

THE METABOLIC DEMANDS OF CULTURALLY-SPECIFIC
POLYNESIAN DANCES

by

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NOMENCLATURE

Cardiac rehabilitation (CR): is a branch of rehabilitation medicine and physical therapy dealing with optimizing physical function in patients with cardiac disease or recent cardiac surgeries.

Cardiometabolic disorders: a cluster of diseases of cardiovascular disease (CVD), diabetes, and obesity.

Dance therapy: is the psychotherapeutic use of movement and dance to support intellectual, emotional, and motor functions of the body.

Dance routine: Each cultural dance routine is made up of dance moves from a specific culture. A typical dance routine lasts between 3 and 5 minutes.

Exercise prescription: refers to the specific plan of fitness-related activities that are designed for improving physical fitness and health. It includes the frequency, intensity, duration and mod of exercise.

Metabolic demand (or metabolic cost, energy expenditure, exercise intensity): the energy consumption of particular physical activities, usually expressed as MET. Moderate intensity activity refers to 3 to 5.9 MET.

Metabolic Equivalent (MET): is defined as the ratio of metabolic rate during a specific physical activity to a reference metabolic rate at rest, set by convention to $3.5 \text{ mL}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ of oxygen uptake. The MET is used to express the intensity of activities in a way comparable among persons who vary in body mass.

Oxygen uptake (VO_2): the rate of oxygen utilization by the working muscle tissue during exercise.

Physical activity (PA): is defined as any bodily movement produced by the contraction of skeletal muscles that result in a substantial increase in caloric requirements over resting energy expenditure.

Physical Activity Readiness Questionnaire (PAR-Q): A health screening questionnaire designed to determine whether or not you should see a doctor before starting/resuming physical activity.

ABSTRACT

It is suggested that dancing is a form of exercise that induces favorable physiological and psychological effects comparable to aerobic exercise training. The current study sought to measure the metabolic demands for several Polynesian dances (i.e., Hawaiian hula, Fijian, Maori haka and poi balls, Samoan sasa and slap, Tahitian, and Tongan), and to evaluate possible gender differences in these measures in a group of experienced Polynesian dancers. Thirty participants (13 men and 17 women) were tested through a dance testing protocol, using indirect calorimetry. Metabolic demands were evaluated in units of metabolic equivalent (MET), as well as both aerobic and anaerobic activity energy expenditure (AEE) contributions to total AEE. One sample t-test was used to compare the mean MET values for each cultural dance to the cutoff values (3-MET and 6-MET, respectively) for moderate and vigorous physical activity. Gender differences were examined using independent t-tests. The mean MET values for all, but Maori poi balls dance, were significantly greater than 3.0 METs. The mean MET values for Samoan sasa, Samoan slap and Tahitian were also significantly greater than 6.0 METs. The men's MET values for Hawaiian hula, Samoan sasa, Tongan, Fijian, and Maori haka were all significantly greater ($P < 0.001$) than the corresponding values for women, while the Tahitian MET values were similar ($P = 0.526$) between both genders. Aerobic and anaerobic AEE contribute 83.4% and 16.6%, respectively, on average, for Polynesian dances, with Hawaiian hula being the most aerobic (88.7% and 11.3%, respectively) and Samoan slap being the least aerobic (74.2% and 25.8%, respectively). The aerobic AEE for men was significantly greater than that for women for the Hawaiian hula, Samoan sasa, Fijian, Maori haka, and Tongan ($P < 0.001$), while no significance gender difference was observed in anaerobic AEE ($P = 0.087 - 0.989$). The present study indicated that the Polynesian dance of various forms met the current PA recommendations, and thus can be used as an appropriate mode of aerobic exercise to increase regular physical activity in the ethnic minorities in Hawaii and the south Pacific for health promotion and disease prevention.

CHAPTER ONE - INTRODUCTION

Historical Background

The growing popularity of recreational and competitive dancing has paralleled the growing knowledge documenting the potential health benefits of dance (Belardinelli et al. 2008). Dance therapy, as first introduced to patients participating in cardiac rehabilitation (CR) programs, uses movement to support the physical and emotional well-being of patients and has been proven to improve exercise capacity and quality of life. Different forms of dance (i.e., Waltz, Latin, and aerobic dance training), have been implemented as physical activity intervention strategies in both CVD patients and healthy populations. For example, Waltz dance was compared to aerobic exercise training and was reported to result in the same beneficial effects, such as improved functional capacity and endothelium-dependent dilation in patients with chronic heart failure (Belardinelli et al. 2008). Aerobic dance training has also been shown to reduce low-density lipoprotein cholesterol (LDL-C) and triglyceride levels, as well as lowering systolic and diastolic blood pressure, in hypertensive patients (Maruf et al. 2014). Favorable psychological effects has also been reported by Domene and his group (2014) in Latin partnered social dance.

Dance therapy was introduced to a CR program in Hawaii. The Hula Empowering Lifestyle Adaptation Study (the HELA Study) (Look et al. 2012) is a project funded by the National Institute on Minority Health and Health Disparities. The project aimed to

develop a community-based physical activity CR program integrating hula dancing, an indigenous cultural practice, as a form of physical activity (PA). This practice not only improved functional capacity of participants, but also enhanced their sociocultural bonds and deepened their appreciation of the Hawaiian culture (Maskarinec et al. 2015b). Therefore, it is reasonable to predict that these traditional culture dances can be regarded as an effective exercise modality for general health promotion for people of all ages in Native Hawaiians and other Pacific Islanders.

Polynesian dances, such as the Hawaiian hula, were developed throughout the Pacific Islands where the Polynesians originally settled. Each Polynesian culture tended to have its own culturally-specific dances, the most well-known of which are taught in schools and group exercise classes, practiced by men and women of all ages, and are popular with all ethnicities (Look et al. 2012). Some of the most popular Polynesian dances include those from the Hawaiian, Fijian, Maori, Samoan, Tahitian, and Tongan cultures. As a culturally-related PA, Polynesian dance could be used as an alternative form of aerobic exercise for CVD patients and for the general public.

The application of basic exercise prescription principles (i.e., duration and frequency of performing these kinds of dances) is difficult, however, without knowing the metabolic demands of these dances. Although the metabolic demands of a comprehensive variety of activities have been listed in the Compendium of Physical Activities (Ainsworth et al. 2011), the number of culturally-based activities is very limited, and many of those values were based on self-reported exertion levels or

unpublished thesis data, without directly measuring oxygen uptake (VO_2). To our knowledge, only one study (Usagawa et al. 2014) has objectively measured the metabolic demands of hula, one of the Polynesian culture dances. Usagawa and colleagues (2014) determined the metabolic cost of hula to be 5.7 to 7.5 metabolic equivalents (METs), which is classified as equivalent to moderate-to-high intensity exercise. However, hula is just one of many popular Polynesian dances. The metabolic costs of all other commonly practiced and performed Polynesian dances are completely unknown. Due to the limited research in this field, the present study aims at determining the metabolic demands of several culturally-specific Polynesian dances that are most commonly practiced and performed at the Polynesian Culture Center on the island of Oahu in Hawaii, USA.

Statement of Purpose

The primary purpose of this study is to determine and compare the metabolic demands of several culturally-specific Polynesian dances within experienced Polynesian dancers. The secondary purpose is to compare the exercise intensity of each cultural dance with the current PA guidelines for moderate (3-MET) and vigorous (6-MET) intensity exercises.

Significance of Study

Due to limited research in this field, the present study will provide objective

measures on the metabolic demands of several commonly practiced Polynesian dances that are specific to six different Polynesian cultures: Hawaiian, Fijian, Maori, Samoan, Tahitian, and Tongan. In addition, the results from this study will be of value to health practitioners, coaches and health intervention researchers to prescribe PA dosage for CVD patients and the general public using Polynesian dance as an alternative form of PA.

Hypotheses

It is hypothesized that the MET value for at least one of the Polynesian dances to be tested is significantly different from the other Polynesian dances:

$$H_{01}: \mu_{MET1} = \mu_{MET2} = \mu_{MET3} = \mu_{MET4} = \mu_{MET5} = \mu_{MET6} = \mu_{METn}$$

$$H_{A1}: \mu_{MET1} \neq \mu_{MET2} \neq \mu_{MET3} \neq \mu_{MET4} \neq \mu_{MET5} \neq \mu_{MET6} \neq \mu_{METn}$$

Where μ_{MET1} to μ_{METn} are the population mean MET values for the n types of Polynesian dance.

It is also hypothesized that all Polynesian dances to be tested will have mean MET values ≥ 3.0 METs:

$$H_{02}: \mu_{METi} < 3.0 \text{ METs}$$

$$H_{A2}: \mu_{METi} \geq 3.0 \text{ METs}$$

Where: μ_{METi} represents the population mean MET value for each Polynesian dance to be tested.

Limitations

One limitation of the present study is that the Polynesian dances tested are dependent upon the skill and experience of each study volunteer. As currently designed, this study will request that each subject perform each Polynesian dance of interest, but each subject may not be able to perform all the dance routines. While an a priori attempt will be made to recruit subjects who can perform all the cultural dance routines, the success of this plan will be unknown until the study is completed. Therefore, it is possible that there will be missing data for some dances to be tested.

Delimitations

The scope of inference for this study is delimited to experienced Polynesian dancers due to non-random sampling.

CHAPTER TWO - REVIEW OF THE LITERATURE

Introduction

Native Hawaiians and other Pacific Islanders (NHOPI) suffer a disproportionately higher prevalence of cardiometabolic disorders when compared to the general population of the United States (Mau et al. 2009). Physical inactivity and sedentary lifestyle in this population is an independent risk factor for the higher prevalence of cardiovascular diseases (CVD), obesity, and metabolic syndrome (Grandinetti et al. 2015). Cultural dances of Polynesia, such as the hula from the Hawaiian culture, could be adopted as culturally-specific form of physical activity (PA) for general health promotion (Maskarinec et al. 2015b). However, it is necessary to prescribe the dose of PA by exercise intensity, duration and frequency, while the knowledge about the energy expenditure of these Polynesian dances is very limited. Currently, only the hula has had energy expenditure objectively evaluated for exercise prescription (Usagawa et al. 2014), while no other Polynesian dances have been measured directly. The lack of research in the determination of metabolic demands for Polynesian dances has prompted the current study.

Health Status in NHOPI

NHOPI refer to those of indigenous ancestry on the islands of Polynesia, Melanesia and Micronesia (Mau et al. 2009). This population consists of Native

Hawaiians, Caucasians, Blacks, Latinos, and Asian Americans (mainly Japanese, Filipinos, Chinese and Koreans).

