METABOLIC COST OF AEROBIC DANCE BENCH STEPPING AT VARYING CADENCES

THESIS

Presented to the Graduate Council of
Southwest Texas State University
in Partial Fulfillment of
the Requirements

For the Degree of

Master of Education

By

Tamara Denise Grier, B.A.

San Marcos, Texas
May, 2000

ACKNOWLEDGEMENTS

Thanks to God for giving me the strength to endure all feats put before me.

Thanks to my parents, Farris and Cheryl Grier, who have made me the woman I am. Without their love, support, and guidance, I would be lost. I Love You!

Thanks to Jimmy for the love and understanding for the many nights I spent my desk.

Thanks to Angye for all the countless hours in the Human Performance Laboratory.

Thanks to my Chair, Dr. John Walker for guidance with my Thesis.

Finally, thanks Dr. Lisa Lloyd for truly being an inspiration. You have taught me more about life, love, determination, and will than any other woman. Thanks for being a strong, positive role model that I sincerely hold on a pedestal. (You better be around for the Ph.D. dissertation.)

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

ABSTRACT

METABOLIC COST OF AEROBIC DANCE BENCH STEPPING AT VARYING CADENCES

By

Tamara Denise Grier, B.A.
Southwest Texas State University
May 2000

SUPERVISING PROFESSOR: John L. Walker

Previous research has failed to examine cadence and bench height when determining metabolic cost of aerobic dance bench stepping. The purpose of this study was to determine the acute metabolic and cardiovascular responses of aerobic dance bench stepping at 6 and 8 inch bench heights at cadences of 125 and 130 $beats \cdot min^{-1}$. Subjects were 30 moderately fit females, ages 19-47 years, with a minimum of 2 months aerobic dance bench stepping experience. VO_2max was determined using the Balke-Ware treadmill protocol. Subjects performed 4 submaximal aerobic dance bench stepping tests. Each test measured VO_2, VCO_2, HR, and RPE at a cadence of 125 or 130 $beats \cdot min^{-1}$ and 6 or 8 inch bench heights. A two-way repeated measures factorial ANOVA revealed no physiological differences between the two selected cadences. This suggests that the cadence does not affect the intensity of aerobic dance bench stepping. A significant difference was seen in all variables tested which suggests that the height of the bench does influence intensity. A multiple regression model revealed that the relationship between bench height and body weight was linear ($R = .49$, $p < .05$, SEE = 1.03 $kcal \cdot min^{-1}$). Caloric cost ($kcal \cdot min^{-1}$) = 3.06 + (.07 x body weight in kg). The inclusion of step height in the model increased R to .67 and decreased the SEE to .90 $kcal \cdot min^{-1}$. Caloric cost ($kcal \cdot min^{-1}$) for 6-inch bench = 2.64 + (.07 x body weight in kg). Caloric cost ($kcal \cdot min^{-1}$) for 8-inch bench = 3.68 + (.07 x body weight in kg).

Inclusion of body height into the regression model did account for additional variance in the caloric cost ($R = .71$, $SEE = .85$ kcal· min^{-1}, $F1, 53 = 6.45$, $p < .05$) Caloric cost (kcal· min^{-1}) for 6-inch bench = 8.22 + (.08 x body weight in kg) – (0.04 x height in cm). Caloric cost (kcal· min^{-1}) for 8-inch bench = 9.26 + (.08 x body weight in kg) – (0.04 x height in cm). It was concluded that cadences of 125 and 130 beats·min^{-1} do not affect the cardiovascular and metabolic responses in aerobic dance bench stepping. The data suggests that the height of the bench does influence intensity, an 8 inch bench produce a higher metabolic response than a 6 inch bench. A model that estimates caloric cost was devised using bench height, body weight, and body height.

List of Tables

List of Figures

METABOLIC COST OF AEROBIC DANCE BENCH STEPPING AT VARYING CADENCES

Recent reports suggest that a majority of Americans are overweight, inactive, and at risk for serious health complications such as cardiovascular disease, cancer, and adult onset diabetes (Mokdad, Serdula, Dietz, Bowman, Marks, and Koplan, 1999; U.S. Department of Health and Human Services, 1996). Such conditions are interrelated and may lead to poor quality of life, low self-efficacy, and/or death. Many strategies exist to reduce risk of chronic disease and improve physical as well as mental health (Jakicic, Winters, Lang, and Wing,1999). The most practical and successful techniques involve proper diet and exercise (Ludwig, Pereira, Kroenke, Hilner, Van Horn, Slattery, Jacobs, 1999). The U. S. Surgeon General's report suggests that significant health benefits can be obtained by performing a variety of moderate physical activities on most days of the week (U.S. Department of Health and Human Services, 1996).

Currently, there are a variety of options available to promote participation in physical activity and help individuals meet the U.S. Surgeon General's recommendations for physical activity and health. Leisure physical activities such as walking, jogging, cycling, swimming, in-line skating, and aerobic dance are popular forms of aerobic exercise that promote weight loss and maintenance as well as cardiovascular health (Tarrant & McNaughton, 1997). It has been recommended that for optimal body composition and cardiovascular fitness gains, an individual should perform 20 to 60 minutes of continuous aerobic exercise at an intensity of 50 to 85% of maximum oxygen uptake reserve (VO_2R), 3 to 5 days per week

(American College of Sports Medicine, 2000). It is also suggested that each exercise session should be performed at sufficient intensity and duration to expend at least 250 – 300 kcals (American College of Sports Medicine, 1998).

Aerobic dance bench stepping is a popular and dynamic form of leisure physical activity that meets the recommendations and promotes optimal health benefits. This activity involves performing choreographed aerobic dance movements while stepping on and off a bench (Olson, Williford, Blessing, & Greathouse, 1991). Although an estimated 23 million individuals participate in this activity nationwide (Blessing, Wilson, Puckett, & Ford, 1987), research on aerobic bench stepping is limited. Most investigations on aerobic dance bench stepping have measured the metabolic and cardiovascular responses of: 1) bench stepping at cadences of 120 beats$\cdot$min^{-1} ; 2) bench stepping with bench heights of 4 to 12 inches; and 3) use of hand-held weights while bench stepping (Woodby-Brown, Berg, & Latin, 1993; Francis & Francis, 1996; Olson et al., 1991; Goss, F., Robertson, R., Spina, R., Auble, T., Cassinelli, D., Silberman, R., Galbreath, R., & Metz K., 1989; Scharff-Olson, M. & Williford, H., 1996).

To increase the energy cost of aerobic dance bench stepping, the use of hand-held weights while bench stepping has been examined. Olson et al., (1991) found no significant increase in VO_2 during aerobic dance bench stepping with 0.45 kg (1 lb) hand-held weights. Bench stepping with 0.91 kg (2 lb) hand-held weights elicited an approximate 2 ml $\cdot$kg^{-1} $\cdot$min^{-1} increase in VO_2 compared with no added weight. Such an increase, although statistically significant, resulted in only minimal increase in energy expenditure (approximately 20 kcals) over a 20-min aerobic session. Blessing et al.(1987) has also suggested that the use of hand-held weights during aerobic dance may cause muscular fatigue and discomfort to upper body muscles There appears to be a reduced range of motion of arms and legs and reduced amount of muscle mass actively engaged in exercise. Because the supplementation of aerobic dance with hand-held weights does not result in large increases in energy expenditure and may exacerbate muscular fatigue, the use of hand-held weights during aerobic exercise may not offer increased fitness benefits.

The Aerobic and Fitness Association of America (AFAA) (1997) recommends that aerobic dance bench stepping should be performed at a cadence of 118 to 128 beats$\cdot$min^{-1} on a bench ranging in height from 6 to 8 inches. Although these guidelines suggest that these wide range of cadences are a safe and effective means of physical activity, previous research has failed to investigate the intensity of aerobic bench stepping at cadences other than 120 beats$\cdot$min^{-1}. Woodby-Brown, Berg, & Latin (1993) found that the energy cost of bench stepping at a cadence of 120 beats$\cdot$min^{-1} at bench heights of 4, 8, and 10 inches is 6.3, 8.0, and 9.2 kcal$\cdot$min^{-1}, respectively. Francis&Francis (1994) found that the energy cost of bench stepping at 120 beats$\cdot$min^{-1} and at bench heights of 4, 6, 8, and 10 inches to be 4.5, 5.5, 6.4, and 7.2 kcal$\cdot$min^{-1},respectively. Both of these studies fail ed to consider body weight and body height in the energy cost analysis.

However, AFAA safety guidelines suggest that these bench heights are not ideal for all participants (Aerobic and Fitness Association of America, 1997). The 4-in benches are generally recommended for beginners, less fit, and older individuals, whereas the 10-in benches are generally not recommended due to the increased risk of patellofemoral injuries (Aerobic and Fitness Association of America, 1997; Woodby-Brown et al., 1993). To promote optimal cardiovascular fitness improvements while reducing the risk of musculoskeletal injury during aerobic dance bench stepping, bench height should be limited to 6 to 8 inches (Aerobic and Fitness Association of America, 1997)

Group exercise instructors are teaching aerobic dance bench stepping classes much faster than the safety guidelines. Previous research has failed to investigate metabolic and cardiovascular responses of aerobic dance bench stepping at the most widely used bench heights of 6 and 8 inches combined with the most common cadences of 125 and 130 beats·min^{-1}. There is also a need for models to estimate the caloric cost of aerobic dance bench stepping. Information from such research would enable aerobic participants to select proper bench heights and cadences to meet the ACSM recommended guidelines of aerobic exercise for the development of cardiorespiratory fitness.

Purpose of the Study

The purpose of this investigation was to determine the acute metabolic and cardiovascular responses of aerobic dance bench stepping at 6 and 8-in bench heights at cadences of 125 and 130 beats·min^{-1}.

Hypotheses

1. It was hypothesized that aerobic bench stepping at a cadence of 130 beats·min^{-1} will result in a greater energy cost than bench stepping at a cadence of 125 beats·min^{-1}.
2. It was hypothesized that aerobic bench stepping on an 8-inch bench will result in a greater energy cost than bench stepping on a 6-inch bench.

Delimitation

The study was delimited to female subjects ranging in ages from 19 to 47 years with a minimum aerobic dance bench stepping experience of 2 months. The testing conditions were delimited to aerobic dance bench stepping at cadences of 125 and 130 beats·min^{-1} at bench heights of 6 and 8 inches. Metabolic measures were limited to heart rate (HR), oxygen consumption (VO_2), rate of perceived exertion (RPE), and kilocalories (kcals).

Operational Definitions

1. Aerobic dance bench stepping: A form of aerobic exercise that combines aerobic dance and bench stepping on a 6 to 8-inch bench at a cadence of 118 to 128 beats·min^{-1}.
2. Cadence: Often referred to as beats per minute. Aerobic dance bench stepping is typically performed at a cadence of 118 to 128 beats·min^{-1}.
3. VO_2max: The individual maximal rate of oxygen consumption that can be maintained at a maximal workload.
4. Body composition: Individual percent fat based on the body's fat mass divided by total body mass.
5. Cardiorespiratory Fitness: The ability of an individual to exercise continuously for an extended period of time.

