump</td>
<td>4 sets/2x ea</td>
</tr>
<tr>
<td>I.</td>
<td>Leg swings front to back w/ plie pas de borre</td>
<td>2 sets/ 8 x each</td>
</tr>
<tr>
<td>J.</td>
<td>Leg swings side to side</td>
<td>6 sets/ 4 x each</td>
</tr>
<tr>
<td>K.</td>
<td>Flat Back fwd w/ plie</td>
<td>4x</td>
</tr>
<tr>
<td>L.</td>
<td>Flat Back fwd w/ plie releve</td>
<td>4x</td>
</tr>
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Across the Floor Exercises

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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<tbody>
<tr>
<td>M.</td>
<td>Trippelets</td>
</tr>
<tr>
<td>N.</td>
<td>Prance</td>
</tr>
<tr>
<td>O.</td>
<td>Parallel soutes</td>
</tr>
<tr>
<td>P.</td>
<td>Combination:</td>
</tr>
<tr>
<td></td>
<td>&lt;Consisting of contractions, parallel walks, hindges, side &quot;T&quot;, flat back &quot;T&quot;, layout, side attitude, inverted back leap, releases, pencil turn&gt;</td>
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</tbody>
</table>
Tap Dance Movements and Repetitions

<table>
<thead>
<tr>
<th>Center Floor Exercises</th>
<th>Repetitions</th>
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</thead>
<tbody>
<tr>
<td>C. Top taps</td>
<td>2 sets/8x ea</td>
</tr>
<tr>
<td>D. Toe/heel/toe toe</td>
<td>2 sets/ 8x ea</td>
</tr>
<tr>
<td>E. Flap heel/ Flap heel heel</td>
<td>4x w/o arms; 4x with arms ea</td>
</tr>
</tbody>
</table>

Across the Floor Exercises

<table>
<thead>
<tr>
<th>Across the Floor Exercises</th>
<th>Repetitions</th>
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</thead>
<tbody>
<tr>
<td>F. Flap Flap Step</td>
<td>2 x 20yds</td>
</tr>
<tr>
<td>G. Draw Backs</td>
<td>2 x 20yds</td>
</tr>
<tr>
<td>H. Cincinnatti</td>
<td>2 x 20yds</td>
</tr>
<tr>
<td>I. Maxie Ford</td>
<td>2 x 10yds</td>
</tr>
<tr>
<td>J. Double foot pickups</td>
<td>2 x 10yds</td>
</tr>
<tr>
<td>K. Single Foot pickups</td>
<td>1 x 10yds ea</td>
</tr>
<tr>
<td>L. Graboffs</td>
<td>2 x 20yds</td>
</tr>
<tr>
<td>M. Combination:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt;Consisting of heel digs, 5 count riffs, cramp rolls, grab offs, heel grids, toe stands, cincinnatis, maxie fords, stomps, claps, single pickups, toe clips&gt;</td>
</tr>
</tbody>
</table>

Ballet Dance Movements and Repetitions

<table>
<thead>
<tr>
<th>Barre Exercises</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>C.</td>
<td>Demi plie, Battement tendu with plie and flex, releve, port de bra f&amp;b</td>
</tr>
<tr>
<td>D.</td>
<td>Battement degage 4x ea, Frappe 4x ea, soutenu</td>
</tr>
<tr>
<td>E.</td>
<td>4 rond de jambe, 1 grande rond de jamb, Reverse; Passe develope 2nd, 2 double rond de jambe en l' air, Reverse; Grande port de bra forward into lunge w/ back foot, port de bra back, arabesque back leg, penche, passé balance</td>
</tr>
<tr>
<td>F.</td>
<td>Grand battement 4x ea soutenu</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Center Floor Exercises</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>G.</td>
<td>Degage front 4 x, coupe ballone, degage back 4 x, coupe ballone ; pas de bourree 2x, prepare pirouette 2 x; Repeat (back first)</td>
</tr>
<tr>
<td>H.</td>
<td>Adagio: pique arabesque, penche, passe, plie develope front efface; Reverse; grande plie; port de bra forward, plie degage side, back pa de bourre, grande port de bra forward into lunge; Reverse combination</td>
</tr>
<tr>
<td>I.</td>
<td>Petit allegro: changement 4x, echappe 2x, entrechat 2x, back cabriole; Reverse; Repeat</td>
</tr>
<tr>
<td>J.</td>
<td>Turns: 2 pique turns, 1 lame duck, 2 chaines; Repeat, pa de bourree prepare, 3 fouette turns; Repeat</td>
</tr>
<tr>
<td>K.</td>
<td>Grand allegro: grand jete; temps de fleche</td>
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</table>
## Jazz Dance Movements and Repetitions