NHOPI have been categorized as high-risk populations that are most susceptible to cardiometabolic disorders of CVD, diabetes, and obesity in the United States (Usagawa et al. 2014). It is worthwhile mentioning that the mortality rate in this population are among the highest in the United States (Johnson et al. 2004). In the NHOPI, CVD is the leading cause of mortality, which accounts for 55% of all deaths. Diabetes stands out as a major risk factor of CVD in this population. It is reported that CVD rates are four-fold higher in those with diabetes than those without (Aluli et al. 2010). Hawaiians have also been reported to have a higher incidence of type 2 diabetes (Maskarinec et al. 2015a), which could result from central obesity and physical inactivity (Grandinetti et al. 1999).

Are NHOPI genetically more susceptible to cardiometabolic diseases? Mau et al. (2009) found that CVD risk factors, such as high cholesterol concentration, hypertension, and elevated diastolic blood pressure were significantly related to the degree of Hawaiian ancestry. According to a genetic study (Grandinetti et al. 2006), prolonged heart-rate corrected QT interval, which has been blamed for the cause of sudden death and increased mortality, was observed in populations of Filipino, Japanese and Hawaiian ancestry, compared to Caucasian populations. Besides, the odds of diabetes diagnoses were reported 70% higher among Asian Americans than whites in Hawaii, after adjustment for age, gender and Body Mass Index (BMI) (King et

al. 2012). Grandinetti et al. (1998) also found that the prevalence of glucose intolerance was significantly higher among Native Hawaiians than whites. And it is interesting to note that full Hawaiians suffered a higher prevalence of diabetes than part-Hawaiians (Mau et al. 2009), suggesting a possible genetic factor. Furthermore, the prevalence for overweight and obesity in this population hit 84% (Duncan et al. 2015), compared to 69% of national level (Ogden et al. 2014). BMI was higher in both Native Hawaiians and among other ethnic mixtures that had Native Hawaiian ancestry (Grandinetti et al. 1999). Additionally, increased BMI and waist to hip ratio (WHR) were significantly associated with percentage Hawaiian ancestry (Grandinetti et al. 1999). Collectively, this evidence suggested that there might be some genetic link between Hawaiian ancestry and the onset of cardiometabolic diseases in this population.

However, unhealthy lifestyles were also reported to be responsible for the higher prevalence of cardiometabolic disorders in this population (Kim et al. 2013). A prospective study (Maskarinec et al. 2007) indicated that due to a high frequency of smoking and alcohol use, Native Hawaiians had the highest chronic disease risk scores compared to other ethnic groups. Approximately one in three Native Hawaiians were smokers, compared to 15% of adult smokers in the US population (Johnson et al. 2004). Over 51% of Native Hawaiians reported drinking alcohol, slightly higher than the average rate of 48.6% in the general population of the United States (Johnson et al. 2004). Although genetic influences could be a contributing factor to the onset of type 2 diabetes (Mau et al. 2009), Steinbrecher et al. (2011) investigated the preventable

proportion of type 2 diabetes risk in multiethnic population of Hawaii. They found that being overweight and physically inactive, as well as smoking and having a high meat consumption, were the primary risks of diabetes in all ethnic groups. Indeed, Kim et al. (2008) found that Native Hawaiians and Filipinos have higher consumption of local ethnic foods, such as Lau Lau, Kalua pig, Poi and Portuguese sausage, Pinacbet, Sinigang and Dinengdeng, and that the preference of consuming these traditional foods was positively associated with type 2 diabetes due to the high energy density.

PA – A Strategy for Better Health Outcomes

Physical Activity and Health Outcomes

Physical activity is defined as any bodily movement produced by the contraction of skeletal muscles that results in a substantial increase in caloric requirements over resting energy expenditure (Caspersen et al. 1985). PA plays a fundamental role in health maintenance and in reducing the risks of chronic diseases.

That PA promotes health and fitness has been recognized for centuries and is now a widely accepted concept. Regular PA has short-term benefits, such as increased energy expenditure, increased insulin secretion and insulin sensitivity post-exercise, improved sleep quality, and long-term benefits, including a healthier heart, improved fitness level, as well as having less chance of being obese and developing diabetes and other chronic diseases (JAMA Patient Page 2000). There is a general consensus in the literature that regular PA is associated with a lower BMI (Okeyo et al. 2009), reduced

cardiovascular risk (Hegde and Solomon 2015), decreased cancer risk (Thune and Furberg 2001), as well as a better cognitive function (Domene et al. 2014). In addition, there is a graded dose-response relationship between PA and overall health (Kesaniemi et al. 2001). Furthermore, it is believed that lifestyle intervention is more effective in preventing diabetes and CVD risks, such as hypertension and hyperlipidemia, than pharmaceutical therapies (Aas et al. 2006). Lastly, both leisure time and occupational PA were reported to have a graded dose-response association with lower overall cancer risk (Thune and Furberg 2001).

Physical inactivity has been a major concern in the past 50 years as people adopted more sedentary tasks as one of their lifestyle changes in the modern society. While it is well documented that less PA is strongly associated with an increased risk of all-cause mortality in apparently healthy individuals (Szostak & Laurant 2011), sedentary time is now believed to be an independent risk factor for chronic diseases and mortality (Cull et al. 2015). Booth et al. (2000) found that sedentary lifestyles could be responsible for at least one-third of all-cause mortality in U.S. adults. Decreased daily PA was also reported to have a strong dose-response relationship with metabolic disorders (Kesaniemi et al. 2001). A 6-year longitudinal study (Menai et al. 2015) found that the time spent in watching television and using a computer had a strong association with increased BMI and percent body fat.

Physical Inactivity in Hawaiian Populations

According to the 2008 Guidelines of Physical Activity (USDHHS 2008), the

minimal dose of 150 min per week of moderate intensity, aerobic activity performed in episodes of at least 10 minutes are generally recommended in the adult population to maintain body weight and prevent weight gain, reduce cardiovascular risk factors, and to improve cardiorespiratory fitness and overall well-being.

However, it is reported that 59.1% of men and 64.1% of women of the NHOPI (versus 51.6% of men and 56.7% of women of the overall U.S. population) did not meet the federally recommended levels of PA (Centers for Disease Control and Prevention (CDC) 2004; USDHHS 2008). Physical inactivity results in the excessive storage of calories in the body, which in turn leads to a higher prevalence of obesity, diabetes and metabolic syndrome (Szostak & Laurant 2011). Physical inactivity also undermines one's cardiopulmonary fitness, with elevated resting heart rate (RHR) as an indicative factor. Grandinetti et al. (2015) investigated a multiethnic cohort in Hawaii, including Native Hawaiian, Japanese, Filipino, Caucasian, and mixed ethnic ancestries, and reported that those with increased RHR and who were also less physically active were more likely to develop insulin resistance. Elevated RHR has also been identified as an independent risk factor for CVD and mortality (Ruiz Ortiz et al. 2010).

Since regular PA, especially moderate-intensity aerobic exercise, can improve functional capacity and serve as an alternative treatment for specific cardiorespiratory and metabolic diseases similar to pharmacological treatments (Faude et al. 2015), increasing PA should result in beneficial health outcomes in the NHOPI.

Polynesian Dance Study

Dancing as a Form of PA

Dancing involves rhythmic movements of the body with music. It is reported that dancing has a similar effect on health as traditional aerobic exercise training (i.e., treadmill, stationary bicycle, and step machine) (Belardinelli et al. 2008) and therefore can be regarded as an alternative culturally-specific PA.

Dance therapy, as first introduced to patients participating in cardiac rehabilitation (CR) programs, uses dance movements to support the physical and emotional well-being of patients and has been proven to improve exercise capacity and quality of life (Belardinelli et al. 2008). Different forms of dance, such as Waltz, Latin, and aerobic dance training, have been used as intervention strategies in both CVD patients and healthy populations.

Belardinelli et al. (2008) examined the benefits and safety of Waltz dancing in patients with chronic heart failure. They compared a Waltz dance protocol with a supervised aerobic exercise training and a control group. The results of the study showed that Waltz dancing was safe and that both functional capacity and endothelium-dependent dilation improved significantly in both training groups (i.e., Waltz dancing and aerobic training), while there was also no difference between the two groups. Another randomized study (Maruf et al. 2014) identified that aerobic dance training for 12 weeks helped reduce LDL-C and triglyceride levels, and lowered systolic and diastolic blood pressure in hypertensive patients. Domene and his group

(2014) investigated the effects of Latin partnered social dance using an Exercise Benefits/Barriers Scale (EBBS), and reported a positive psychological outlook with Latin dance participation. Collectively, these studies demonstrate that dance, as an alternative form of aerobic exercise, has beneficial effects on cardiorespiratory fitness, metabolic profiles, and psychological health in both CVD patients and healthy adults.

Dance therapy has been introduced to a CR program in Hawaii. The Hula Empowering Lifestyle Adaptation Study (the HELA Study) (Look et al. 2012) is a project funded by the National Institute on Minority Health and Health Disparities. The project aimed to develop a community-based physical activity CR program integrating hula dancing, an indigenous cultural practice, as physical activity (PA). This practice not only improved functional capacity of participants, but also enhanced their sociocultural bonds and deepened their appreciation of Hawaiian culture (Maskarinec et al. 2015b). Therefore, it is reasonable to predict that these traditional culture dances can be regarded as an effective exercise modality for people of all ages in the NHOPI population as a form of general health promotion.

The Polynesian Dances

Polynesian dances, such as the hula, were developed throughout the Pacific Islands where the Polynesians originally settled. Each Polynesian culture tended to have its own culturally-specific dances, the most well-known of which are taught in schools and group exercise classes, practiced by men and women of all ages, and are popular with all ethnicities (Look et al. 2012). Some of the most popular Polynesian

dances include those from the Hawaiian (indigenous peoples of the Hawaiian Islands), Fijian (indigenous peoples of the Fiji Islands), Maori (indigenous peoples of New Zealand), Samoan (indigenous peoples of the Samoan Islands), Tahitian (indigenous peoples of Tahiti), and Tongan (indigenous peoples of The Kingdom of Tonga, a collection of 177 islands) cultures. Hula, for instance, is a Hawaiian-specific dance, which can be either Hula Auana, where the dance is accompanied by chant and string instruments, or the Hula Kahiko, where the dance is accompanied by chant and ancient drums. Meke, a traditional style of dance in Fiji, is often referred to as a spirit dance which involves quick upper and lower body movements and jumping. While most of the Polynesian cultural dances involve both men and women dancing together, the Maori have a clear gender difference on choreography. For instance, the haka is a Maori battle dance, traditionally only performed by men who stand with hips and knees in a slightly flexed position. This dance includes foot movements that resemble stomping with hand and arm movements that slap the upper torso and legs. Dancers often perform this dance in a heightened arousal state inferring intimidation. The poi ball dance, however, is more common for Maori women, where poi balls are attached to one or both ends of a rope and are swung around in different movements throughout the dance. The Samoan culture has two major culturally-specific dances: Taupo, which is often referred to as the princess dance, and Sasa, which includes upper body movements with clapping and slapping mimicking the beat of a drum. The Tahitian Ori dance is made up of quick bodily movements featured by women's quick

hip movements (Tamure) and men's quick knee movements (Pa oti). The Tongan culture has three major types of dance: Nafa (drummer), Taulunga (woman's graceful dance) and Ma'ulu'ulu. The Ma'ulu'ulu, usually performed while sitting, has upper body movements characterized by arm and hand movements along with torso and head movements. Advanced Polynesian dance routines require complex movements, advanced technique and aesthetics, as well as a high physiological capacity (Koutedakis & Jamurtas 2004).