Significance of the Study

Most research on aerobic dance bench stepping has been conducted on college-aged females. However, aerobic dance bench stepping appears to target the middle-aged participants (Dowdy, Cureton, DuVal, & Ouzts, 1985). Aerobic dance bench stepping is considered to be a life-long leisure activity that individuals can participate throughout their lifetime (Williford, Blessing, Olson, & Smith, 1989). Therefore, the metabolic costs of aerobic bench stepping should be determined for both young adult to moderate-aged individuals.

Of major significance in this study is whether cadence of music (beats·min^{-1}) and height of bench affect metabolic cost of aerobic dance bench stepping. Research has only investigated metabolic cost of performing aerobic dance bench stepping at 120 beats·min^{-1} using varying bench heights (4 – 10-in). The present study will examine the effects of cadence (125 and 130 beats·min^{-1}) and bench height (6 and 8-in) on metabolic and cardiovascular responses to aerobic dance bench stepping.

The results of this study may prove to be valuable for those who are interested in improving cardiovascular fitness and health. Woodby-Brown, Berg, and Latin (1993) and Francis and Francis (1994) indicate that aerobic dance bench stepping meets the American College of Sports Medicine guidelines for intensity (60 to 90% of maximum heart rate or 50 to 85% of maximum oxygen uptake reserve) while participating in aerobic activity.

The current models for estimating caloric cost of aerobic dance bench stepping are limited to cadences up to 120 beats$\cdot$min^{-1} (American College of Sports Medicine, 1998). These models are based on bench height and cadence and fail to account for body weight and body height. Weight loss is the goal for many adults who participate in exercise. A model that considers body weight and body height for energy expenditure of aerobic dance bench stepping would be useful to those individuals who are at risk for obesityand want to lose weight. For this reason, there is a need for the development of a model that considers bench height, cadence, body weight, and body height.

Chapter 2
Review of the Literature

The purpose of this investigation was to determine the acute metabolic and cardiovascular responses of aerobic dance bench stepping at 6 and 8-in bench heights at cadences of 125 and 130 beats·min^{-1}. The U.S. Surgeon General in 1996 suggested that a majority of Americans are overweight, inactive, and at risk for serious health complications such as cardiovascular disease, cancer, and adult onset diabetes (U.S. Department of Health and Human Services, 1996). When combined with other lifestyle changes, moderate physical activity and exercise, are important for reduction in body fat, improvement in cardiorespiraoty fitness, and overall enhancement of quality of life (Zelasko, 1995; U.S. Department of Health and Human Services, 1996).

Chronic Disease

Recent reports suggest that a majority of Americans are overweight, inactive, and at risk for serious health complications such as cardiovascular disease (CVD), colon cancer, high blood pressure, adult onset diabetes, and poor mood state (U.S. Department of Health and Human Services, 1996). Cardiovascular diseases have resulted in more deaths than all other causes of death combined, including cancer, AIDS, and accidents (Wilmore and Costill, 2000). This high incidence is on the decline, and researchers are still attempting to find the primary causes and risk factors of CVD. Even though the pathology of CVD is somewhat unique to each individual with CVD, certain risk factors associated with CVD have been identified. Most of these risk factors are controllable and include but are not limited to physical inactivity, elevated blood lipids, hypertension, cigarette smoking, obesity, diabetes, and stress. Through lifestyle and behavioral modifications, such as proper diet, increased levels of physical activity, and cessation of smoking, risk of chronic ailment can be reduced and quality of life can be enhanced (U.S. Department of Health and Human Services, 1996; Prentice, 1999)

Physical Activity and Disease Prevention

A predominant interest to health fitness professionals and physicians is the role of physical activity in prevention of chronic diseases and enhancement of quality of life. It is recommended that men and women of all ages should participate in moderate physical activity on most days of the week (U.S. Department of Health and Human Services, 1996). However, more than 60 percent of U.S. adults do not meet these recommendations and approximately 25 percent are not active at all (U.S. Department of Health and Human Services, 1996).

The benefits of physical activity have been noted throughout history, however, it was not until the 1970s that recommendations on physical activity were devised (U.S. Department of Health and Human Services, 1996). According to the U. S. Surgeon General, a moderate amount of physical activity is equivalent to physical activity that expends approximately 150 kcals per day or 1,000 kcals per week. This includes such activities as 30 minutes of brisk walking, 15 minutes of running, 45 minutes of playing volleyball, and 30 minutes of aerobic dance (U.S. Department of Health and Human Services, 1996).

More comprehensive exercise guidelines have been developed by the American College of Sports Medicine (ACSM) to further enhance prescription of exercise (American College of Sports Medicine, 1998). According to the these guidelines, the following recommendations for developing and maintaining cardiorespiratory fitness are as follows:

1) *Mode of Activity:* Any activity that uses large muscle groups, is maintained continuously, and is rhythmical and aerobic in nature.
2) *Frequency*: 3 to 5 days per week.
3) *Intensity*: 60 to 90% of maximum heart rate or 50 to 85% of maximum oxygen uptake reserve (VO_2R).
4) *Duration*: 20 to 60 minutes of continuous aerobic activity
5) *Caloric expenditure*: Each exercise session should expend at least 250 to 300 kcals of energy.

An exercise program that meets the ACSM guidelines should include exercise modalities that are enjoyable to the participant. Many popular activities such as walking, jogging, swimming, aerobic dance, in-line skating, and cycling, when performed in coherence with the ACSM guidelines, can provide sufficient improvements in an individual's cardiorespiratory fitness (Astrand & Rodahl,1986; Fox & Matthews, 1981; Cearly, 1984).

Energy Metabolism

Energy to perform mechanical, chemical, and transport work comes indirectly from food nutrients, i.e., carbohydrates, fats, and proteins (McArdle, Katch, & Katch, 1996). Energy is transferred from these food sources to Adenosine Triphosphate (ATP) via a process known as phosphorylation (Wilmore & Costill, 1999). ATP is composed of adenosine and three phosphates that are held together via high energy bonds. The hydrolysis of the outermost high energy phosphate bond, breaks down ATP to Adenosine Diphosphate (ADP) and inorganic phosphate (P_i). As a result, approximately 7.3 kcals of free energy is released (McArdle et al., 1996; Wilmore & Costill 1999; Lindle, 1995; Marieb,1995).

There are three energy systems that generate ATP for mechanical work: 1) the ATP-PCr system (Immediate Energy System); 2) Glycolytic system, and 3) Oxidatvie system (Lindle, 1995; Marieb,1995; Wilmore & Costill, 1999). The generation of energy from the ATP-PCr system does not require oxygen. Because it is anaerobic in nature, it is able to immediately supply the working muscles with energy from stored high energy phosphagens, i.e., ATP and Creatine Phosphate (CP). Most of the energy required to perform high intensity exercises, such as weight lifting and sprinting, is fueled by this immediate energy system. Depending on the level of intensity, this system provides up to the first minute of exercise with energy (McArdle at al., 1996).

Because cells do not have an unlimited supply of stored ATP and CP, ATP must be continuously resynthesized by other energy systems to meet the demands of longer duration exercise. The glycolytic energy system is an anaerobic energy system that can resynthesize ATP and generate adequate amounts of energy to fuel the first two to three minutes of exercise. The anaerobic glycolytic system does not require oxygen and it involves the breakdown of carbohydrate, specifically glucose and glycogen, to pyruvic acid. The ability of this energy system to produce energy for bouts of exercise lasting longer than two to three minutes is limited by the production of the by-product, lactic acid (Lindle, 1995; Marieb,1995; Wilmore & Costill, 1999). The body is able to withstand lactate accumulate for up to three minutes of exercise. However, excessive amounts of lactic acid build-up inhibits further breakdown of glycogen, impairs glycolytic enzymes, and ultimately impedes muscle contraction (Wilmore & Costill, 1999).

Exercise lasting longer than two or three minutes is usually fueled by a combination of both the glycolytic and oxidative energy systems (McArdle et al., 1996). The oxidative energy system generates large amounts of ATP in the presence of oxygen from fatty acids and pyruvic acid without the accumulation lactic acid. For instance, this energy system can produce 147 ATP from an 18-carbon fatty acid compared to 36 ATP produced from the breakdown of glucose via glycolysis. Because aerobic metabolism produces the greatest amount of ATP, this system is the primary method of energy production during long duration endurance exercise, such as jogging, walking, aerobic dance, and cycling (Lindle, 1995; Marieb,1995; Wilmore & Costill, 1999).

Consumption of oxygen reflects caloric expenditure during aerobic types of exercise. By measuring a person's oxygen uptake under conditions of steady-rate exercise, it is possible to obtain an indirect estimate of energy metabolism because the anaerobic energy yield is quite negligible (McArdle et al., 1996). Breakdown of fuels, specifically glucose and fatty acids, in the presence of oxygen is the primary pathway for generation of ATP during aerobic dance bench stepping. Therefore, meaurements of oxygen consumption during aerobic dance bench stepping will provide estimates of caloric expenditure during this type of submaximal exercise (Woodby-Brown et al., 1993; Scharff-Olson & Williford, 1996).

<u>Energy Cost and Physical Activity</u>

Previous research has examined the metabolic costs of various exercise modalities including walking, jogging, cycling, swimming, jump roping, and aerobic dance. For instance, the energy expenditure for: 1) walking and running in female adolescents has been shown to be 0.080 $kcal \cdot kg^{-1} min^{-1}$ and 0.171 $kcal \cdot kg^{-1} min^{-1}$, respectively (Walker, Murray, Jackson, Morrow, & Michaud, 1999); 2) performing the crawl stroke during swimming at 3 mph has been shown to be 0.285 $kcal \cdot kg^{-1} min^{-1}$, which is equivalent to 15.7 $kcal \cdot min^{-1}$ for a 120-lb female (Wilmore & Costill, 1999); 3) cycling at 9.4 mph for a 123 pound woman to be 5.6 $kcal \cdot min^{-1}$ (Katch, Katch, and McArdle, 1996); and 4) rope skipping at a rate of 80 turns per minute to be 11.6 – 11.9 $kcal \cdot min^{-1}$ (Getchell & Cleary, 1980). Literature suggests that if these exercises are performed at an optimal intensity, duration, and frequency, then the oxygen cost is high enough to provide an aerobic training effect and, thus, promote improvements in cardiorespiratory fitness (Jakicic, Winters, Lang, & Wing, 1999; Milburn, S. & Butts, N., 1983; Wilmore & Costill, 1999; American Council on Exercise, 1995; American College of Sportsmedicine, 1998).

Weight Loss and Physical Activity

Over fifty percent of American adults are overweight (Jakicic, et al., 1999). Overweight is defined as a body mass index (BMI) of 26 $kg \cdot m^{-2}$ or greater (Bouchard, Depres, & Tremlay, 1993; Mokdad, Serdula, Dietz, Bowman, Marks, & Koplan, 1999). Weight gain results when energy intake exceeds energy expenditure (Fahey, Insel, & Roth, 1997). Therefore, overweight individuals have the option of decreasing energy intake through dieting, increasing energy expenditure through exercise, or combining both diet and exercise to lose weight (Flegal, Carrol, Kuczmarski, & Johnson, 1988).