<table>
<thead>
<tr>
<th>Center Floor Exercises</th>
<th>Repetitions</th>
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<tbody>
<tr>
<td>C. Isolations - Head, Ribs and Hips</td>
<td>8 x ea, 4 x ea, 2 x ea</td>
</tr>
<tr>
<td>D. Arches around</td>
<td>8x ea</td>
</tr>
<tr>
<td>E. Lateral flexion to flat back stretch</td>
<td>2 x ea way</td>
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### Across the Floor Exercises

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Repetitions</th>
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</thead>
<tbody>
<tr>
<td>F. Plie R L into chaines</td>
<td>2 x 20yds</td>
</tr>
<tr>
<td>G. Ball change to 2nd pos releve 2x, double chest bump 2x, release over, arms up then down body, kick ball change 2 single turns</td>
<td>2 x 20 yds</td>
</tr>
<tr>
<td>H. Straight battements (parallel) with no develope</td>
<td>1 x 20 yds</td>
</tr>
<tr>
<td>I. Straight battements (parallel) with develop</td>
<td>1 x 20yds</td>
</tr>
<tr>
<td>J. 2 jazz walks (open first), chaine plie axel turn, jazz rond de jambe, body roll</td>
<td>2 x 20 yds</td>
</tr>
<tr>
<td>K. Step tilt (side battement), step over, plie forced arch drag turn, layout to releve</td>
<td>2 x 20 yds</td>
</tr>
<tr>
<td>L. Combination:</td>
<td></td>
</tr>
<tr>
<td>&lt; Consisting of kick ball change, pencil turn, jazz pirouette, side leap, jazz rond de jambe, tilt, axel turn, jazz walks, body roll, chaines, lay out, jazz lunge &gt;</td>
<td></td>
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**APPENDIX I**

**Dance Movement Survey Completed by Panel of Experts**

Movements/Combinations/Steps Representative of CLASSICAL BALLET

(Please circle the 20 most widely utilized movements for a typical collegiate level intermediate/advanced ballet class. Please keep in mind these movements should NOT include warm-up exercises. Please read through all responses before making your final selections)

- Passe balance
- Balance en tournant
- Arabesque turn
- Attitude turn (front or back attitude)
- Entrechachat
- Changement
- Echappe
- Temps de fleche
- Arabesque Penche
- Cabriole
- Grand Jete
- Pas de chat
- Tour jete
- Rond de jambe en l’air
- Battements fondu
- Glissade
- Battement tendu
- Battement degage
- Developpe
- Grand battement
- Demi Plie
- Grand Plie
- Pas de cheval
- Rond de jambe a terre (on the ground)
- Frappe
- Coupe ballonee
- Pas de bourre
- Pirouettes (en dehor and en dedans)
- Port de bra
- Pique turns
- Grand rond de jambe
- Fouette turns
Movements/Combinations/Steps Representative of JAZZ Dance
(Please circle the 20 most widely utilized movements for a typical collegiate level intermediate/advanced jazz class. Please keep in mind the movements you select should NOT include warm-up exercises. Please read through all responses before making your final selections)