Nowadays, many of these culturally-specific dances are taught in schools or to exercise groups and are commonly practiced by men and women of all ages, as well as with all ethnicities (Look et al. 2012). As a culturally-related PA, Polynesian dance could be more attractive and more adherent to these at-risk populations than traditional aerobic exercise (Maskarinec et al. 2015b).

Metabolic Demands of Polynesian Dance

Although the metabolic demands of a comprehensive variety of activities have been listed on the Compendium of Physical Activities by Ainsworth et al. (2011), the number of culturally-specific dance activities is very limited. To our knowledge, there is only one study (Usagawa et al. 2014) that has objectively determined the energy expenditure of hula, one of the Polynesian culture dances. They determined the metabolic equivalent (MET) value via direct measurements of oxygen uptake and reported that the hula dance expends 5.7 to 7.5 METs, which can be classified as equivalent to moderate-to-high intensity physical activity (MVPA).

While hula is probably one of the most widely recognized Polynesian dances, it is not the only Polynesian dance that is commonly practiced and performed. At the Polynesian Culture Center on the island of Oahu (Hawaii), some other Polynesian cultural dances are frequently performed to the public at the “Ha: Breath of Life” show, which includes Hawaiian, Fijian, Maori, Samoan, Tahitian, and Tongan culture dances. So far, the physiological demands of these dances are completely unknown.

Energy expenditure of dance varies with the intensity of body movements, the dominance of the upper and/or lower body limbs, the skill level of the dancers, as well as the fitness level of the dancers. According to previous literature, most types of dance require at least a moderate intensity (3.0 METs). One study (Massidda et al. 2011) reported the competitive Latin American dance to be MVPA, where Latin partnered social dance was determined to require 5.1 and 7.3 METs when performed moderately or vigorously, respectively (Domene et al. 2014). Salsa dancing ranges from 3.9 to 5.5 METs (Emerenziani et al. 2013), while Waltz dancing was 4.1 METs (Belardinelli et al. 2008). Finally, recreational ballroom dance (Mixture of Waltz, Foxtrot, Swing, and Cha-Cha) costs an average of 6.1 METs for a total testing duration of 30mins (Lankford et al. 2014).

Assuming that the exercise intensity of Polynesian dances is at least at moderate level, then practicing these culturally-specific dances would contribute favorably to meeting the U.S. National PA Guidelines (≥ 150 mins/week of moderate intensity, aerobic activity). Therefore, it would be useful to examine the exercise intensity of

each type of the commonly practiced Polynesian dances, and eventually provide more information for exercise prescription to the at-risk populations in Hawaii and throughout Polynesia.

Summary

Although the Compendium of Physical Activities lists the energy expenditure for a wide variety of PAs, there are a very limited number of culturally-based activities. Many of the reported MET values were based upon self-reported data and not direct measures of oxygen uptake. Thus, the metabolic demands of most Polynesian dances are unknown. The current study is designed to fill the obvious gap in the literature by objectively measuring the exercise intensity for these cultural dances, which could be used through more appropriate exercise prescriptions for the at-risk NHOPI population.

CHAPTER THREE - THESIS MANUSCRIPT

POLYNESIAN DANCE AS A FORM OF PHYSICAL ACTIVITY: EXERCISE INTENSITY, ENERGY
EXPENDITURE, AND ENERGY SYSTEM CONTRIBUTIONSIntroduction

Native Hawaiians and other Pacific Islanders (NHOPI) suffer a disproportionately high prevalence of cardio-metabolic disorders when compared with the general population of the United States (U.S.) (Mau et al. 2009). Physical inactivity and sedentary lifestyle are believed to be independent risk factors contributing to the higher prevalence of cardiovascular diseases (CVD), obesity, and metabolic syndrome (Grandinetti et al. 2015) in the NHOPI population. It is reported, for example, that 59.0% of men and 64.2% of women of the NHOPI did not meet the federally recommended levels of PA (USDHHS 2008; CDC 2004). However, there is a general consensus in the literature that regular moderate-to-vigorous intensity physical activity (MVPA) that satisfies the U.S. Federal PA Guidelines is associated with a lower BMI (Okeyo et al. 2009), reduced cardiovascular risks (Hegde and Solomon 2015), improved glucose tolerance (Slentz et al. 2016), as well as a better cognitive function (Domene et al. 2014). Thus, by encouraging regular MVPA in this population, the NHOPI could improve both cardiovascular and metabolic fitness levels, as well as decrease their risks for many chronic diseases. As such, MVPA is being used as an equivalent method

of therapy for cardiometabolic diseases that has similar benefits as pharmacological treatments (Faude et al. 2015).

Polynesian dances, such as the well-known Hawaiian hula, refer to a large collection of dances that are each specific to the Polynesian cultures (e.g., Hawaiian, Fijian, Maori, Samoan, Tahitian, Tongan, etc.) and Pacific islands on which they were developed. Some of the most popular Polynesian dances are taught in schools and are practiced by men and women of all ages and ethnicities (Look et al. 2012). Thus, Polynesian dancing could be considered a culturally specific type of PA for the at-risk NHOPI population. Waltz, aerobic dance, and Latin partnered social dance have all been studied as intervention tools for increasing MVPA in various populations, and were found to improve the functional capacity and endothelium-dependent dilation (Belardinelli et al. 2008), blood lipid profile and blood pressure (Maruf et al. 2014), as well as psychological outlook for the participants (Domene et al. 2014). Thus, dancing is considered to be a form of PA that can induce similar physiological effects as traditional aerobic exercise training (Belardinelli et al. 2008). As a matter of fact, “dance therapy” has been introduced to patients with cardiovascular and metabolic diseases and has become popular in recent years (Faude et al. 2015). The Hula Empowering Lifestyle Adaptations (HELA) study, for example, successfully used hula dancing, a culturally-relevant dance to native Hawaiians, as a means for increasing MVPA and improve health benefits in cardiac rehabilitation program participants (Look

et al. 2012). Thus, dancing may be an effective form of PA for promoting healthy outcomes in populations that are receptive to dancing activities.

Unfortunately, there is relatively little objective information available about the cardiometabolic consequences of regular dancing, which makes the application of basic exercise prescription principles (i.e., determining the “dose” of exercise) difficult without knowing the metabolic demands (or exercise intensity, as commonly expressed with metabolic equivalents (MET) or energy expenditure (EE)) for each Polynesian dance. For example, there are very few MET values for culturally-based activities listed in the Compendium of Physical Activities (Ainsworth et al. 2011), and none of these values were based upon direct measures of oxygen uptake (VO_2). So far, the hula is the only Polynesian dance to have direct MET intensity measures reported in the literature (5.7 and 7.6 METs for low and high intensity dances, respectively) (Usagawa et al. 2014). To our knowledge, the MET intensity for other Polynesian dances has never been assessed objectively (e.g., using indirect calorimetry). Thus, the lack of MET intensity evaluations for most Polynesian dances may be a deterrent to their use as MVPA intervention tools for the NHOPI and other high risk populations.

While the *aerobic* demands for Polynesian dancing are weakly understood, the *anaerobic* energy demands of Polynesian dancing are completely undocumented. According to the literature, the traditional strategy for determining PA MET intensities is to average the last several minutes of directly-measured oxygen consumption for a steady-state bout lasting 3-10 mins. While this strategy provides the information

needed to assess *aerobic* exercise intensity, no information is provided about *anaerobic* energy expenditure or anaerobic work intensity. Blood lactate measures, however, taken during the same steady-state bout have been used to estimate the anaerobic EE for both low and high intensity activities (e.g., weight lifting, rock climbing, and running) (Scott 2006; Bertuzzi et al. 2007; Duffield et al. 2005). Given that many Polynesian dances are not purely steady-state activities, it may be useful for healthcare professionals to know both the aerobic and anaerobic contributions to whole-body EE (Scott 2005). However, to our knowledge, there have been no published evaluations of both the aerobic and anaerobic EE contributions for any type of dancing.

Thus, the primary purpose of this study was to measure and compare the metabolic demands (both aerobic and anaerobic) for several popular forms of Polynesian dance as commonly practiced and performed by a convenience sample of experienced Polynesian dancers. When expressed as METs, these results can be compared to the 2008 U.S. Physical Activity Guidelines (USDHHS) to determine whether dance intensity exceeds the commonly-used intensity thresholds for moderate ($3.0 \text{ METs} \leq \text{“moderate”} < 6.0 \text{ METs}$) or vigorous intensity ($\geq 6 \text{ METs}$) PA. We hypothesized that all of the Polynesian dances tested would exceed the 3-MET threshold, while some of the dances (but not all) would also exceed the 6-MET threshold. Since some Polynesian dances are choreographed by gender (with men tending to have more energetic appearing routines), we also hypothesized that the

MET intensity for the men's dances would be significantly higher than that for the women's dances. Finally, given the complete lack of information regarding the anaerobic contribution to total EE of dancing, we also sought to describe how both aerobic and anaerobic energy systems contribute to total EE of Polynesian dancing.

Methodology

Participants

Participants of this study were experienced dancers working full-time or part-time (within the past 12 months) performing the "Hā: Breath of Life" show for the Polynesian Culture Center on the island of Oahu (Hawaii, USA). Inclusion criteria included: 1) Men and women aged 18-64 years; 2) Native Hawaiians and other ethnic groups in Hawaii commonly identified as NHOPI; 3) Those who could perform at least one of the Polynesian dances of interest to this study. Exclusion criteria included: 1) Pregnant women; 2) Those who self-identified as having uncontrolled chronic diseases or orthopedic conditions that could adversely affect cardiometabolic measurements or the participant's ability to dance; 3) Those who had contraindications to performing MVPA. The study protocol was approved by the Brigham Young University (BYU) – Hawaii (Laie, Oahu) Institutional Review Board. Participants read and signed the informed consent form that fully described the risks and benefits associated with participating in this study.