The diet strategies available to combat the growing epidemic of obesity include but are not limited to: 1) low fat diets, such as The Rice Diet, The Pritikin Diet, and The Pasta Diet; 2) low carbohydrate diets, such as Dr. Atkins' Diet Revolution and the Wild Weekend Diet; 3) very-low-calorie diets, such as the Cambridge Diet and the Last Chance Diet; and 4) the premeasured diets such as Jenny Craig and Weight Watchers (Wardlaw & Insel, 1996). Despite the short-term effectiveness of these diets, many individuals regain weight within a one-year period (Jakicic et al., 1999). As a result, the most practical and successful methods to weight loss and maintenance appear to include sensible eating behaviors as well as increased levels of physical activity (U.S. Department of Health and Human Services, 1996; Bouchard et al., 1993).

The literature attributes not only an increase in caloric intake but also a decrease in levels of physical activity to obesity. According to the U.S. Surgeon General, 60% of American adults do not engage in the recommended amount of daily activity and approximately 25% of adults are not active at all (U.S. Department of Health and Human Services, 1996). Many weight loss treatment programs emphasizing increased energy expenditure have been employed by physicians, exercise physiolgists, nutritionists, and other health and fitness professionals. Previous studies have shown that exercise is essential to weight loss, is relatively easy to implement in a daily routine, and is more tolerated than dietary changes. (Goodrick & Foreyt, 1991; Skender, Goodrick, Del Junco, Reeves, Darnell, Gotto, & Foreyt, 1996).

Aerobic Dance

In an effort to maintain high levels of interest in physical activity, alternatives to such common physical activities as walking, jogging, and cycling, have been developed. In particular, aerobic dance has become a popular form of leisure activity enjoyed by individuals of all age groups (Milburn & Butts, 1983). It is a choreographed routine of movements performed to music that combine various types of dance with calisthenics (Dowdy et al, 1985).

In the late 1970's, dance aerobics included leaps, bounds, and high impact movements (Dowdy et al., 1985). Participants believed that this form of high impact exercise would result in greater fitness gains and larger energy expenditure (Williford, Blessing, Olson, & Smith, 1989). However, during high-impact aerobic dance, both feet elevate off the ground and meet the ground together. As a result, the feet, ankles, and lower leg absorb the impact of total body weight upon landing (Johnston, R., Morton, A., & Elliott, B., 1993; Tarrant & McNaughton, 1997). Although there has been a growth in aerobic dance participation, there has been a subsequent increase in lower limb injury due to repetitive pounding (Johnston, Williford). This increase in lower limb injury has led to the development of low-impact classes, in which one foot remains in contact with the ground at all times so the impact is not as forceful as when both feet land together (Tarrant & McNaughton, 1997).

Aerobic Dance Bench Stepping

Alternatives have been developed, such as low impact dance aerobics, aerobic dance bench stepping, kickboxing, and circuit training, due to the prevalence of injury sustained from high-impact aerobic dance. For instance, in the 1980's Gin Miller, a high-impact aerobics instructor, suffered a knee injury. In order to rehabilitate her knee, she was prescribed to perform a series of step-up exercises on a bench. Gin discovered a new and innovative workout that evolved into what isnow known as aerobic dance bench stepping (Francis & Francis, 1994). Aerobic dance bench stepping involves performing choreographed aerobic dance movements while stepping on and off a bench to the instruction of a group exercise leader. Because the choreography is relatively easy to follow and the level of intensity remains fairly moderate, aerobic dance bench stepping appeals to both female and male particpants of all age groups and fitness levels.

Aerobic dance bench stepping is a relatively new mode of aerobic exercise, and its cardiovascular and metabolic effects have not been fully investigated. The majority of research has investigated the physiological effects of bench stepping at 120 beats$\cdot$min^{-1}, bench stepping with bench heights of 4 – 12 inches, and use of hand-held weights while bench stepping (Woodby-Brown, Berg, & Latin, 1993; Francis & Francis, 1996; Olson et al., 1991; Goss, F., Robertson, R., Spina, R., Auble, T., Cassinelli, D., Silberman, R., Galbreath, R., & Metz K., 1989; Scharff-Olson, M. & Williford, H., 1996).

The Aerobic and Fitness Association of America (AFAA) (1997) recommends that aerobic dance bench stepping should be performed at a cadence of 118 to 128 beats$\cdot$min^{-1} on a bench ranging in height from 6 to 8 inches. Although these guidelines suggest that these wide range of cadences are a safe and effective means of physical activity, research has only investigated aerobic bench stepping at cadences of 120 beats$\cdot$min^{-1}.

The literature has shown that the energy cost of bench stepping at a cadence of 120 beats$\cdot$min^{-1} at bench heights of 4, 8, and 10 inches to be 6.3, 8.0, and 9.2 kcal$\cdot$ min^{-1}, respectively (Woodby-Brown, Berg, & Latin, 1993) and at bench heights of 4, 6, 8, and 10 inches to be 4.5, 5.5, 6.4, and 7.2 kcal$\cdot$min^{-1}, respectively (Francis & Francis, 1994). However, AFAA safety guidelines suggest that these three bench heights are not ideal for all participants (Aerobic and Fitness Association of America, 1997). The 4-in benches are generally recommended for beginners, less fit, and older individuals, whereas the 10-in benches are generally not recommended due to the increased risk of patellofemoral injuries (Aerobic and Fitness Association of America, 1997; Woodby-Brown et al., 1993). Bench heights greater than 8-inches increases the amount of stress placed on the knee leaving the knee and lower leg vulnerable to injury (Francis & Francis, 1994). Therefore, to reduce the risk of injury, the bench height during aerobic dance bench stepping is usually limited to 6 to 8 inches (Aerobic and Fitness Association of America, 1997).

To increase the energy cost of aerobic dance bench stepping, the use of hand-held weights while bench stepping has also been examined. Bench stepping with 0.91 kg (2 lb) hand-held weights compared with no added weight elicited an approximate 2 ml$\cdot$ kg$^{-1}\cdot$ min^{-1} increase in VO_2. Such an increase, although statistically significant, resulted in only a minimal increase in energy expenditure (approximately 20 kcals) over a 20-min aerobic session (Olson et al., 1991).

The use of hand-held weights during an aerobic dance bench stepping class may increase risk of unnecessary musuclar fatigue and discourage beginning and low fit participants. It has been suggested that the use of hand-held weights during aerobic dance may cause muscular fatigue and discomfort of upper body muscles. In order to compensate for muscular fatigue, range of motion of arms and legs as well as amount of muscle mass actively engaged in exercise are reduced (Blessing et al., 1987). In addition, the use of hand-held weights during bench stepping should be limited to those advanced aerobic dance bench participants. Consequently, the exclusion of novice and lower fit individuals from use of hand-held weights while bench stepping, may result in disinterest and withdrawal from participation in aerobic dance bench stepping (Scharff-Olson & Williford, 1996). The minimal increase in energy expenditure from the use of hand-held weights during bench stepping is not enough of a benefit to out weigh the increased risk of injury and muscle fatigue and of losing participation.

To create exciting and challenging aerobic dance bench stepping classes, a recent survey suggests that a majority of group exercise leaders teach aerobic dance bench stepping at cadences of 125 to 133 beats$\cdot$min^{-1} (http://www.turnstep.com). More research is needed to investigate metabolic and cardiovascular responses of aerobic dance bench stepping at these most common cadences . Information from such research would enable aerobic participants to select proper bench heights and cadences to meet the ACSM recommended guidelines of aerobic exercise for the development of cardiorespiratory fitness.

Chapter 3

Methods

Subjects

Subjects were thirty females (ages 19-47 years). The subjects were volunteers recruited from personal and fitness wellness aerobic classes at Southwest Texas State University. The criteria for subject participation included a minimum of 2 months of regular attendance, at least 2 days/week in formal bench step aerobic classes in order to ensure that the subjects could follow a video-tape routine and to reduce the risk of injury. Written consent was obtained from all subjects after explanation of the study protocol, including the benefits and potential risks involved. This investigation was approved by Southwest Texas State University's Committee of Protection of Human Subjects.

Instruments

The exercise test was performed on a Quinton treadmill (Quinton, Inc., Seattle, WA). Subject's heart rate (HR) was measured with a Polar Vantage XL telemetric heart rate monitor (Polar USA, Inc., Stanford, CT). Expired air was analyzed throughout the test with an Aerosport TEEM 100 (Aerosport, Ann Arbor, MI) metabolic analyzer. Ventilation, oxygen consumption (VO_2), carbon dioxide production (VCO_2), and respiratory quotient (RQ) were determined from 60 sec averages. The metabolic analyzers were calibrated with gases of known concentrations before and after each test.

<u>Laboratory Procedures</u>

Subjects were required to meet at the testing area on three different occasions. They were instructed to abstain from caffeine and alcohol for at least 24 hours and from all food, drink, and nicotine 2 hours prior to all three testing sessions.

Pre-Max VO_2 Measurements. During the first visit to the Human Performance Laboratory, informed consent, Physical Activity Readiness Questionnaire (PARQ), and (ARIC)/Baecke Physical Activity Questionnaire were completed and anthropometric measures (height, weight, and body composition) were taken. Any YES answers to the PAR-Q exempted the subjects from participation in the study (Howley & Franks, 1992). The (ARIC)/Baeke Physical Activity Questionnaire determined physical activity levels of each participant (Richardson, Ainsworth, Wu, Jacobs, & Leon, 1995). The questionnaire includes 4 items to determine a person's sport- and exercise-related leisure activity and 4 items to determine non-sport-and exercise-related leisure activity.

A calibrated physician's scale was used to obtain height and weight for each participant. A Lafayette skinfold caliper (Lafayette Instruments, Lafayette, IN) was used for measuring skinfold thickness. The triceps, supraillium, and thigh skinfold thicknesses were measured (American College of Sports Medicine, 2000). Body density was estimated from sum of skinfolds using the equations by Jackson, Pollock, and Ward (1980). Percent body fat was estimated from body density using the Siri equation (Siri, 1961).

Maximal Exercise Testing. During the first visit to the laboratory, subjects maximal oxygen uptake (VO_2max) was predicted using a Balke-Ware treadmill protocol (1959). Subjects began the maximal treadmill test by walking at 91.1 $m \cdot min^{-1}$ (3.4 mph) at 0% grade. The treadmill speed was held constant at 91.1

$m \cdot min^{-1}$ and the treadmill grade was increased by 2% after the first minute and 1% after each subsequent minute until volitional exhaustion or achievement of max VO_2. The highest full-minute VO_2 that was observed during the final stage of the test was accepted as VO_2max if two of the following criteria were met: 1) failure to maintain pace on the treadmill despite strong encouragement; 2) achievement of age predicted maximal heart rate (i.e., 220-age); and 3) a respiratory exchange ratio (RER) in excess of 1.00 (McArdle, Katch & Katch, 1996). Oxygen consumption (VO_2), carbon dioxide production (VCO_2), ventilation (V_E), and RER were determined from 60 second averages. Heart rate (HR) and rate of perceived exertion (RPE) were recorded at the end of each minute.

Submaximal Exercise Testing. In order to determine cardiovascular and metabolic responses to bench stepping at bench heights of 6 and 8 inches at cadences of 125 and 130 $beats \cdot min^{-1}$, subjects returned to the laboratory on two additional occasions. Bench heights of 6 and 8 inches and cadences of 125 and 130 $beats \cdot min^{-1}$ were randomly assigned. Subjects performed two 8-minute submaximal aerobic dance bench stepping tests during each visit to the laboratory. Between the two tests, recovery was enhanced by having the subject lie down for at least 10 minutes with her feet elevated .