-Plie drag turn
-Jazz pirouette (parallel)
-Side leap (center leap)
-Battement on releve (front, side or back)
-Rib isolation
-Kick ball change
-Jazz rond de jambe
-Developpe leap (front)
-Step ball change
-Bison leap/jump
-Jazz lunge
-Scissor leap
-Inverted/Reverse leap
-Fan kick (in the air)
-Split slide
-Coupe pirouette (skater turn)
-Tilt (side battement)
-Kick/Flick ball change

-Axel turn
-Pique penche (pitch)
-Illusion
-A la second turns
-Pencil turn
-Clypso
-Forced arch (turn, hinge, lunge, battement, etc.)
-Split turn (holding leg in front)
-Develop extension
-Straddle fan kick (on the floor)
-Jazz walk
-Hitch kick
-Hinge
-Body roll
-Chaines
-Hip isolation and/or roll
-Lay out
Movements/Combinations/Steps Representative of MODERN Dance
(Please circle the 20 most widely utilized movements for a typical collegiate level intermediate/advanced modern class. Please keep in mind these movements should NOT include warm-up exercises. Please read through all responses before making your final selections)

- Flat back with arabesque ("T")
- Tripplettes (Waltz step in parallel)
- Step soute (parallel)
- Backward roll; Fish roll (fish flop)
- Parallel passé/retire
- Hinge
- "C" Jump (arch back, knees bend)
- Release (also with a jump)
- Side attitude
- Plie parallel turns
- Fouette jumps
- Side shoulder roll (into straddle)
- Contraction
- Side angel jump
- Toe rise (up from floor)
- Parallel pirouettes

- Straight pencil turn
- Bison
- Sit roll
- Prance (in parallel) (i.e. up/down jumps)
- Second position jump (knees bent in air)?
- Side facing "T" (also as a jump)
- Battement (front, side, etc.), usually with release or contraction
- Forced arch (turn, hinge, lunge, battement, etc.)
- Rib isolation
- Flat back
- Tilt (upperbody)
- Russian leap (Side jete, one leg bent in)
- Diving roll to floor
- Parallel lunge
- Flex (hands or feet)
Movements/Combinations/Steps Representative of TAP Dance
(Please circle the 20 most widely utilized movements for a typical collegiate level intermediate/advanced tap class. Please keep in mind these movements should NOT include warm-up exercises. Please read through all responses before making your final selections)

- Flap
- Shuffle
- Ball Change
- Draw backs
- Single & double foot Pickups
- Double pickups
- Cincinnati
- 5 count Riff Walk
- Maxie Ford (also while turning)
- Double-Triple Time Step
- Grab offs
- Military Time Step (Single, double or triple)
- Paddle step
- Shim-Sham
- Single and Double Essence (Soft shoe)

Hop
- Toe- dig, clip, scuff
- Stamp/Stomp
- Heel- dig, scuff, drop or chug
- Cramp roll
- Heel click (in the air)
- Triple Time Step
- Toe Stand
- Crossover/Front Irish (Carryback/Back Irish)
- Wings
- Heel grind (time step)
- Buck
- Buffalo
- Cubanola
- Nerve tap
## APPENDIX J

### Testing Minutes and Tempos

#### Modern Dance

<table>
<thead>
<tr>
<th>Class</th>
<th>Music/Tempo</th>
<th>Time (min:sec)</th>
<th>Time of Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jogging</td>
<td>N/A</td>
<td>0:00</td>
<td>12:15 PM</td>
</tr>
<tr>
<td>Dynamic Warm-Up</td>
<td>Andvari - &lt;40 bpm</td>
<td>3:00</td>
<td>12:18 PM</td>
</tr>
<tr>
<td>Center Floor</td>
<td>Unarmed- 60bpm</td>
<td>8:00</td>
<td>12:23 PM</td>
</tr>
<tr>
<td></td>
<td>The Scientist-72bpm</td>
<td>12:00</td>
<td>12:27 PM</td>
</tr>
<tr>
<td>Across the Floor</td>
<td>Valentine- 63bpm</td>
<td>18:00</td>
<td>12:33 PM</td>
</tr>
<tr>
<td>Combination</td>
<td>Jar of Hearts-74bpm</td>
<td>21:00</td>
<td>12:36 PM</td>
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<td>12:51 PM</td>
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<td>Cooldown</td>
<td>Lovesong- 54bpm</td>
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#### Tap Dance