Procedures

Participants who satisfied both inclusion and exclusion criteria were further screened with the Physical Activity Readiness Questionnaire (PAR-Q) to help identify and exclude those with contraindications to MVPA. Demographic and anthropometric data, such as age, gender, body height and mass, self-reported ethnicity, as well as total years of Polynesian dance experience, were collected at the beginning of each test session. Prior to their visit, participants were instructed to wear appropriate clothing and footwear for dancing, to be rested and well hydrated, and to avoid caffeine intake at least 2 – 3 hours prior to testing. Body height was measured barefoot using a portable stadiometer (Invicta Model #IP0955; Invicta Plastics Limited, Leicester, England) to the nearest 0.1 cm, and body mass was obtained to the nearest 0.1 kg using a digital scale (Tanita model #BF-683W; Tanita Corporation Tokyo Japan). These data were subsequently used to calculate body mass index (BMI, kg/m^2) as body mass (kg) divided by body height (m) squared.

Polynesian Dances Tested

The Polynesian dances tested by this study were those commonly practiced and performed by experienced dancers in the “Hā: Breath of Life” show at the Polynesian Culture Center (Laie, Oahu, Hawaii). The theme of this show was to highlight specific Polynesian cultures by combining traditional stories about each culture’s origin with traditional music and dancing. As such, this show focused on six popular Polynesian cultures and their respective dances: 1) The Hawaiian hula (both traditional and

contemporary forms) from the islands of Hawaii; 2) Traditional Fijian dance from the islands of Fiji; 3) Maori dances (the haka for both men and women, as well as poi balls for women) from New Zealand; 4) Samoan sasa (men and women) and slap (men only) dances from the island of Samoa and American Samoa; 5) Traditional Tahitian dance from the islands of Tahiti; 6) Traditional Tongan dance from the islands of Tonga.

The *Hawaiian hula*, tells a story with a combination of smoothly coordinated hand, head, and lower body motions while in a standing position. The traditional hula is performed to a chant and traditional Hawaiian instruments (such as drums) and is characteristic of the hula style prior to Westernization of the islands. The contemporary hula, in contrast, is performed to music with modern instruments (such as guitar). Traditional *Fijian* dance reflects the spirit world, and is characterized by quick upper and lower body movements with some jumping. The Maori *haka* dance (for both men and women) is a traditional ancestral war (battle) dance during which dancers perform in a heightened arousal state inferring intimidation. The men included more squatting movements, while the women performed a supporting haka with arm movements, without the large lower body squatting type movements. The Maori *poi balls* dance (for women), using poi balls (two padded balls attached by a string) as a performance equipment, integrates story-telling, singing and dancing. The Samoan culture has two main forms of dance: the *sasa* (for both men and women) and *slap* (only for men), both of which depict everyday life activities. Sasa is generally performed by a large group of people, usually in a seated position, while some parts

of the dance require standing up. Slap is traditionally performed by men and requires strength and stability, during which dancers forcefully slap their hands on their own bodies, in sync with each other, with hands clapping and feet stamping forwards and backwards. Traditional *Tahitian* dance is performed by men and women together or separately, and is characterized by a rapid hip-shaking motion to percussion accompaniment (i.e., drums) at a fast rhythm. The traditional *Tongan* dance features story-telling through lots of hand and feet gestures. The graceful movements of women dancers contrast with the great vigor of the men dancers. The tempo of all the dance music used in the “Hā: Breath of Life” show is approximately 130 beat per minute (bpm), with the exception of the contemporary Hawaiian hula (80 bpm) and the Samoan slap (180 bpm).

Dance Testing Protocol

Participants were tested either individually (i.e., they were the only dancer tested) or in groups of two or three with all dancers being tested simultaneously. The group limit of three dancers was set to match the amount of testing equipment available. All dance testing was performed in a large ballroom with hardwood flooring on the campus of BYU-Hawaii. Participants, wearing all of the measurement equipment, began the testing with 5 minutes of quiet sitting for the determination of sitting resting metabolic rate (RMR or $VO_{2\text{REST}}$) and resting blood lactate concentration ($[LA_{\text{REST}}]$). Next, participants were given another 5 minutes to warm-up using self-directed activities (i.e., walking, flexibility exercises, dancing, etc.). Next, as the first

piece of dance music began, the participants started the first dance routine and continued for 4.5 – 5.0 minutes before another 5 minutes of quiet sitting rest. The individual music pieces lasted from 1.5 – 3.5 minutes each, so each dance testing bout required the music piece to be looped 2 – 3 times to provide continuous music for 4.5 – 5.0 minutes. Even though Polynesian dancing does not usually last longer than the longest music piece (i.e., 3.5 minutes), the duration of dance testing (4.5 – 5.0 minutes) was considered necessary to provide the best opportunity for steady-state cardiorespiratory and blood lactate measures. In addition, when dancing as a group of 2 or 3 simultaneously, the dancers performed the same choreography. Finally, while most of the participants danced to the “Hā: Breath of Life” show music, a few dancers brought their own music for dancing which was characteristic of the same cultural dance style and tempo as that used in the show. This testing process (i.e., dance 5 minutes and rest for 5 minutes) was then repeated for as many of the cultural dances that the participants could perform without self-reporting undue fatigue. The order for performing the dance types was randomly assigned prior to the start of each testing session.

Measurement of Cardiometabolic Demands

The testing was conducted under room temperature between and 20 – 21°C, relative humidity of 57 – 71%, and at an altitude within 10 m above sea level. Each participant was fitted with a heart rate monitor chest strap (Polar Electro Inc., NY, USA) and a small backpack that carried a portable indirect calorimetry metabolic

measurement system (Oxycon Mobile®; VIASYS, San Diego, CA, USA). The metabolic system was calibrated prior to each test according to the manufacturer's instructions. During all testing, participants wore a face mask affixed with an adjustable fabric headpiece which contained the flow tachometer and expired gas sampling tubes for the metabolic system. Heart rate (HR) data were transmitted to the metabolic system, while the real-time respiratory gas measures for oxygen consumption and carbon dioxide production (VCO_2) were recorded continuously (breath-by-breath) throughout the participant's resting and dance testing without recalibration. The breath-by-breath sampling by the metabolic system was then used to summarize all cardiometabolic data at one-minute sample intervals for subsequent analyses. The total mass of all testing equipment carried by participants when dancing was 1.5 kg.

Measurement of Blood Lactate

Fingertip blood samples were drawn for lactate analysis (Lactate Plus™, Nova Biomedical UK, Chesire, UK) right after RMR measurement (while still sitting), as well as immediately following each dance routine to characterize the anaerobic exercise intensity.

Data Processing and Calculations

Aerobic EE Calculations. The MET (dimensionless) was used to represent the aerobic exercise intensity while aerobic activity energy expenditure (aerobic AEE; $\text{kcal}\cdot\text{min}^{-1}$) was calculated to represent the net aerobic energy produced from the

oxidative system. To determine these variables (MET and aerobic AEE), the 1-minute sample averaged data from the portable metabolic system were averaged over the last 2 minutes for each dance bout, including absolute VO_2 ($\text{mL}\cdot\text{min}^{-1}$), VCO_2 ($\text{mL}\cdot\text{min}^{-1}$), HR ($\text{beat}\cdot\text{min}^{-1}$), and respiratory exchange ratio (RER). First, relative VO_2 was calculated as: $\text{relative } \text{VO}_2$ ($\text{mL}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$) = $\text{absolute } \text{VO}_2$ ($\text{mL}\cdot\text{min}^{-1}$) / mass (kg), where mass was either the participant's body mass (for RMR measurement) or the sum of body mass and the 1.5 kg equipment mass (for dance testing). Relative VO_2 was then transformed to MET as: $\text{MET} = \text{relative } \text{VO}_2 / 3.5$. Aerobic AEE for dancing was calculated as: Aerobic EE ($\text{kcal}\cdot\text{min}^{-1}$) = $[(\text{EE for dance}) - (\text{EE for RMR})]$, where both EE values were calculated using Weir's equation, EE ($\text{kcal}\cdot\text{min}^{-1}$) = $3.9 \times \text{VO}_2$ ($\text{mL}\cdot\text{min}^{-1}$) + $1.1 \times \text{VCO}_2$ ($\text{mL}\cdot\text{min}^{-1}$) (Weir 1949).

Anaerobic EE Calculations. Anaerobic AEE, or the net anaerobic energy produced from the glycolytic system, was estimated by the accumulation of blood lactate concentration ($[\text{LA}]$) above resting values (i.e., $[\text{LA}_{\text{REST}}]$), where $1.0 \text{ mmol}\cdot\text{L}^{-1}$ was assumed to be equivalent to a relative VO_2 of $3.0 \text{ mL O}_2\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ (di Prampero 1981). This VO_2 equivalent was then transformed into anaerobic AEE, with a unit of $\text{kcal}\cdot\text{min}^{-1}$, using a caloric equivalent of 20.9 kJ (5 kcal) per liter of O_2 (Bertuzzi et al. 2013). If this VO_2 equivalent was negative (i.e., $[\text{LA}_{\text{REST}}] > [\text{LA}]$), then the anaerobic AEE during dance was considered to be $0 \text{ kcal}\cdot\text{min}^{-1}$. It was also assumed that the contribution of alactic metabolism during these activities was negligible because the ATP-PCr system

is predominantly used during high-intensity (3 – 5 times the power output that elicits VO_{2MAX}), short-duration (10 – 15 seconds) exercises (Bertuzzi et al. 2013).

Total EE Calculations. Total AEE was then calculated as the sum of both aerobic AEE (from measured VO_2) and anaerobic AEE (from [LA]) contributions. The contribution of both aerobic and anaerobic metabolisms for each type of dance was expressed in both absolute ($kcal \cdot min^{-1}$) and relative units (% of total AEE).

Statistical Analyses

Intraclass correlations (ICC) for reliability were computed between the last two minutes of the raw cardiometabolic measures: VO_2 , CO_2 , and HR (Baumgartner and Jackson 1995). Descriptive statistics were presented as mean \pm SD unless otherwise specified. A one-way ANOVA with Tukey's HSD post-hoc analysis was used to evaluate the differences in MET values across dances, while one sample t-tests were used to compare the mean MET values for each type of dance to the 3-MET and 6-MET MVPA thresholds. Gender differences in aerobic and anaerobic EE, as well as their respective contributions to total EE, were examined using independent t-tests. All statistical tests were evaluated for significance at the 0.05 alpha level, while a Bonferroni correction was used to correct the 0.05 alpha for groups of similar tests. As such, the t-tests for gender comparisons had an adjusted alpha of 0.008 (0.05 / 6 tests), while the alpha level was adjusted to 0.006 (0.05 / 8 tests) for the 3-MET and 6-MET threshold comparisons. All statistical analyses were conducted using SPSS 13.0 for windows

(SPSS Inc., Chicago, USA).