Two bench stepping routines with the same choreography but difference cadences (125 versus 130 $beats \cdot min^{-1}$) were developed and videotaped by the primary investigator. The cadences of 125 $beats \cdot min^{-1}$ and 130 $beats \cdot min^{-1}$ were established by a metronome to ensure proper cadence. The AFAA certified group exercise leader with 5 years teaching experience developed a choreographed bench stepping routine of moderate intensity consisting of movements commonly used in aerobic dance bench stepping (Francis & Francis, 1994). A detailed description of the choreographed steps can be found in Appendix A.

Subjects were asked to follow the exact movements of the instructor on the videotape with the same degree of intensity as projected by the instructor. Oxygen consumption (VO_2), carbon dioxide production (VCO_2), ventilation (V_E), and RER were determined from 60 second averages. Heart rate (HR) and rate of perceived exertion (RPE) were recorded at the end of each minute.

Data Analysis

The dependent variables to determine the difference in cadences and step heights include: 1) VO_2; 2) HR; 3) RPE; and 4) caloric cost (kcals$\cdot$min^{-1}) of bench stepping. The independent variables were cadences of 125 and 130 beats$\cdot$min^{-1} and step heights of 6 and 8 inches. A two-way (2 x 2) repeated measures factorial analysis of variance (ANOVA) was used to determine significant differences among the different cadences (125 and 130 beats$\cdot$min^{-1}) and step heights (6 and 8 inches).

The dependent variables for estimating metabolic cost of bench stepping was caloric cost (kcals$\cdot$min^{-1}). The independent variables were: 1) body weight (kg); 2) cadence (125 and 130 beats$\cdot$min^{-1}); 3) step height (6 and 8 inches); 4) body height; 5) age; and 6) percent body fat. A multiple regression model was developed to estimate caloric cost of bench stepping from cadence, step height, body height, age, and percent body fat.

Chapter 4
Results

Table 1 reports the subjects' descriptive characteristics. The sample appears to be representative of female aerobic bench stepping participants that are active, moderately fit, and experienced in the techniques required for aerobic bench stepping. The sample does not include sedentary, unfit subjects who are unfamiliar with aerobic bench stepping.

Table 1. Descriptive Statistics of Subjects

Variable	Mean	St. Dev.	Min	Max
Age (years)	26.40	9.41	19.00	47.00
Height (cm)	163.57	7.81	139.50	176.53
Weight (kg)	62.85	8.18	52.50	85.45
SSF (mm)	60.49	12.80	39.67	86.00
Percent Bodyfat	23.88	3.87	16.90	31.46
Max VO_2 ($L \cdot min^{-1}$)	2.27	0.51	1.00	3.62
Max VO_2 ($ml \cdot kg^{-1} \cdot min^{-1}$)	36.26	8.06	17.81	60.80
Physical Activity(METS)	44.14	12.03	33.32	90.50

Note: SSF= Sum of Skinfolds

Tables 2 and 3 report the physiological data derived from the exercise tests. Table 2 categorizes the measured variables according to cadence and step height. Repeated measures analyses of variance revealed no physiological differences between the two selected cadences (125 beats$\cdot$min^{-1} and 130 beats$\cdot$min^{-1}) for any of these variables. However, significant differences were observed between the two step heights (6 inches and 8 inches) for each variable.

Table 2. Cardiovascular and Metabolic Responses to Bench Stepping

Variable	**125 bpm**		**130 bpm**	
	6-in bench	8-in bench	6-in bench	8-in bench
Heart Rate (HR)	153.60±19.3	165.43±19.3	156.92 ± 19.8	165.10±18.5
VO_2 (L$\cdot$ min^{-1})	1.42 ± 0.27	1.69 ± 0.26	1.50 ± 0.29	1.64 ± 0.30
RPE	10.80 ± 1.41	12.22 ± 2.61	10.87 ± 2.5	12.43 ± 2.13
VO_2 (ml $\cdot$ kg^{-1} $\cdot$ min^{-1})	22.75 ± 4.52	27.03 ± 4.55	23.97 ± 4.75	26.00 ± 3.64
Kcal $\cdot$ min^{-1}	6.79 ± 1.31	8.17 ± 1.31	7.20 ± 1.47	7.93 ± 1.50

Note: No difference beteen cadences

Table 3 reports the average values across the two selected cadences and step heights. To further demonstrate the effect of bench height on energy expenditure and the lack of variability due to cadence, Table 3 reports mean metabolic responses across cadences.

Table 3. Cardiovascular and Metabolic Responses to Bench Stepping According to Cadence and Step Height

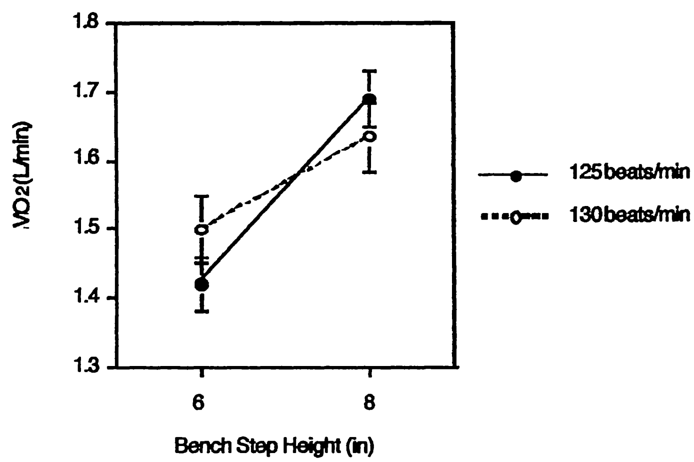
Variable	Cadence		Bench Height	
	125 bpm	130 bpm	6-In bench	8-In bench
Heart Rate (HR)	159.52 ± 18.1	161.01 ± 18.7	155.26 ± 18.9	165.27 ± 17.9
VO_2 ($L \cdot min^{-1}$)	1.56 ± 0.20	1.57 ± 0.25	1.46 ± 0.19	1.66 ± 0.23
RPE	11.51 ± 1.70	11.65 ± 2.06	10.83 ± 1.62	12.33 ± 2.25
VO_2 ($ml \cdot kg^{-1} \cdot min^{-1}$)	24.89 ± 3.48	24.98 ± 3.37	23.36 ± 3.10	26.51 ± 3.14
$Kcal \cdot min^{-1}$	7.51 ± 0.98	7.56 ± 1.26	6.99 ± 0.92	8.07 ± 1.16

No significant difference ($F1, 28 = 0.09$, $p > .05$) in absolute VO_2 ($L \cdot min^{-1}$) was observed between 125 $beats \cdot min^{-1}$ (1.56 ± 0.20 $L \cdot min^{-1}$) and 130 $beats \cdot min^{-1}$ (1.57 ± 0.25 $L \cdot min^{-1}$). No significant differences ($F1,28 = 0.02$, $p > .05$) in relative VO_2 ($ml \cdot kg^{-1} \cdot min^{-1}$) were observed between 125 $beats \cdot min^{-1}$ (24.89 ± 3.48 $ml \cdot kg^{-1} \cdot min^{-1}$) and 130 $beats \cdot min^{-1}$ (24.98 ± 3.37 $ml \cdot kg^{-1} \cdot min^{-1}$). No significant differences ($F1,28 = 1.82$, $p > .05$) in heart rate ($beats \cdot min^{-1}$) were observed between 125 $beats \cdot min^{-1}$ (159.52 ± 18.09 $beats \cdot min^{-1}$) and 130 $beats \cdot min^{-1}$ (161.01 ± 18.68 $beats \cdot min^{-1}$). No significant differences ($F1,28 = 0.32$, $p > .05$) in ratings of perceived exertion (RPE) were observed between 125 $beats \cdot min^{-1}$ (11.51 ± 1.70) and 130 $beats \cdot min^{-1}$ (11.65 ± 2.06). No significant differences ($F1,28 = 0.14$, $p > .05$) in caloric cost ($kcal \cdot min^{-1}$) were observed between 125 $beats \cdot min^{-1}$ (7.51 ± 0.98 $kcal \cdot min^{-1}$) and 130 $beats \cdot min^{-1}$ (7.56 ± 1.26 $kcal \cdot min^{-1}$). This analysis suggests that the speed of the cadence does not affect the intensity of aerobic bench stepping.

The significant differences in absolute VO_2 ($L \cdot min^{-1}$) between 6-inch and 8-inch bench heights ($F1,28 = 36.28$, $p < .05$) are demonstrated in Figure 1. Absolute

$\dot{V}O_2$ increases from 1.46 ± 0.19 L·min^{-1} for a bench height of 6 inches to 1.66 ± 0.23 L·min^{-1} for a bench height of 8 inches.

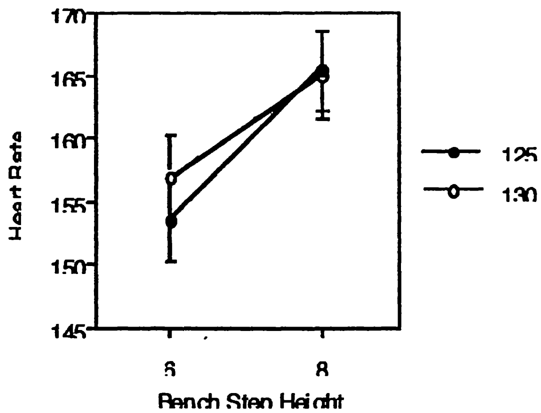
Figure 1. The Effect of Bench Step Height and Pace on the Oxygen Cost of Aerobic Exercise.



p < .05 for cadence
p > .05 for bench height

The significant differences in heart rate (beats·min^{-1}) between 6-inch and 8-inch bench heights ($F_{1,28}$ = 75.86, $p < .05$) are demonstrated in Figure 2. Heart rate increases from 155.26 ± 18.92 beats·min^{-1} for a bench height of 6 inches to 165.27 ± 17.88 beats·min^{-1} for a bench height of 8 inches.

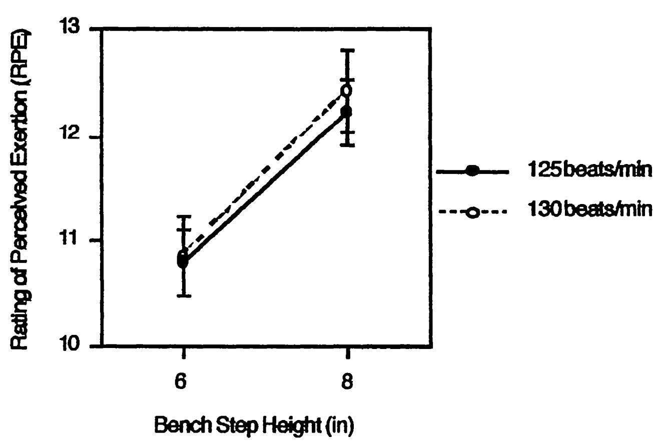
Figure 2. The Effect of Bench Height and Pace on Heart Rate during Aerobic Exercise.



p < .05 for cadence
p > .05 for bench height

The significant differences in ratings of perceived exertion (RPE) between 6-inch and 8-inch bench heights (F1,28 = 24.38, $p < .05$) are demonstrated in Figure 3. RPE increases from 10.83 ± 1.62 for a bench height of 6 inches to 12.33 ± 2.25 for a bench height of 8 inches.