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<th>Time of Day</th>
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<td>Jogging</td>
<td>N/A</td>
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<td>12:20 PM</td>
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<tr>
<td>Dynamic Warm-Up</td>
<td>Andvari- &lt;40bpm</td>
<td>3:00</td>
<td>12:23 PM</td>
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<tr>
<td>Tap shoes on</td>
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<td>7:00</td>
<td>12:27 PM</td>
</tr>
<tr>
<td>Center Floor</td>
<td>King of Anything-112bpm</td>
<td>10:00</td>
<td>12:30 PM</td>
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<tr>
<td>Across the Floor</td>
<td>Dog Days Are Over-112bpm</td>
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<td>12:34 PM</td>
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<tr>
<td></td>
<td>Alejandro- 112bpm</td>
<td>18:00</td>
<td>12:38 PM</td>
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<tr>
<td>Combination</td>
<td>We Speak No Americano-126bpm</td>
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<td></td>
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<td></td>
<td>12:57 PM</td>
</tr>
<tr>
<td>Cooldown</td>
<td>Arms- 72bpm</td>
<td>35:00</td>
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## Ballet

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<td>Dynamic</td>
<td>Andvari- &lt;40bpm</td>
<td>3:00-7:00</td>
<td>12:12 PM</td>
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<tr>
<td>Warm-Up</td>
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<tr>
<td>Barre</td>
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<td>demi plie &lt; 40bpm</td>
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<td></td>
<td>degage 80bpm</td>
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<tr>
<td></td>
<td>rond de jambe 40bpm</td>
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<td>grand battement 69bpm</td>
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<td>Centre</td>
<td></td>
<td>20:00</td>
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<td></td>
<td>degage 116bpm</td>
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<td>adagio &lt;40bpm</td>
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<td>petit allegro 108bpm</td>
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<td></td>
<td>turns 102bpm</td>
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<tr>
<td></td>
<td>grand allegro 66bpm</td>
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<tr>
<td>Reverence</td>
<td>&lt;40bpm</td>
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<td>12:42 PM</td>
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<tr>
<td>Stretches</td>
<td>Arms 72bpm</td>
<td>35:00</td>
<td>12:44 PM</td>
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<td></td>
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<td>39:00</td>
<td>12:49 PM</td>
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## Jazz Dance

<table>
<thead>
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<th>Music/Tempo</th>
<th>Time (min:sec)</th>
<th>Time of Day</th>
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<tbody>
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<td>Jogging</td>
<td>N/A</td>
<td>0:00</td>
<td>12:14 PM</td>
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<tr>
<td>Dynamic</td>
<td>Andvari- &lt;40bpm</td>
<td>3:00</td>
<td>12:17 PM</td>
</tr>
<tr>
<td>Warm-Up</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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APPENDIX K

Average Heart Rate and Corresponding Activity VO$_2$, MET, and Caloric Expenditure Values

Modern Dance

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Tap Dance

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APPENDIX L

Average Activity Count and Corresponding MET and Caloric Expenditure Values

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Tap Dance

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## Ballet

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## Jazz Dance

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APPENDIX M

Percent Time Spent in Physical Activity by Dance Style

Modern Dance

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Mean: 40.00 | 57.40 | 1.80 | 0.60
Std. Dev.: 6.67 | 7.09 | 1.64 | 1.34

Tap Dance

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Mean: 75.00 | 18.60 | 5.80 | 0.80
Std. Dev.: 12.17 | 11.08 | 4.09 | 1.79
### Ballet

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### Jazz Dance

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APPENDIX N

Pilot Study Data

Tap Dance

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Ballet

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Jazz Dance

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