Results

Characteristics of Participants

The demographic and anthropometric statistics for the 13 men and 17 women participants are listed in Table 1, such as age (Mean \pm SD; 22.8 ± 3.1 yrs), body mass index (BMI; 27.6 ± 5.5 kg·m⁻²), and Polynesian dance experience (6.6 ± 7.3 yrs). According to BMI classification standards for adults (American College of Sports Medicine 2014), the men were represented within all BMI categories from underweight to obese while the women were classified within normal weight, overweight, and obese categories (see Table 1). In addition, the mean BMI values for men was significantly higher than those for women ($P = 0.018$). There were no gender differences in resting HR (HR_{REST}) or VO_{2REST}, but women had significantly lower [LA_{REST}] (1.0 ± 0.4 vs. 1.5 ± 0.5 mmol·L⁻¹; $P = 0.011$), and self-reported more Polynesian dance experience than men (8.9 ± 7.9 vs. 3.5 ± 5.4 yrs; $P = 0.043$). The self-reported ethnicity for the participants was very diverse with 16 participants reporting a combination of 1 – 3 specific Polynesian ethnicities (i.e., Hawaiian, Fijian, Maori, Samoan, Tahitian, and Tongan), five others reporting either Asian ($n = 2$) or Polynesian ($n = 3$), and the remainder reporting a combination of ≥ 1 Polynesian with ≥ 1 non-Polynesian ethnicity (White/Caucasian, German, Japanese, or Swedish).

Table 1. Descriptive statistics for Polynesian dance study participants.

	All subjects (n = 30)	Men (n = 13)	Women (n = 17)
Age (years)	22.8 ± 3.1	24.1 ± 2.9	21.8 ± 2.9
Body height (cm)	168.5 ± 9.7	175.1 ± 9.6	163.5 ± 6.4
Body mass (kg)	79.1 ± 20.6	93.0 ± 23.4	68.4 ± 9.1
BMI (kg·m ⁻²)	27.6 ± 5.5	30.2 ± 6.7	25.6 ± 3.3
<u>BMI Classifications^a</u>			
Underweight	1	1	0
Normal	9	3	6
Overweight	13	3	10
Obese	7	6	1
HR _{REST} (beat·min ⁻¹)	77.6 ± 12.4	75.2 ± 16.6	79.0 ± 9.5
VO _{2REST} (mL·kg ⁻¹ ·min ⁻¹)	3.9 ± 1.0	3.9 ± 1.0	4.0 ± 1.1
LA _{REST} (mmol·min ⁻¹)	1.2 ± 0.5	1.5 ± 0.5	1.0 ± 0.4
Dance experience (years)	6.6 ± 7.3	3.5 ± 5.4	8.9 ± 7.9

All values expressed as mean ± SD unless otherwise specified. BMI: body mass index. The participant was considered underweight when BMI < 20.0; normal weight when 20 ≤ BMI < 25; overweight when 25 ≤ BMI < 30; and obese when BMI ≥ 30. HR_{REST}: resting heart rate; VO_{2REST}: resting oxygen uptake; LA_{REST}: resting blood lactate concentration

^a BMI classification are indicated as the number of participants

Cardiorespiratory Responses to Polynesian Dancing

Prior to summarizing the cardiometabolic data, the last two minutes of data were evaluated for intraclass reliability. First, repeated measures ANOVA found no significant differences between the last two minutes of cardiometabolic data ($P = 0.17 - 0.95$). Additionally, the ICC calculations were consistently high in magnitude with all values > 0.90. Given the lack of significant differences and high ICC values, the last two minutes of cardiometabolic were averaged for all subsequent analyses. Table 2 summarizes the cardiorespiratory and blood lactate responses for each of the Polynesian dances evaluated. A preliminary analysis found that mean MET values for

the traditional hula (5.8 ± 1.9 ; $n = 6$) and contemporary hula (6.7 ± 2.6 ; $n = 19$) were statistically similar ($P = 0.436$), so these data were pooled and referred to as “hula” for all subsequent analyses. Given the varied samples sizes across dances ($n = 3$ for poi balls to $n = 25$ for hula), the unequal variances ($SD = 1.0$ to 3.1 METs), as well as the slightly skewed distributions for some samples, the samples were transformed and analyzed with the planned One-way ANOVA. The ANOVA results for the transformed, however, did not differ from using untransformed data. Thus, the results of the ANOVA with untransformed data are reported. The ANOVA comparing mean MET across the dances was significant ($P = 0.001$), with only Maori poi balls (lowest mean MET at 3.7) and Samoan slap (highest mean MET at 9.6) being statistically different. As shown in Table 2, percent HR_{MAX} ranged between 64.2% (Tongan) and 79.5% (Tahitian); RER ranged from 0.81 (Maori poi balls) to 0.95 (Tahitian); and blood lactate from 1.8 $\text{mmol}\cdot\text{L}^{-1}$ (Maori haka) to 5.2 $\text{mmol}\cdot\text{L}^{-1}$ (Samoan slap). Interestingly, Tahitian had both the highest percent HR_{MAX} (79.5 %), and the highest RER value (0.95), and a moderately high [LA] (3.8 $\text{mmol}\cdot\text{L}^{-1}$), while Samoan slap had the highest [LA] (5.2 $\text{mmol}\cdot\text{L}^{-1}$) but neither the highest percent HR_{MAX} (76.7%) nor the highest RER (0.93). The mean MET values for all dances tested, but Maori poi balls dance ($P = 0.168$), were significantly greater than 3.0 METs ($P = 0.003$ for Maori haka; $P < 0.001$ for Hawaiian hula, Samoan sasa and slap, Tahitian, Tongan, and Fijian). The mean MET values for Samoan sasa, Samoan slap and Tahitian were also significantly greater than 6.0 METs ($P = 0.037$, $P = 0.001$ and $P < 0.001$, respectively).

Table 2. Cardiorespiratory responses and blood lactate concentration for each of eight Polynesian dances.

Dance (n)	VO ₂ (mL·kg ⁻¹ ·min ⁻¹)	MET	HR (beat·min ⁻¹)	Percent HR _{MAX} (%)	RER	LA (mmol·L ⁻¹)
Hawaiian hula (25)	22.7 ± 8.4	6.5 ± 2.4 ^{*†}	138.1 ± 20.3	69.7 ± 10.3	0.82 ± 0.07	2.2 ± 1.9
Fijian (15)	24.5 ± 9.3	7.0 ± 2.6 ^{*†}	140.7 ± 12.9	71.3 ± 7.4	0.84 ± 0.06	2.4 ± 1.2
Maori haka (13)	20.8 ± 10.9	5.9 ± 3.1 ^{*†}	127.1 ± 15.1	64.6 ± 8.2	0.82 ± 0.09	1.8 ± 1.0
Maori poi balls (3)	13.0 ± 3.7	3.7 ± 1.0	130.4 ± 29.9	65.7 ± 15.2	0.81 ± 0.05	2.7 ± 2.9
Samoan sasa (14)	23.1 ± 4.1	6.6 ± 1.2 ^{*†‡}	145.6 ± 14.2	73.1 ± 6.7	0.87 ± 0.07	3.0 ± 1.6
Samoan slap (6)	33.6 ± 5.1	9.6 ± 1.5 ^{†‡}	150.5 ± 16.5	76.7 ± 8.1	0.93 ± 0.05	5.2 ± 2.0
Tahitian (17)	28.9 ± 6.4	8.3 ± 1.8 ^{†‡}	156.9 ± 23.0	79.5 ± 11.3	0.95 ± 0.07	3.8 ± 2.5
Tongan (16)	20.9 ± 8.1	6.0 ± 2.3 ^{*†}	127.4 ± 23.8	64.2 ± 12.2	0.88 ± 0.06	2.1 ± 1.3

All values expressed as mean ± SD unless otherwise specified. n: sample size; VO₂: oxygen uptake; MET: metabolic equivalent; HR: heart rate; Percent HR_{MAX}: Percent of age-predicted maximal HR, calculated as Percent HR_{MAX} = (HR / age-predicted maximal HR) x 100; RER: respiratory exchange ratio; LA: blood lactate

* Mean value for men was significantly higher than that for women

† significantly ≥ 3 METs

‡ significantly ≥ 6 METs

Given that five of the eight Polynesian dances (i.e., all but Tahitian, Samoan slap, and Maori poi balls) included gender-specific dance choreography with identical music, it was of interest to compare MET values by gender. However, splitting the MET data in Table 2 by gender created some extreme differences in sample size and unequal variances. Thus, in addition to the planned t-tests, the Satterthwaite Approximation (Satterthwaite 1946) was used which is a method for handling two-sample comparisons with different sample sizes and (or) unequal variances. The statistical results for this technique, however, were identical to the originally-planned t-tests. Thus, the results of the t-tests are reported. When comparing the MET values between men and women using independent t-tests, the men's MET values for Hawaiian hula, Samoan sasa, Tongan, Fijian, and Maori haka were all significantly greater ($P < 0.001$; see Figure 1) than the corresponding values for women, while the Tahitian MET values were similar ($P = 0.526$) between genders (see Figure 1).

Aerobic and Anaerobic Contributions to Total AEE

Calculation results for both aerobic and anaerobic AEE for both men and women are shown in Figure 2(a), while the respective contributions of the aerobic and anaerobic AEE to the total AEE are shown in Figure 2(b). According to Figure 2, aerobic AEE was the predominant energy source for all Polynesian dances tested. The average contribution of aerobic AEE to total AEE was $83.4 \pm 14.4\%$ with a range of $74.2 \pm 10.9\%$ (Samoan slap) to $88.7 \pm 13.7\%$ (Hawaiian hula). In contrast, the mean contribution of anaerobic AEE was $16.6 \pm 14.4\%$, with a range of $11.3 \pm 13.7\%$ (Hawaiian hula) to 25.8

$\pm 10.9\%$ (Samoan slap). The same calculations for aerobic and anaerobic AEE, as well as the contribution of these AEE sources relative to total AEE, are summarized by gender in Table 3. The aerobic AEE for men was significantly higher than that for women dancing the Hawaiian hula, Samoan sasa, Fijian, Maori haka, and Tongan ($P = 0.006$ for Hawaiian hula; $P < 0.001$ for the other four types of dance). For anaerobic AEE, in contrast, there were no significant difference between men and women for the six dances performed by both genders ($P = 0.037 - 0.500$).