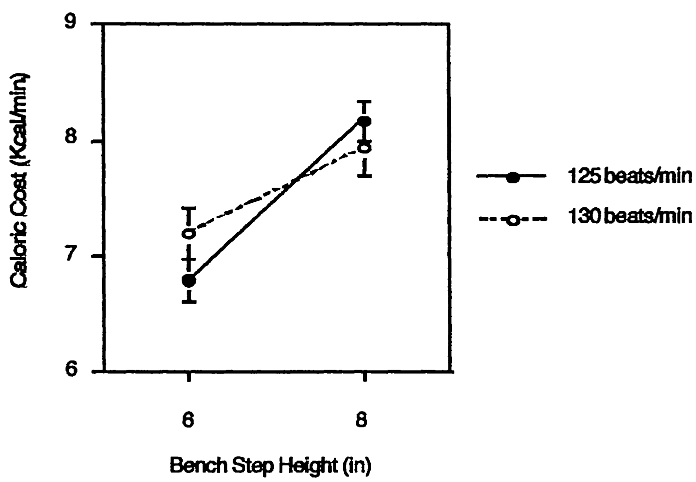
Figure 3. The Effect of Bench Step Height and Pace on Ratings of Perceived Exertion during Aerobic Exercise.



p > .05 for cadence
p < .05 for bench height

The significant differences in caloric cost (kcal · min^{-1}) between 6-inch and 8-inch bench heights ($F_{1,28} = 38.74$, $p < .05$) are demonstrated in Figure 4. Caloric cost increases from 6.99 ± 0.92 kcal · min^{-1} for a bench height of 6 inches to 8.07 ± 1.16 kcal · min^{-1} for a bench height of 8 inches. These analyses suggests that the height of the bench does influence aerobic bench stepping intensity, and the higher the step, the more intense the exercise.

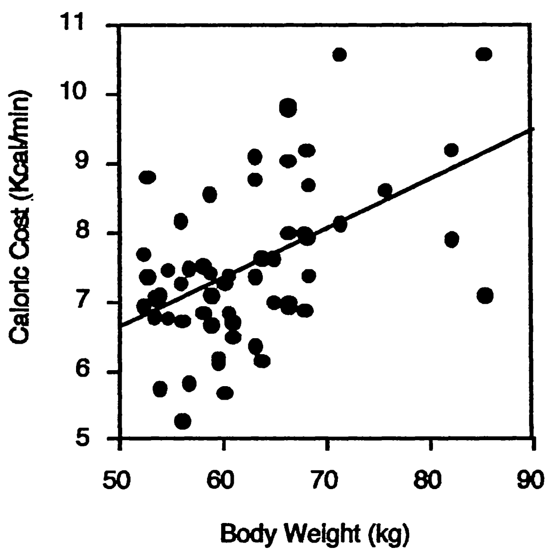
Figure 4. The Effect of Bench Step Height and Pace on the Caloric Cost of Aerobic Exercise.



P > .05 for cadence
P < .05 for bench height

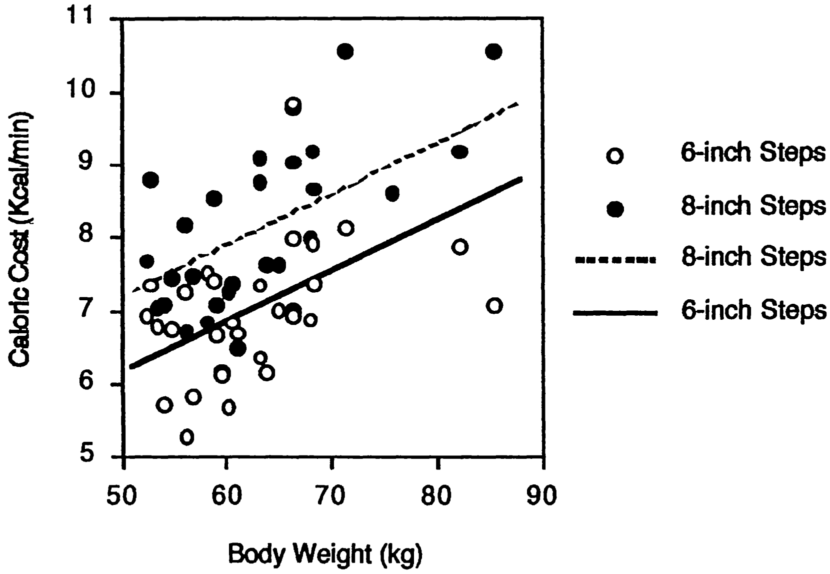
The next stage of the analysis involved the development of a model for estimating the caloric cost of aerobic bench stepping from body weight, cadence, bench height, and other physiological variables. Since the cadence of the music did not affect caloric cost in this sample, cadence was eliminated as a variable in this analysis. The relationship between body weight and caloric cost was linear ($R = .49$, $p < .05$, SEE = 1.03 kcal · min^{-1}). Caloric cost may be estimated from body weight by the following linear equation: Caloric cost (kcal · min^{-1}) = 3.06 + (0.07 x body weight in kg). This relationship is demonstrated in Figure 5.

Figure 5. The Relationship Between Body Weight and the Caloric Cost of Aerobic Dance.



The percent of additional variance accounted for by the inclusion of a quadratic term for body weight was not significant ($F1, 54 = 0.068$, $p > .05$). Tests for homogeneity of 6-inch and 8-inch regression lines revealed significantly different intercepts between step heights ($F1, 54 = 19.45$, $p < .05$), but failed to detect significantly different slopes between step heights, ($F1, 53 = 2.22$, $p > .05$). The inclusion of step height in the model increased R to .67 and decreased the SEE to 0.90 kcal · min^{-1}. The effect of step height on the relationship between body weight and caloric cost is demonstrated in Figure 6.

Figure 6. The Effect of Step Height in Estimating the Caloric Cost of Aerobic Dance from Body Weight.



Caloric cost may be estimated from body weight and step heights by the following linear equations: Caloric cost (kcal · min^{-1}) for 6-inch bench = 2.64 + (0.07 x body weight in kg). Caloric cost (kcal · min^{-1}) for 8-inch bench = 3.68 + (0.07 x body weight in kg). The addition of age into the regression model failed to account for significant additional variance in caloric cost ($F1, 53 = 0.01, p > .05$). Also, the addition of percent fat into the regression model failed to account for significant additional variance in caloric cost ($F1, 53 = 0.40, p > .05$). However, the inclusion of height into the regression model did account for significant additional variance in caloric cost ($F1, 53 = 6.45, p < .05$). The inclusion of height in the model increased R to .71 and decreased the SEE to 0.85 kcal · min^{-1}. Caloric cost may be estimated from body weight, height, and step heights by the following linear equations: Caloric cost (kcal · min^{-1}) for 6-inch bench = 8.22 + (0.08 x body weight in kg) - (0.04 x height in cm). Caloric cost (kcal · min^{-1}) for 8-inch bench = 9.26 + (0.08 x body weight in kg) - (0.04 x height in cm). The estimated caloric cost (kcal · min^{-1}) of aerobic bench stepping for bench heights of 6 inches and 8 inches based on these prediciton equations can be found in Appendix B and C.

Chapter 5

Discussion, Conclusions, & Recommendations

The present study investigated the metabolic and cardiovascular responses of aerobic dance bench stepping at the most widely used bench heights of 6 and 8-in and the most common cadences of 125 and 130 beats$\cdot$min^{-1} in active, moderately fit, and experienced female aerobic dance bench stepping participants. This study revealed no cardiovascular or metabolic differences between the two selected cadences of 125 and 130 beats$\cdot$min^{-1}. However, significant differences were observed between the two step heights of 6 and 8 inches for HR, VO_2, RPE, and caloric expenditure.

The Effect of Cadence on Aerobic Dance Bench Stepping

National Aerobic Organizations, e.g., AFAA and Step Reebok, recommend cadences of 118 to 122 beats$\cdot$min^{-1} for beginning and intermediate participants and 118 to 128 beats$\cdot$min^{-1} for advanced participants (Francis & Francis, 1994; Aerobics and Fitness Association of America, 1995). However, in an effort to create exciting and challenging aerobic dance bench stepping classes, a recent survey suggests that a majority of group exercise leaders are disregarding safety guidelines and are teaching aerobic dance bench stepping at cadences of 125 to 133 beats$\cdot$min^{-1} (http://www.turnstep.com). By increasing the cadence, beginning exercise participants are at a disadvantage because they: 1) cannot keep up with the pace; 2) cannot perform movements with full range of motion; and 3) are at increased risk of injury (Goss, Robertson, Spina, Auble, Cassinelli, Silberman, Galbreath, & Metz, 1989; Francis & Francis, 1994). Aerobic dance bench stepping at higher than recommended cadences seems to be appropriate for skilled and experienced exercisers who possess the motor abilities for effectively performing more vigorously paced routines (Olson et al., 1991).

From the results of this study, it appears that increasing cadence does not offer any additional physiological benefits, specifically any increases in energy expenditure. As Table 3 indicates, a non-significant difference exists between the means of the physiological variables tested for the different cadences. For example, mean VO_2 ($ml \cdot kg^{-1} \cdot min^{-1}$) at 125 $beats \cdot min^{-1}$ is 24.89 $ml \cdot kg^{-1} \cdot min^{-1}$ and the mean at 130 $beats \cdot min^{-1}$ is 24.98 $ml \cdot kg^{-1} \cdot min^{-1}$, a difference of .09 $ml \cdot kg^{-1} \cdot min^{-1}$; mean heart rate ($beats \cdot min^{-1}$) at 125 $beats \cdot min^{-1}$ is 155.26 $beats \cdot min^{-1}$ and the mean at 130 $beats \cdot min^{-1}$ is 165.27 $beats \cdot min^{-1}$; and mean $kcal \cdot min^{-1}$ at 125 $beats \cdot min^{-1}$ is 6.99 $kcal \cdot min^{-1}$ and the mean at 130 $beats \cdot min^{-1}$ is 8.07 $kcal \cdot min^{-1}$. Therefore, faster cadences increase the risk of injury, intimidate and discourage beginning aerobic dance participants, and do not appear to increase levels of intensity to promote greater energy expenditure.

<u>The Effect of Bench Height on Aerobic Dance Bench Stepping</u>

This investigation found that bench height influences metabolic and cardiovascular responses while performing aerobic dance bench stepping. As Table 3 indicates, a significant difference exists between the means of the variables tested for the different bench heights. For example, mean VO_2($ml \cdot kg^{-1} \cdot min^{-1}$) on a 6-in bench is 23.36 $ml \cdot kg^{-1} \cdot min^{-1}$ and the mean on an 8-in bench is 26.51, a difference of 3.15 $ml \cdot kg^{-1} \cdot min^{-1}$; mean heart rate ($beats \cdot min^{-1}$) on a 6-in bench is 155.26 $beats \cdot min^{-1}$ and the mean on an 8-in bench is 165.27 $beats \cdot min^{-1}$; and mean

$kcal \cdot min^{-1}$ on a 6-in bench is 6.99 $kcal \cdot min^{-1}$ and the mean on an 8-in bench is 8.07 $kcal \cdot min^{-1}$.

The model developed in this study indicates that stepping on and off an 8-inch bench generates a greater caloric expenditure, approximately 1.04 $kcal \cdot min^{-1}$ greater, than a 6-inch bench. The 1.04 $kcal \cdot min^{-1}$ difference in bench heights is demonstrated as the coefficient in the current model. A 1.04 $kcal \cdot min^{-1}$ increase would result in a difference in energy expenditure of approximately 42 $kcal \cdot min^{-1}$ over a 40-min aerobic session.

Previous research has examined bench heights of 4 to 12 inches. However, according to AFAA and Step Reebok, bench heights of 6 and 8 inches are the most optimal heights for protecting the knee from injury. Injury prevention is important for step aerobics and research poses that safe bench heights should be limited to 6 and 8-inches. In addition, literature suggests that stepping on a 10-inch bench may cause particiapants to exercise above their lactic acid threshold (Woodby-Brown et al., 1993). Performing at such a high intenisty makes the participant rely more heavily on anaerobic metabolism and results in a reduced ability to sustain exercise for an extended duration.

Effect of Body Size on Economy

The correlation between energy cost ($kcal \cdot min^{-1}$) of aerobic dance bench stepping and body weight was 0.49. This correlation indicates that the caloric cost of bench stepping is directly related to body weight, supporting the paradigm that aerobic performance and caloric cost are related to body weight (Cureton, Boileau, & Lohman, 1975; Cureton, Boileau, Lohman, & Misner, 1977; Walker et al., 1999; Lloyd, Walker, Bishop, & Richardson, 2000). In contrast to other studies on the influence of height on the caloric cost of running (Walker et al., 1999; Rolland, Auchinachie, Keenan, & Green, 1987), height accounted for additional variance in energy cost of bench stepping after the variation due to body weight and bench height was considered. This illustrates that taller individuals, at the same body weight, (lower body mass index (BMI)), who tend to be leaner expend less energy than shorter individuals. Leanness may result in greater economy of movement as indicated by lower oxygen cost for the same workload. Taller individuals may be at a biomechanical advantage during step aerobics. Taller individuals, with longer levers, engage less muscle mass and expend less energy compared to shorter individuals stepping on and off a bench of the same height Thomas, Weller, Cox, 1993).

Guidelines for Cardiovascular Fitness

Equations for determing oxygen cost of bench stepping have been determined for bench stepping at cadences between 84 and 120 beats$\cdot$min^{-1} and bench heights between 0.04 and 0.40 m (1.6 to 15.7 inches) (American College of Sports Medicine, 2000). However, typical aerobic dance bench stepping classes use faster cadences, i.e., 125 to 130 beats$\cdot$min^{-1}. Equations for estimating aerobic dance bench stepping at 6- and 8-inch bench heights and cadences of 125 and 130 beats$\cdot$min^{-1}have note been determined. Therefore, one of the primary purposes of this study were to measure the oxygen cost of bench stepping at the common cadences of 125 and 130 beats$\cdot$min^{-1}. From the results, cadence does not appear to impact caloric cost of bench stepping, but body weight, body height, and bench height does.

Such information can be applied to exercise prescription for meeting the U. S. Surgeon General and/or the ACSM guiidelines for developing cardiorespiratory health and fitness. According to the U. S. Surgeon General, individuals are recommended to perform moderate amount of physical activity most days of the week. It is estimated that energy expenditure from performing such activities most days of the week would be equivalent to physical activity that expends approximately 150 kcals per day or 1,000 kcals per week (U.S. Department of Health and Human Services, 1996). ACSM recommends that for developing and maintaining cardiorespiratory each exercise session should require a training duration of at least 20 minutes at an exercise intensity of 50 to 85 % of maximum oxygen uptake reserve, and result in an energy expnditure of at least 250 to 300 kcals of energy (American College of Sports Medicine, 1996). The model developed in this study is useful for estimating energy cost in moderately fit women to meet both the ACSM and U.S. Surgeon General's guidelines. For 30 minutes of aerobic dance bench stepping on a 6 inch bench,it is estimated that a moderately fit female who weighs 70 kg and is160 cm in height will expend approximately 7.665 $kcal \cdot min^{-1}$. Total energy expenditure for the 30 minute workout would be approximately 230 $\pm$ 25 $kcals \cdot min^{-1}$. This model is also beneficial for weight loss and maintenance for aerobic dance bench stepping participants.

Due to the present equation, other models of energy expenditure at this bench height according to participant's weight and height, could not be cross-validated. The ACSM's calculated energy cost of aerobic dance bench stepping measures the stepping rate of the participant. However, this study focuses on cadence. Cadence is more applicable to aerobic dance bench stepping than stepping rate since the bench classes are performed to music and not the amount of steps.

Conclusions

Based on the results of this study the following conclusions can me made:

1. This study revealed no cardiovascular or metabolic differences between the selected cadences of 125 and 130 beats·min^{-1}.

2. This investigation found that bench height influences physiological responses while performing aerobic dance bench stepping. The results of this study found that stepping on an 8-inch bench generates a greater caloric expenditure, approximately 1.04 kcals·min^{-1}, than a 6-inch bench.

3. This investigation found a linear relationship between step height and body weight for determining energy cost in moderately fit women.

4. Height of the participant influences the cardiovascular and metabolic responses in moderately fit women. As body height increases, a decrease in energy cost occurs.

5. The results of this study may be useful to practitioners when developing exercise prescription for individuals to meet both the ACSM and U.S. Surgeon General's guidelines for developing and maintaining cardiorespiratory fitness.

Recommendations for Future Research

1. The metabolic effects of aerobic dance bench stepping should be examined in males. The testing of male subjects would better represent the bench stepping population.

2. Subjects for this study were moderately fit females ranging in age from 19-47 years. Homogeneity was seen in body size of subjects with a mean percent body fat of 23.9±3.9%. Subjects should include a wide range of body types and sizes to depict the bench stepping population.

3. Subjects should range in exercise experience. The participants of the present study were intermediate to advanced bench steppers. More accurate predictions could be made with participants with all levels of bench stepping experience.

4. The prediction equations of caloric cost in this study should be cross-validated with the ACSM's sub-maximal step equation. The ACSM's equation to determine VO_2 is represented in step cycles which does not account for cadence of music.

5. The metabolic cost of aerobic dance bench stepping should be compared with other forms of aerobic exercise. Equivalent exercise modalites promote exercise adherence.

References

Aerobics and Fitness Association of America. (1997). AFAA's basic exercise standards & guidelines: the practical way. Sherman Oaks, CA : AFAA.

American College of Sports Medicine. (1998). The recommended quantity and quality of exercise for developing and maintaining cardiorespiratory and muscular fitness, and flexibility in healthy adults. Medicine and Science in Sports and Exercise, 30, 975-91.

American College of Sports Medicine. (2000). American college of sports medicine guidelines for exercise testing and prescription (6th Ed.). Philadelphia: Lippincott Williams & Wilkins.

Astrand, P., & Rodahl, K. (1986). Textbook of work physiology. (3rd ed.) New York: McGraw-Hill.

Blessing, D. L., Wilson, D. Puckett, J. R., & Ford, H. T. (1987). The physiological effects of eight weeks of aerobic dance with and without hand-held weights. American Journal of Sports Medicine, 15, 508-510.

Bouchard, C., Depres, J., & Tremblay, A. (1993). Exercise and obesity. Obesity Research, 1, 133-147.

Cearly, M., Mofat, R., Knutzen, K. (1984). The effects of two-and three-day per-week aerobic dance programs on maximal oxygen uptake. Research Quarterly, 55, 172-174.

Cureton, K. J., Boileau R. A., & Lohman, T. G. (1975). Relationship between body composition and AAHPER test performance in young boys. Research Quarterly, 46, 218-229.

Cureton, K. J., Boileau, R. A., Lohman, T. G., & Misner, J. E. (1977). Determinants of distance running performance in children: Analysis of a path model. Research Quarterly, 48(2), 270-279.

Dowdy, D., Cureton, K., DuVal, H., & Ouzts, H. (1985). Effects of aerobic dance on physical work capacity, cardiovascular function and body composition of middle-aged women. Research Quarterly, 56, 227-233.

Fahey, T. D., Insel, P., & Roth, W. (1997). Fit and well. Moutain View, CA: Mayfield Publishing Co.

Flegal, K.M., Carrol, M.D., Kuczmarski, R.J., & Johnson, C.L. (1988). Overweight and obesity trends in the United States: prevalence and trends. International Journal of Obesity Related Metabolic Disorders, 22, 39-47.

Fox, E., & Matthews, D. (1981). The physiological basis of physical education and athletes. (3rd ed.) Philadelphia, PA: Saunder.

Francis, P., & Francis, L. (1994). Step reebok: the first aerobic work-out, with muscle instructor training manual. Stockton: MA: Reebok International, Ltd.

Getchell, G., & Cleary, P. (1980). The caloric costs of rope skipping and running. Physician and Sportsmedicine, 8, 56 – 71.

Goodrick, G.K., & Foreyt, J.P. (1991). Why treatments for obesity don't last. Journal of the American Dietetic Association, 91, 1243-1247.

Goss, F., Robertson, R., Spina, R., Auble, T., Cassinelli, D., Silberman, R., Galbreath, R., & Metz K. (1989). Energy cost of bench stepping and pumping light handweights in trained subjects. Research Quarterly for Exercise and Sport, 60, 369-372.

Howley, E. T., & Franks, B. D. (1992). Health fitness instructor's handbook (2nd Ed.). Champaign, IL: Human Kinetics Books.

Jackson, A. S., Pollock, M. L., & Ward, A. (1980). Generalized equations for predicting body density of women. Medicine Science in Sports, 12, 175 –182.

Jakicic, J.M., Winters, C., Lang, W., and Wing, R. (1999). Effects of intermittent exercise and use of home exercise equipment on adherence, weight loss, and fitness in overweight women. Journal of American Medical Association, 282, 1554-1560.

Johnston, R., Morton, A., & Elliot, B. (1993) Forces and energy expenditure associated with selected aerobic movements. Sport Health, 12, 31-32.

Katch, Katch, & McArdle. (1996). Energy Expenditure in Household, Occupational, Recreational, and Sports Activities. Amherst, MA: Fitness Technologies.

Lindle, J (ed). (1995). Aquatic fitness professional manual. Nakomis, FL: Aquatic Exercise Association.

Ludwig, D.S., Pereira, M.A., Kroenke, C.H., Hilner, V.E, Van Horn, L., Slattery, M.L., & Jacobs, D.R. (1999). Dietary fiber, weight gain, and cardiovascular disease risk factors in young adults. The Journal of the American Medical Association, 282, 1539-1546.

Lloyd, L. (1999). The influence of body size on exercise performance in youth (Doctoral dissertation, University of Alabama).

Marieb, E. (1995). Human anatomy and physiology. Redwood City, CA: The Benjamin/Cummings Publishing Company, Inc.

McArdle, W. D., Katch, F. I., & Katch, V. L. (1996). Exercise physiology: energy, nutrition, and human performance. Baltimore, MD: Williams and Wilkins.

Milburn, S. & Butts, N. (1983). A comparison of the training responses to aerobic dance and jogging in college females. Medicine & Science in Sports and Exercise, 15, 510-513.

Mokdad, A.H., Serdula, M.K., Dietz, W., Bowman, B., Marks, J., and Koplan, J. (1999). The spread of the obesity epidemic in the United States, 1991-1998. The Journal of the American Medical Association, 282, 1519-1522.