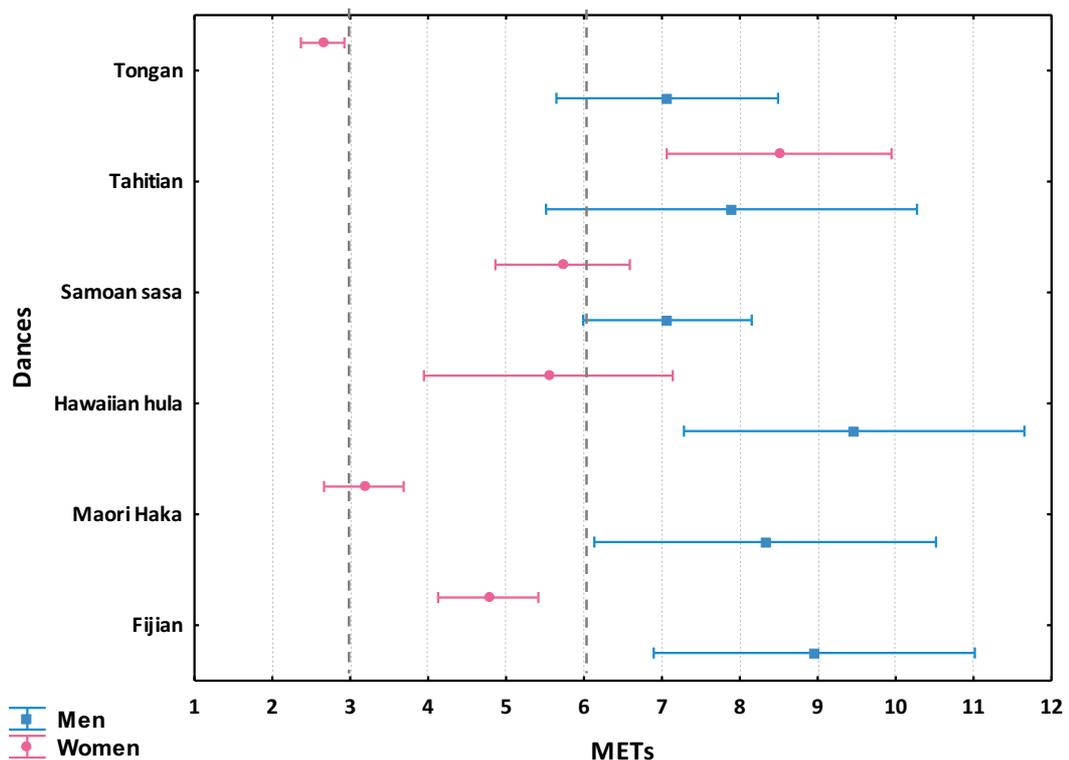


Figure 1. Metabolic equivalents (MET) for eight Polynesian dances by gender with reference to the 3-MET and 6-MET thresholds commonly used to define moderate and vigorous exercise intensities, respectively. All values expressed as mean \pm SD.

Table 3. Aerobic and anaerobic activity energy expenditures (AEE) and their respective contributions to total EE by gender for eight Polynesian dances.

	Gender (n)	Aerobic AEE and its contribution to total AEE			Anaerobic AEE and its contribution to total AEE		
		Aerobic AEE (kcal·min ⁻¹)	<i>p</i> -value	Contribution (%)	Anaerobic AEE (kcal·min ⁻¹)	<i>p</i> -value	Contribution (%)
Hawaiian hula	M (6)	11.1 ± 4.0	0.006 *	92.2 ± 7.7	1.0 ± 1.0	0.329	7.8 ± 7.7
	W (19)	5.0 ± 2.1		87.6 ± 15.1	1.3 ± 2.3		12.4 ± 15.1
Fijian	M (8)	12.8 ± 4.3	< 0.001 *	84.6 ± 5.5	2.4 ± 1.1	0.070	15.4 ± 5.5
	W (7)	4.3 ± 1.0		85.0 ± 14.5	1.1 ± 1.8		15.0 ± 14.5
Maori haka	M (7)	10.2 ± 3.4	< 0.001 *	88.0 ± 10.1	1.4 ± 1.1	0.037	12.0 ± 10.1
	W (6)	2.5 ± 0.5		83.8 ± 9.5	0.5 ± 0.3		16.2 ± 9.5
Maori poi balls	W (3)	2.9 ± 1.4	N.A.	81.5 ± 32.1	1.9 ± 3.2	N.A.	18.5 ± 32.1
Samoan sasa	M (9)	10.1 ± 1.7	< 0.001 *	80.5 ± 16.3	3.0 ± 3.1	0.109	19.5 ± 16.3
	W (5)	5.7 ± 1.2		81.8 ± 10.6	1.4 ± 1.3		18.2 ± 10.6
Samoan slap	M (6)	14.5 ± 4.8	N.A.	74.2 ± 10.9	5.1 ± 3.0	N.A.	25.8 ± 10.9
Tahitian	M (7)	9.8 ± 3.6	0.282	84.1 ± 14.1	1.5 ± 1.1	0.048	15.9 ± 14.1
	W (10)	8.3 ± 2.1		75.3 ± 14.1	3.4 ± 3.0		24.7 ± 14.1
Tongan	M (12)	10.5 ± 3.7	< 0.001 *	90.0 ± 10.0	1.4 ± 2.4	0.500	10.0 ± 10.0
	W (4)	1.9 ± 0.4		58.5 ± 16.3	1.4 ± 0.6		41.5 ± 16.3

All values expressed as mean ± SD unless otherwise specified. M: men; W: women

* Mean value for Aerobic AEE or Anaerobic AEE was significantly higher for men than that for women when *p*-value < 0.008

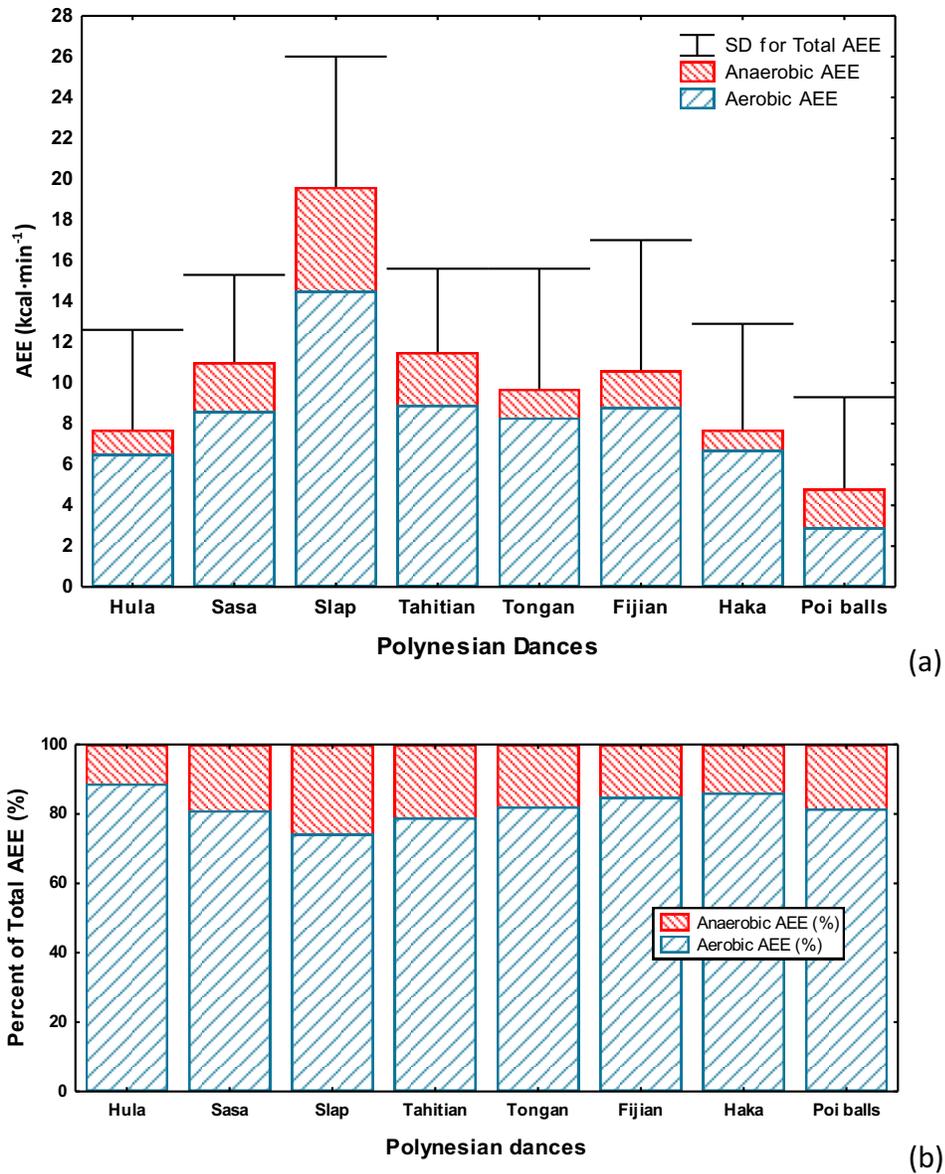


Figure 2. Aerobic and anaerobic contributions to the total activity energy expenditure for eight Polynesian dances. Mean values for aerobic and anaerobic AEE, as well as standard deviations for total AEE, are shown in Figure 2(a, top) where the total AEE is the sum of both aerobic and anaerobic AEE. The respective contributions as a percent of the total AEE for the aerobic and anaerobic systems are shown in Figure 2(b, bottom).

Discussion

The present study provides insight into both aerobic and anaerobic metabolic demands for several popular forms of Polynesian cultural dance. Our results indicate that all Polynesian dances tested (except for Maori poi balls) have MET intensities that exceed the 3-MET MVPA threshold, and thus may be considered an appropriate exercise modality for the at-risk NHOPI population to meet the current recommendations for PA (USDHHS 2008). However, it was also clear that the men's dances tended to have much higher MET values than the women's dances (i.e., Hawaiian hula, Fijian, Maori haka, Samoan sasa, and Tongan) so both gender and the type of Polynesian dance should to be considered together when designing a dance-specific PA intervention.

MET Values across the Polynesian Dances Tested

The mean MET values for the Polynesian dances evaluated by this study ranged broadly from a low of 3.7 METs for Maori poi balls and a high of 9.6 METs for the Samoan slap (see Table 2). Interestingly, the Maori poi balls and Samoan slap were also the only two dances specific to one gender (women and men, respectively). The mean MET values for the other six dances were more similar (5.9 – 8.3 METs; see Table 2), but included both men and women dancers. When compared to the 3-MET and 6-MET thresholds for MVPA, all, but Maori poi balls dance, exceeded 3.0 METs, while Samoan sasa, Samoan slap and traditional Tahitian exceeded 6.0 METs. Thus, the hypothesis that all Polynesian dances

tested would exceed the 3-MET threshold was nearly satisfied, while the hypothesis that only some (not all) of the dances would exceed the 6-MET threshold held true.