Olson, M.S., Williford, H. N., Blessing, D., and Greathouse, R. (1991). The cardiovascular and metabolic effects of bench stepping exercise in females. Medicine and Science in Sports and Exercise, 23, 1311-1318.

Prentice, W. (1999). Fitness and wellness for life. Boston, Mass: WCB/McGraw-Hill.

Richardson, M. T., Ainsworth, B. E., Wu, H., Jacobs, D. R., & Leon, A. S. (1995). Ability of the atherosclerosis risk in communities (ARIC)/Baecke questionnaire to assess leisure time physical activity. International Journal of Epidemiology, 24, 685 – 693.

Rowland, T.W., Auchinachie, J.A, Keenan, T.J., & Green, G.M. (1987). Physiological responses to treadmill running in adult and prepubertal males. Internation al Journal of Sports Medicine, 8, 292-297.

Scharff-Olson, M. & Williford, H. (1996). The energy cost associated with seledted step training exercise techniques. Research Quarterly for Exercise and Sport, 67, 465-468.

Siri, W. E. (1961). Body composition from fluid space and density. In J. Brozek and A. Hanschel (Eds.) Techniques for measuring body composition. Washington DC: National Academy of Science.

Skender, M., Goodrick, K., Del Junco, D., Reeves, R., Darnell, L., Gotto, A., & Foreyt, J. (1996). Comparison of 2-year weight loss trends in behavioral treatments of obesity: diet, exercise, and combination interventions. Journal of the American Dietetic Association, 96, 342-345.

Tarrant, K., and McNaughton, L. (1997). A comparison of the metabolic effects of high and low impact aerobic dance exercise. Sports Medicine and Training Rehabilitation, 7, 255-264.

Thomas, S., Weller, I., & Cox, M. (1993). Sources of variation in oxygen consumption during a stepping task. Medicine & Science in Sports and Exercise, 25, 139-144.

Turnstep LLC. (2000). How fast do you teach step [Survey]? Retrieved April 15, 2000, from the World Wide Web http://www.turnstep.com.

U.S. Department of Health and Human Services (1996). Physical activity and health: a report of the surgeon general. Atlanta, GA: Centers for Disease Control and Prevention.

Walker, J., Murray, T., Jackson, A., Morrow, J., and Michaud, T. (1999). The energy cost of horizontal walking and running in adolescents. Medicine & Science in Sports and Exercise, 31, 311-322.

Wardlaw, G.M., and Insel, P.M. (1996). Perspectives in nutrition (3rd ed.). St. Louis, MO: Mosby.

Wilmore, J., and Costill, D. (1999). Physiology of sport and exercise (2nd ed). Champaign, IL: Human Kinetics.

Williford, H., Blessing, D., Olson, M., and Smith, F. (1989). Is low-impact aerobic dance an effective cardiovascular workout? The Physician and Sportsmedicine, 17, 95-107.

Woodby-Brown, S., Berg, K., and Latin, R.W. (1993). Oxygen cost of aerobic dance bench stepping at three heights. Journal of Strength and Conditioning Research, 7, 163-167.

Zelasko, C. (1995). Exercise for weight loss: what are the facts? Journal of the American Dietetic Association, 95, 1414-1417.

APPENDIX A

CHOREOGRAPHED STEP ROUTINE

Right Basic	x8
Left Basic	x8
Right Basic	x4
Left Basic	x4
Right Basic	x2
Left Basic	x2
Alternating Basics	x8
Turnstep	x8
Alternating Knees	x8
Alternating Kicks	x8
Alternating Curls	x8
Alternating Glutes	x8
Alternating Knees	x4
Alternating Kicks	x4
Alternating Curls	x4
Alternating Glutes	x4
Alternating Knees	x2
Alternating Kicks	x2
Alternating Curls	x2
Alternating Glutes	x2
(Repeat)	
T-Step (2 L Steps)	x4
Turnstep	x8
Over Top	x8
Turnstep	x4
Over Top	x4
Turnstep	x2
Over Top	x2

APPENDIX B

Caloric Cost (Kcals·min^{-1}) of Aerobic Bench Stepping for a Bench Height of 8 Inches based on Body Weight and Height

Appendix B

Caloric Cost (Kcals·min^{-1}) of Aerobic Bench Stepping for a Bench Height of 8 Inches based on Body Weight and Height

	Height (cm)										
Body Weight (kg)	140	145	150	155	160	165	170	175	180	185	190
50	7.887	7.697	7.507	7.317	7.127	6.937	6.747	6.557	6.367	6.177	5.987
52	8.045	7.855	7.665	7.475	7.285	7.095	6.905	6.715	6.525	6.335	6.145
54	8.203	8.013	7.823	7.633	7.443	7.253	7.063	6.873	6.683	6.493	6.303
56	8.361	8.171	7.981	7.791	7.601	7.411	7.221	7.031	6.841	6.651	6.461
58	8.519	8.329	8.139	7.949	7.759	7.569	7.379	7.189	6.999	6.809	6.619
60	8.677	8.487	8.297	8.107	7.917	7.727	7.537	7.347	7.157	6.967	6.777
62	8.835	8.645	8.455	8.265	8.075	7.885	7.695	7.505	7.315	7.125	6.935
64	8.993	8.803	8.613	8.423	8.233	8.043	7.853	7.663	7.473	7.283	7.093
66	9.151	8.961	8.771	8.581	8.391	8.201	8.011	7.821	7.631	7.441	7.251
68	9.309	9.119	8.929	8.739	8.549	8.359	8.169	7.979	7.789	7.599	7.409
70	9.467	9.277	9.087	8.897	8.707	8.517	8.327	8.137	7.947	7.757	7.567
72	9.625	9.435	9.245	9.055	8.865	8.675	8.485	8.295	8.105	7.915	7.725
74	9.783	9.593	9.403	9.213	9.023	8.833	8.643	8.453	8.263	8.073	7.883
76	9.941	9.751	9.561	9.371	9.181	8.991	8.801	8.611	8.421	8.231	8.041
78	10.099	9.909	9.719	9.529	9.339	9.149	8.959	8.769	8.579	8.389	8.199
80	10.257	10.067	9.877	9.687	9.497	9.307	9.117	8.927	8.737	8.547	8.357
82	10.415	10.225	10.035	9.845	9.655	9.465	9.275	9.085	8.895	8.705	8.515
84	10.573	10.383	10.193	10.003	9.813	9.623	9.433	9.243	9.053	8.863	8.673
86	10.731	10.541	10.351	10.161	9.971	9.781	9.591	9.401	9.211	9.021	8.831
88	10.889	10.699	10.509	10.319	10.129	9.939	9.749	9.559	9.369	9.179	8.989
90	11.047	10.857	10.667	10.477	10.287	10.097	9.907	9.717	9.527	9.337	9.147

APPENDIX C

Caloric Cost (Kcals·min^{-1}) of Aerobic Bench Stepping for a Bench Height of 6 Inches based on Body Weight and Height

Appendix C

Caloric Cost (Kcals·min^{-1}) of Aerobic Bench Stepping for a Bench Height of 6 Inches based on Body Weight and Height

	Height (cm)										
Body Weight (kg)	140	145	150	155	160	165	170	175	180	185	190
50	6.845	6.655	6.465	6.275	6.085	5.895	5.705	5.515	5.325	5.135	4.945
52	7.003	6.813	6.623	6.433	6.243	6.053	5.863	5.673	5.483	5.293	5.103
54	7.161	6.971	6.781	6.591	6.401	6.211	6.021	5.831	5.641	5.451	5.261
56	7.319	7.129	6.939	6.749	6.559	6.369	6.179	5.989	5.799	5.609	5.419
58	7.477	7.287	7.097	6.907	6.717	6.527	6.337	6.147	5.957	5.767	5.577
60	7.635	7.445	7.255	7.065	6.875	6.685	6.495	6.305	6.115	5.925	5.735
62	7.793	7.603	7.413	7.223	7.033	6.843	6.653	6.463	6.273	6.083	5.893
64	7.951	7.761	7.571	7.381	7.191	7.001	6.811	6.621	6.431	6.241	6.051
66	8.109	7.919	7.729	7.539	7.349	7.159	6.969	6.779	6.589	6.399	6.209
68	8.267	8.077	7.887	7.697	7.507	7.317	7.127	6.937	6.747	6.557	6.367
70	8.425	8.235	8.045	7.855	7.665	7.475	7.285	7.095	6.905	6.715	6.525
72	8.583	8.393	8.203	8.013	7.823	7.633	7.443	7.253	7.063	6.873	6.683
74	8.741	8.551	8.361	8.171	7.981	7.791	7.601	7.411	7.221	7.031	6.841
76	8.899	8.709	8.519	8.329	8.139	7.949	7.759	7.569	7.379	7.189	6.999
78	9.057	8.867	8.677	8.487	8.297	8.107	7.917	7.727	7.537	7.347	7.157
80	9.215	9.025	8.835	8.645	8.455	8.265	8.075	7.885	7.695	7.505	7.315
82	9.373	9.183	8.993	8.803	8.613	8.423	8.233	8.043	7.853	7.663	7.473
84	9.531	9.341	9.151	8.961	8.771	8.581	8.391	8.201	8.011	7.821	7.631
86	9.689	9.499	9.309	9.119	8.929	8.739	8.549	8.359	8.169	7.979	7.789
88	9.847	9.657	9.467	9.277	9.087	8.897	8.707	8.517	8.327	8.137	7.947
90	10.005	9.815	9.625	9.435	9.245	9.055	8.865	8.675	8.485	8.295	8.105

APPENDIX D

Informed Consent

The Metabolic Effects of Aerobic Dance Bench Stepping at Varying Cadences

You are invited to participate in a study to determine the metabolic cost of aerobic dance bench stepping at 6" and 8" bench heights at cadences of 125 and 130 beats per minute. In other words, your participation in this study will help us determine how many calories are burned during aerobic dance bench stepping. We will be able to use this information to make individual recommendations for exercising at an optimal level.

You will be one of 30 subjects chosen to participate in this study. You were selected as a possible participant in this study because you have shown interest and have been a participant of group exercise for at least 2 months.

If you decide to participate, we will explain and demonstrate the following procedures step by step:

1. I understand that I must wear a T-shirt and shorts in order to participate in this study. I understand that my body composition will be: 1) determined from skinfold measurements taken with skinfold calipers; and 2) conducted in private (however, I realize that I will remain fully clothed).

   Body composition will be estimated from the measurement of skinfold thickness taken from three sites (i.e., the triceps, supraillium, and thigh).

   1. The triceps skinfold will be measured on the back of my arm midway between the elbow and the shoulder joint. At this midpoint, the skin will be pinched slightly and the thickness will be measured with a caliper.

   2. The supraillium skinfold will be measured on the right side, slightly anterior to the iliac crest.

   3. The thigh skinfold will be measured on the front portion of the right leg, midway between the head of the femur and the knee cap.

2. I understand that my VO_2 max (the amount of oxygen I consume while exercising at a maximal intensity) will be determined using a Balke protocol.

My VO_2max will be estimated with VO2000, an apparatus designed to measure the amount of oxygen consumed while exercising.