Comparable MET data for Polynesian dancing is relatively scarce in the published research literature. The Hawaiian hula, for example, appears to be the only Polynesian dance previously reported upon with direct measures of oxygen uptake. Usagawa et al. (2014) evaluated the Hawaiian hula (described by the authors as a combination of traditional and contemporary forms of hula) in competitive Polynesian dancers and reported mean MET values of 5.7 and 7.6 METs for slow tempo (low-intensity) and fast tempo (high-intensity) hula, respectively. The present study measured traditional and contemporary hula separately and found these two sub-styles of hula to be statistically similar (5.8 and 6.7 METs, respectively; $P = 0.436$). Regardless, both of these evaluations for hula, whether the style was traditional, contemporary, or some combination, consistently report the intensity to exceed the 3-MET threshold but not the 6-MET threshold.

Focusing on ballroom dancing, Lankford et al. (2014) reported that the exercise intensity of four dance styles (5.3, 5.3, 6.4, and 7.1 METs for waltz, foxtrot, cha cha, and swing, respectively) with recreational dancers also exceeded the 3-MET threshold. Recent work from our own lab (Zhu et al. 2016) focused on evaluating the metabolic demands for Tinikling, a traditional Philippine bamboo dance. Using mostly middle-aged adults with a recreational familiarity of the dance style, Tinikling had a mean MET intensity of 6.9 METs which exceeded the 6-MET threshold ($P = 0.0015$). The commonality amongst these dance

studies is that MET values were based upon the indirect calorimetry technique for assessing aerobic metabolic demands. However, despite the different types of dances reported upon (Polynesian, ballroom, Tinikling), the different populations assessed (competitive and professional dancers, as well as college-aged and middle-aged dancers), the results consistently suggest that many forms of dance have a metabolic demand that easily exceeds the 3-MET threshold, while some also exceed the 6-MET threshold.

Gender Comparisons for MET Values

The result of the present study supported our second hypothesis that the MET intensities for some of the men's dances would be significantly higher than those for the women's dances (see Figure 1). Five of the six Polynesian dances performed by both men and women (i.e., Hawaiian hula, Fijian, Samoan sasa, Maori haka, and Tongan) had gender-specific choreography while dancing to identical music. For example, the Maori haka (a traditional battle dance) has men and women performing in a heightened arousal state that encourages yelling with exaggerated facial expressions. However, the men's haka emphasizes high-intensity upper and lower body motions, while the women's haka involves relatively quiet standing and less exaggerated upper body motions. These choreography differences explain why women's haka had a metabolic demand of only 3.2 METs while the men's haka averaged 8.3 METs. Tahitian was the only dance that had no significant gender difference in MET values, and could also be classified as vigorous-intensity PA for both genders.

The lower metabolic demands exhibited by the women dancers might also be due to the women dancers reporting more Polynesian dance experience than the men (8.9 vs. 3.5 yrs, $P = 0.043$). This observation is consistent with the women hula dancers in Usagawa's study (2014) who started training at the age of 5 while men dancers started in late adolescence or early adulthood. As such, it is presumed that more years of dance experience would lead to higher dancing skill levels and possibly more energetically efficient dance movements. However, this explanation seems unlikely given the contrast in choreography between men and women dancers described above. While a movement analysis was not performed on these dancers, the visual appearance of the men's dance choreography often appeared more highly energetic (i.e., jumping, stomping, dynamic large range of motion gestures) while the women's dances appeared relatively subdued (i.e., smooth and graceful body motions without jumping or stomping). Finally, the men in the present study also had a significantly higher BMI ($30.2 \text{ kg}\cdot\text{m}^{-2}$) than the women dancers ($25.6 \text{ kg}\cdot\text{m}^{-2}$) which could have increased the aerobic energy cost for men simply because of having more body mass when dancing. While having a higher BMI most certainly contributed to a higher absolute energetic costs for dancing, it is still more likely that differences in dance choreography between genders was the primary cause for gender differences amongst five of the Polynesian dances tested in this study.

Aerobic AEE

As for aerobic AEE, we observed the mean values for the Hawaiian hula, Fijian, Maori haka, Samoan sasa, Samoan slap, as well as the traditional Tahitian and Tongan

dances to range between 6.5 and 14.5 kcal·min⁻¹ (see Figure 2a). Previous dance studies, such as Lankford et al.'s recreational ballroom dance study (2014), reported that waltz, foxtrot, cha cha, and swing cost an average of 5.9 kcal·min⁻¹. For Latin American dancing, Massidda et al. (2011) reported metabolic rates of 9.9, 8.3, 6.6, 8.5, and 8.3 kcal·min⁻¹ for cha cha, samba, rumba, paso doble, and jive, respectively. Emerenziani et al. (2013) measured the AEE in three different forms of salsa dance: typical salsa lesson (5.6 and 4.5 kcal·min⁻¹), rueda de casino lesson (6.8 and 5.3 kcal·min⁻¹), and salsa dancing at night club (7.1 and 4.2 kcal·min⁻¹), for men and women, respectively. These data are comparable to our findings for Hawaiian hula (6.5 kcal·min⁻¹), Samoan sasa (8.6 kcal·min⁻¹), Tahitian (8.9 kcal·min⁻¹), Tongan (8.3 kcal·min⁻¹), Fijian (8.8 kcal·min⁻¹), and Maori haka (6.7 kcal·min⁻¹), though the present study is the only one to have also assessed the anaerobic energy cost.

Anaerobic AEE

It is well known that the aerobic and anaerobic energy contributions to total energy expenditure during PA will change in response to exercise intensity and duration (Nummela and Rusko 1995), as well as with exercise modalities (Scott 2005). Unlike many classic forms of aerobic exercise (e.g., walking, jogging, bicycling), many Polynesian dances are not purely steady-state activities due to changes in choreography that correspond with changes in music tempo and duration. Thus, a better understanding of the aerobic and anaerobic energy system contributions to total energy expenditure during dance may be important for correct administration and structuring of exercise prescription. To our knowledge, this is the first study to evaluate the both absolute (kcal·min⁻¹) and relative

(% of total AEE) aerobic and anaerobic AEE during dancing exercise. In short, the current study found that aerobic energy was predominantly used for all Polynesian dances tested. On average, aerobic and anaerobic AEE contribute 83.4% and 16.6%, respectively, to total AEE for Polynesian dances (see Figure 2b). Across dances, the Hawaiian hula had the highest aerobic energy contribution (88.7% aerobic and 11.3% anaerobic for a total AEE of 7.7 kcal·min⁻¹), while Samoan slap had the lowest aerobic energy contribution (74.2% aerobic and 25.8% anaerobic for a total AEE of 19.6 kcal·min⁻¹). These aerobic energy contributions are comparable to other endurance exercises, such as 1500 m track running (77% and 86% for men and women, respectively), 3000 m track running (86% and 94% for men and women, respectively) (Duffield et al. 2005), and 2000 m rowing (87%) (de Campos Mello et al. 2009). By referring to findings of our study (i.e., the aerobic and anaerobic AEE contributions to total AEE), health practitioners and researchers could design intervention programs using one or more forms of Polynesian dance that have absolute or relative aerobic AEE equivalent to traditional exercise modalities (e.g., Samoan slap vs. men's 1500 m track running, Hawaiian hula vs. 2000 m rowing, etc.).

Limitations and Future Research

One limitation of this study is that our participants were all experienced Polynesian dancers. Novice or beginner dancers may have very different cardiometabolic responses to these forms of dance. While the dependence of cardiometabolic responses on dance experience has been suggested (Bertuzzi et al. 2007), the topic does not seem to have been studied or reported upon in the literature. Second, all the dance testing was

performed for a duration of 4.5 – 5 mins to ensure that the participants reached steady-state for respiratory gas analysis. However, factors such as exercise duration may influence the metabolic fate of blood lactate concentration (Gastin 2001), and therefore, the anaerobic AEE estimates from our study only stands for 4.5 – 5 minutes steady-state measurement, and not generalizable to any longer duration of Polynesian dancing. Other study limitations include the small sample sizes for some of our dance data (e.g., $n = 3$ for the Maori poi balls dance), and that an objective measure of aerobic fitness, such as maximal oxygen uptake (VO_{2MAX}), was not measured for our dance participants.

Future research should consider using dancers with a more diverse range of dance experience and skill to provide a more complete understanding of the energy cost for Polynesian dancing. Also, various durations of dancing exercise should also be addressed in future studies to provide better evidence of the energy system contributions to Polynesian dancing. Finally, the current study's analysis of both aerobic and anaerobic contributions to total energy expenditure should be expanded to other types of dance to determine the generalizability of our observations.

Conclusions

The present found that the average MET intensity for most of the Polynesian dances evaluated (Hawaiian hula, Samoan sasa and slap, Fijian, Maori haka, and Tongan, but not Maori poi balls) exceeded the 3-MET threshold. However, when evaluated by gender, the men's MET values were significantly higher than the women's values for all but traditional

Tahitian dance. Thus, while these results support the use of Polynesian dancing as a means to promote increased MVPA for health promotion and diseases prevention for the NHOPI population, the cardiometabolic dose to be expected will vary between Polynesian dances, as well as between genders. Regardless, the present study can serve as a starting reference for the prescribed use of Polynesian dancing by health practitioners, coaches, exercise physiologist and researchers.

CHAPTER FOUR - CONCLUSIONS

The present study provides insight into both aerobic and anaerobic metabolic demands for several popular forms of Polynesian cultural dance. Our results indicate that the average MET intensity for most of the Polynesian dances evaluated (Hawaiian hula, Samoan sasa and slap, Fijian, Maori haka, and Tongan, but not Maori poi balls) exceeded the 3-MET MVPA threshold, and thus may be considered an appropriate exercise modality for the at-risk NHOPI population to meet the current PA recommendations. It was also clear that the men's dances tended to have a much higher MET value than the women's dances (i.e., Hawaiian hula, Samoan sasa, Fijian, Maori haka, and Tongan), and therefore, both gender and the type of Polynesian dance should to be considered together when designing a dance-specific PA intervention.