- I will wear a gas collection device that will fit snuggly over my mouth and nose. This mask will allow me to breathe normally, while it captures all of the air that I exhale. It will be attached will be attached to a gas collection device by a small tube.

- The VO2000 gas collection device is a very small device that will be strapped to the front of my chest (over my T-shirt) with a harness.

- I understand that my performance will not be hindered with the use of this machine.

3. I understand that there are minimal risks to healthy subjects under the testing conditions specified above.

   - I understand that the potential risks associated with the tests may include muscle soreness and breathlessness, though it is unlikely given the nature of the duration and level of intensity of these tests.

   - I understand that there is a potential risk of an ankle or knee injury, but this risk is minimized because of my familiarity with aerobics. I have been performing aerobics for at least two months.______.
     Initialize

   - I understand that the effort required during the tests is very similar to the physical efforts required during a normal group exercise session.

   - I understand that the test administrators are experienced and have conducted numerous submaximal as well as maximal tests of this nature.

   - I understand that emergency equipment is available at all times.

My participation in the study will provide me with knowledge of energy expenditure while participating in aerobic dance bench stepping. The results obtained from these assessments will be used as research to evaluate the metabolic costs of bench stepping at 6" and " bench heights at cadences of 125 and 130 beats per minute. Although there may be no other direct benefits anticipated from my participation, there may be future benefit to others seeking to accurately make sound recommendations to participants of aerobic dance bench stepping regarding exercise prescription that would include cadence of music and bench height.

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission.

Your decision whether or not to participate will not prejudice your future relations with Southwest Texas State University. If you decide to participate, you are free to discontinue participation at any time without prejudice.

If you have any further questions, please ask us now. If you have any questions later, you may contact Tamara Grier (512) 245-3480 or Lisa Lloyd, (512) 245-8106, in the HPER Department at Southwest Texas State University, San Marcos, TX.

You will be offered a copy of this form to keep.

You are making a decision whether or not to participate. Your signature indicates that you have read the information provided above and have decided to participate. You may withdraw without prejudice at any time after signing this form, should you choose to discontinue participation in this study.

______________________________ __________

Participant's Signature Date

______________________________ __________

Investigator's Signature Date

APPENDIX E

Raw Data

Descriptive Data

Subject	Age	Height (cm)	Weight (kg)	% BF	P.A. (METS)
1	19	170.82	60.23	22.81	42.96
2	23	152.4	52.84	22.85	39.75
3	25	170.18	58.18	16.90	58.86
4	20	157.48	60.91	23.64	37.46
5	24	160.02	68.18	26.02	59.29
6	20	165.1	67.95	26.69	61.43
7	19	163.83	63.18	24.22	39.25
8	19	168.28	59.09	21.93	41.93
9	27	139.5	66.5	25.26	36.57
10	20	160.66	57.27	17.89	90.50
11	24	160.02	60.68	21.47	33.54
12	19	161.29	54.09	22.81	39.04
13	45	168.91	66.4	24.23	38.61
14	23	175.26	63.86	20.16	41.14
15	19	153.6	55.91	23.68	39.57
16	30	168.91	82.27	29.45	34.93
17	19	168.91	56.14	21.27	43.57
18	21	161.29	59.54	25.51	37.93
19	38	152.4	58.86	26.49	33.32
20	27	176.53	71.36	22.21	41.71
21	23	165.1	63.18	30.27	34.32
22	40	167.6	54.8	19.72	41.29
23	19	160.66	66.36	30.01	37.62
24	22	165.1	65	28.44	50.95
25	22	154.94	52.5	18.02	64.00
26	46	167	53.41	20.79	40.46
27	47	173.99	68.5	25.24	44.68
28	47	163.83	56.82	19.09	36.46
29	21	165.1	85.45	31.46	37.64
30	24	168.28	75.9	27.80	45.00

Note: P.A. = Estimated Physical Activity Levels in METS

Raw Scores from Maximal Treadmill Testing

Subject	MaxHR	MaxRPE	MaxRQ	MaxVO_2 (L/O2)	MaxVO_2 (ml/kg/min)
1	207	20	1.14	1.92	31.88
2	185	17	0.88	2.51	47.50
3	186	20	1.11	2.62	45.03
4	183	20	1.11	2.3	37.76
5	188	20	1.04	2.02	29.63
6	196	20	1.04	2.51	36.94
7	192	20	0.99	2.23	35.30
8	195	20	1.03	2.24	37.91
9	194	18	1.01	2.68	40.30
10	196	15	1.01	1.96	34.22
11	169	20	1.08	2.07	34.11
12	205	20	1.22	1.82	33.65
13	180	20	1.16	2.05	30.87
14	188	20	1.18	2.39	37.43
15	201	20	0.83	2.05	36.67
16	181	20	1.04	3.04	36.95
17	187	20	0.84	1	17.81
18	180	20	0.88	3.62	60.80
19	182	20	0.98	1.91	32.45
20	189	20	0.95	3.4	47.65
21	187	20	1.06	1.95	30.86
22	183	20	1.02	2.19	39.96
23	203	20	1.07	2.43	36.62
24	178	17	0.85	1.98	30.46
25	193	20	0.95	2.13	40.57
26	189	20	1.04	2.57	48.12
27	163	20	0.98	1.95	28.47
28	164	20	0.88	1.53	26.93
29	203	20	1.03	2.42	28.32
30	163	20	0.88	2.48	32.67

Averages of Submaximal Aerobic Dance Bench Stepping
6 inch and 125 beats$\cdot$min^{-1}

Subject	Avg HR	Avg VO2	Avg RPE	Avg RQ
1	164.00	1.08	11.67	0.78
2	163.00	0.92	12.00	0.92
3	101.33	1.82	10.00	0.77
4	165.67	1.76	10.00	0.79
5	168.33	1.66	8.00	0.75
6	172.00	1.54	9.67	0.77
7	164.00	1.84	8.67	0.83
8	148.00	1.42	9.33	0.74
9	144.33	1.41	9.33	0.81
10	189.67	6.00	9.67	0.78
11	145.00	1.33	11.67	0.87
12	172.00	1.28	9.00	0.79
13	139.67	1.43	11.67	0.76
14	139.00	1.12	9.33	0.72
15	155.67	1.50	12.67	0.87
16	149.67	1.64	13.00	0.75
17	153.33	0.98	10.67	0.76
18	165.67	1.18	10.00	0.71
19	124.00	1.37	13.67	0.73
20	138.67	1.42	13.00	0.92
21	159.67	1.31	12.67	0.79
22	160.00	1.37	11.33	0.80
23	183.67	2.05	11.00	0.84
24	149.33	1.41	10.33	0.79
25	143.33	1.45	11.00	0.83
26	165.00	1.52	12.00	0.81
27	136.00	1.61	11.00	0.82
28	125.67	1.16	10.67	0.81
29	184.67	1.01	11.00	0.93
30	137.67	1.58	10.00	0.84

Averages of Submaximal Aerobic Dance Bench Stepping
6 inch and 130 beats·min^{-1}

Subject	Avg HR	Avg VO2	Avg RPE	Avg RQ
1	163.00	1.24	11.33	0.96
2	161.33	2.09	12.67	0.85
3	104.67	1.33	10.33	0.78
4	159.33	1.04	11.00	0.79
5	162.00	1.68	9.33	0.75
6	168.67	1.35	9.67	0.77
7	156.67	0.83	8.67	0.66
8	160.00	1.40	9.67	0.75
9	166.00	1.86	10.00	0.92
10	176.00	5.88	11.33	0.81
11	158.67	1.47	13.67	0.87
12	186.67	1.11	9.33	0.79
13	135.00	1.48	11.33	0.78
14	140.67	1.47	9.67	0.79
15	177.67	1.49	11.00	0.82
16	157.33	1.68	8.67	0.77
17	172.33	1.26	10.33	0.72
18	175.67	1.41	12.00	0.77
19	134.33	1.77	13.67	0.74
20	141.00	1.90	13.00	0.84
21	168.67	1.75	13.00	0.83
22	154.33	1.44	0.79	0.81
23	192.00	2.02	12.00	0.82
24	156.67	1.49	9.33	0.86
25	145.00	1.43	12.33	0.80
26	148.67	1.31	12.67	0.78
27	136.33	1.46	11.00	0.81
28	129.67	1.27	12.67	0.79
29	189.33	1.86	14.67	0.90
30	130.00	1.62	10.67	0.84

Averages of Submaximal Aerobic Dance Bench Stepping
8 inch and 125 beats$\cdot$min^{-1}

Subject	Avg HR	Avg VO2	Avg RPE	Avg RQ
1	173.33	1.37	12.67	1.37
2	165.00	2.37	12.33	0.87
3	118.33	1.60	11.33	0.77
4	162.67	1.80	9.33	0.82
5	169.33	1.88	8.33	0.77
6	170.67	1.61	8.67	0.81
7	176.00	1.77	10.33	0.82
8	154.00	1.46	10.67	0.77
9	167.67	1.90	12.67	0.94
10	197.33	1.51	18.00	0.84
11	170.00	1.38	15.67	0.86
12	180.33	1.48	9.67	0.90
13	144.33	1.58	12.67	0.77
14	148.33	1.54	8.33	0.76
15	186.67	1.65	12.67	0.84
16	157.00	1.71	12.00	0.82
17	181.67	1.47	9.33	0.75
18	176.00	1.14	13.00	0.77
19	162.33	1.77	13.67	0.83
20	149.67	2.14	14.33	0.89
21	175.00	1.78	12.33	0.82
22	163.33	1.58	9.33	0.77
23	197.00	2.00	11.67	0.84
24	154.33	1.55	10.33	0.83
25	165.00	1.64	14.67	0.86
26	165.67	1.50	12.67	0.83
27	145.67	1.82	13.33	0.80
28	139.00	1.49	13.67	0.83
29	200.33	2.15	19.00	0.88
30	147.00	1.88	14.00	0.85

Averages of Submaximal Aerobic Dance Bench Stepping
8 inch and 130 beats·min^{-1}

Subject	Avg HR	Avg VO2	Avg RPE	Avg RQ
1	176.33	1.45	13.00	0.83
2	174.00	1.26	13.00	0.77
3	103.00	1.23	10.67	0.91
4	161.67	0.89	12.00	0.83
5	170.00	1.97	9.67	0.77
6	172.00	1.70	10.33	0.82
7	180.33	1.99	9.67	0.85
8	166.67	1.52	10.67	0.77
9	178.00	1.78	13.67	0.83
10	191.67	6.06	16.33	0.83
11	158.33	1.62	13.67	0.92
12	180.33	1.43	10.33	0.81
13	150.33	1.35	11.67	0.80
14	151.67	1.64	9.33	0.83
15	172.33	1.69	13.67	0.90
16	167.00	2.07	11.33	0.86
17	165.67	1.36	12.67	0.77
18	176.33	1.43	12.67	0.83
19	159.33	1.77	13.67	0.83
20	147.00	2.19	13.67	0.85
21	171.00	1.85	15.33	0.82
22	165.33	1.53	11.00	0.82
23	195.67	2.01	11.33	0.89
24	160.67	1.58	9.67	0.88
25	152.67	1.53	11.67	0.83
26	163.67	1.43	15.00	0.79
27	144.33	1.79	12.33	0.81
28	157.33	1.61	15.33	0.80
29	200.00	2.12	18.00	0.96
30	140.33	1.65	11.67	0.88