Also, this study is the first to report the respective aerobic and anaerobic energy expenditures for dancing exercise. We found that aerobic energy was predominantly used for all Polynesian dances tested, and that the contribution of aerobic AEE to total AEE for all dances tested are similar to traditional endurance exercises (i.e., running, rowing, etc.). Given that many Polynesian dances are not purely steady-state activities due to changes in choreography that correspond with changes in music tempo and duration, findings about the aerobic and anaerobic AEE could be important for correct administration and structuring of exercise prescription using one or more forms of Polynesian dance.

The results of our study, however, are limited to experienced Polynesian dancers, who were tested for a duration of 4.5 - 5 minutes. Future research should consider using

dancers with a more diverse range of dance experience and skill to provide a more complete understanding of the energy cost for Polynesian dancing. Also, various durations of dancing exercise should be addressed to provide better evidence of the energy system contributions to Polynesian dancing. Finally, the current study's analysis of both aerobic and anaerobic contributions to total energy expenditure should be expanded to other types of dance to determine the generalizability of our observations.

Thus, while the current study supports the use of Polynesian dancing as a means to promote increased MVPA for health promotion and diseases prevention for the NHOPI population, the cardiometabolic dose to be expected will vary between Polynesian dances, as well as between genders. Regardless, the present study can serve as a starting reference for the prescribed use of Polynesian dancing by health practitioners, coaches, exercise physiologist and researchers.

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APPENDIX A

IRB APPROVED INFORMED CONSENT DOCUMENT

Part A: Application Information

1. Title of Study: The Polynesian Dance Study			
2. Principal Investigator: Joel Reece		3. Contact Person (if different from PI):	
Title: Assistant Professor	Dept: Exercise and Sport Science	Title:	Dept:
Address (+ zip): 55-220 Kulanui St. #1968		Address (+ zip):	
Phone: 675-3353	Email: <u>Joel.reece@byuh.edu</u>	Phone:	Email:
4. Co-Investigator(s) (name & affiliation): Eli Lankford Brigham Young University Idaho, Daniel Heil Montana State University, Wei Zhu Montana State University			
5. Research Originated By (check one): <input checked="" type="checkbox"/> Faculty <input type="checkbox"/> Student <input type="checkbox"/> Staff			
6. Research Purpose (check all that apply): <input type="checkbox"/> Grant <input type="checkbox"/> Thesis <input type="checkbox"/> Dissertation <input type="checkbox"/> ORCA Scholarship <input type="checkbox"/> Honors Thesis <input checked="" type="checkbox"/> Other <input type="checkbox"/> Course Project: Which course?			
7. Correspondence Request: <input type="checkbox"/> Mail <input checked="" type="checkbox"/> Call for Pick-Up			

Part B: Research Study Synopsis

1. Short Study Description: The primary purpose of this study is to determine the metabolic demands of dance from 6 different Polynesian cultures. Participants will perform dances from any of the 6 cultural dances they desire (i.e., Samoan, Hawaiian, Tongan, Fijian, Mauri, and Tahitian). All dances will be performed while participants are wearing a breath-by-breath analyzer during the duration of the dance session. The analyzer will record heart rate, oxygen intake and CO ₂ output. Participants will also wear small electronic activity monitors (1 on each wrist; 1 on each ankle; 1 on the hip) so that we predict the metabolic demands of Polynesian dances in the future, such as for a group intervention. The primary outcome for these data will be energy expenditure.
2. Study Length: What is the duration of the study? October 2015-February 2016
3. Location of Research: a. Where will the research take place? BYUH campus, Ballroom b. Will the PI be conducting and/or supervising research activity at any sites not under the jurisdiction of the BYUH IRB? Yes <u>No</u>

Part B: Research Study Synopsis (continued)

<p>4. Subject Information:</p> <p>a. Number of Subjects: 75</p> <p>b. Gender of Subjects: Male and female</p> <p>c. Ages of Subjects: 18-64</p>								
<p>5. Potentially Vulnerable Population (check all that apply):</p> <table> <tr> <td><input type="checkbox"/> Children</td> <td><input type="checkbox"/> Pregnant Women</td> </tr> <tr> <td><input type="checkbox"/> Cognitively Impaired</td> <td><input type="checkbox"/> Institutionalized</td> </tr> <tr> <td><input type="checkbox"/> Prisoners</td> <td><input type="checkbox"/> Other. Please describe</td> </tr> <tr> <td><input type="checkbox"/> Faculty's Own Students</td> <td></td> </tr> </table>	<input type="checkbox"/> Children	<input type="checkbox"/> Pregnant Women	<input type="checkbox"/> Cognitively Impaired	<input type="checkbox"/> Institutionalized	<input type="checkbox"/> Prisoners	<input type="checkbox"/> Other. Please describe	<input type="checkbox"/> Faculty's Own Students	
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<input type="checkbox"/> Faculty's Own Students								
<p>6. Non-English Speaking Subjects:</p> <p>Will subjects who do not understand English participate in the research: Yes <u>No</u></p> <p>If yes, please provide the following information:</p> <p>a. Describe your resources to communicate with the subjects:</p> <p>b. Into what language(s) will the consent form be translated:</p>								
<p>7. Additional Subject Concerns:</p> <p>Are there cultural attitudes/beliefs that may affect subjects in this study? <u>Yes</u> No</p> <p>If yes, please describe attitudes and how they may affect subjects. Cultural dance activity will be used to collect data. It is possible that some may be sensitive to using culture dance to collect data. Only volunteers willing to dance for data collection will be involved.</p>								
<p>8. Dissemination of Research Findings:</p> <p>a. Will the research be published? <u>Yes</u> No If yes, where if known? Peer reviewed journal</p> <p>b. Will the research be presented? <u>Yes</u> No If yes, where if known? Regional and National conferences</p>								
<p>9. External Function:</p> <p>Are you seeking external funding? Yes <u>No</u></p> <p>If yes, please provide the following information:</p> <p>a. What agency?</p> <p>b. Have you received funding? Yes No If yes, dollar amount?</p>								
<p>10. Method of Recruitment (check all that apply):</p> <table> <tr> <td><input checked="" type="checkbox"/> Flyer</td> <td><input checked="" type="checkbox"/> Third Party</td> </tr> <tr> <td><input checked="" type="checkbox"/> Classroom Announcement</td> <td><input checked="" type="checkbox"/> Random</td> </tr> <tr> <td><input type="checkbox"/> Letter to Subject</td> <td><input checked="" type="checkbox"/> Other</td> </tr> </table>	<input checked="" type="checkbox"/> Flyer	<input checked="" type="checkbox"/> Third Party	<input checked="" type="checkbox"/> Classroom Announcement	<input checked="" type="checkbox"/> Random	<input type="checkbox"/> Letter to Subject	<input checked="" type="checkbox"/> Other		
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<input type="checkbox"/> Letter to Subject	<input checked="" type="checkbox"/> Other							

Part B: Research Study Synopsis (continued)

<p>11. Payment to Subject: Will the subject be compensated for participation? Yes <u>No</u> If yes, please provide the following information:</p> <p>a. Amount:</p> <p>b. Form of Payment:</p> <table style="width: 100%; border: none;"> <tr> <td style="width: 33%;"><input type="checkbox"/> Cash</td> <td style="width: 33%;"><input type="checkbox"/> Check</td> <td style="width: 33%;"><input type="checkbox"/> Gift Certificate</td> </tr> <tr> <td><input type="checkbox"/> Voucher</td> <td><input type="checkbox"/> 1099</td> <td><input type="checkbox"/> Other</td> </tr> </table> <p>c. Will payment be prorated? Yes No If yes, please explain:</p> <p>d. When will the subjects be paid?</p> <table style="width: 100%; border: none;"> <tr> <td style="width: 33%;"><input type="checkbox"/> Each Visit</td> <td style="width: 33%;"><input type="checkbox"/> Study Completion</td> <td style="width: 33%;"><input type="checkbox"/> Other</td> </tr> </table>	<input type="checkbox"/> Cash	<input type="checkbox"/> Check	<input type="checkbox"/> Gift Certificate	<input type="checkbox"/> Voucher	<input type="checkbox"/> 1099	<input type="checkbox"/> Other	<input type="checkbox"/> Each Visit	<input type="checkbox"/> Study Completion	<input type="checkbox"/> Other
<input type="checkbox"/> Cash	<input type="checkbox"/> Check	<input type="checkbox"/> Gift Certificate							
<input type="checkbox"/> Voucher	<input type="checkbox"/> 1099	<input type="checkbox"/> Other							
<input type="checkbox"/> Each Visit	<input type="checkbox"/> Study Completion	<input type="checkbox"/> Other							
<p>12. Extra Credit: Will subjects be offered extra credit? Yes <u>No</u> If yes, describe the alternative:</p>									
<p>13. Risks: Identify all potential risks/discomforts to subjects. No more than minimal risk/discomfort. The risks involved for participating in this study may include mild discomfort during and after dance. These discomforts may include shortness of breath, tired or sore legs, but these discomforts are common for anyone who participates in moderate intensity exercise. The participants may also feel slight discomfort while wearing the equipment (head strap and face mask, back pack with Oxycon Mobile sensors and heart rate monitor), but these discomforts are mostly due to the novelty of wearing this type of equipment during exercise. All attempts will be made to ensure that participants are comfortable with wearing the measurement equipment before any testing occurs.</p>									
<p>14. Benefits:</p> <p>a. Are there direct benefits to participants? Yes <u>No</u> If yes, please list them.</p> <p>b. Are there potential benefits to society? <u>Yes</u> If yes, please list them?</p> <p>c. Increased information on whether Polynesian dance is an effective form of cardiorespiratory exercise.</p>									

Part B: Research Study Synopsis (continued)

15. Study Procedures:

- a. What will be the duration of the subjects' participation? 60-90 minutes
- b. Will the subjects be followed after their participation ends? Yes | No
If yes, please describe?
- c. Describe the number, duration and nature of visits/encounters?
2 visits. Visit 1: 60-90 minutes. Each subject will be screened for participation by completing a Physical Activity Readiness Questionnaire (PARQ). Next, participants will complete a second brief demographic questionnaire, be measured for height and weight, and be fit for the equipment. Visit 2: Body composition test 15-30 minutes.
- d. Which of the following describe the study? Therapeutic
 Non-therapeutic
- e. List all procedures that will be performed to generate data for the research. A questionnaire will include gender, ethnicity, date of birth, and dance experience. Other data will include accelerometer data (wrist, ankle, and hip monitors), oxygen uptake, CO₂ output, heart rate. Blood lactate measurements will be taken after dancing using a finger prick.
- f. List all procedures/questionnaires done solely for the purpose of the research study.
PARQ. Questionnaire for gender, ethnicity, date of birth, dance experience. Accelerometer data, oxygen uptake, CO₂ output, heart rate. Blood lactate measurements will be taken after dancing using a finger prick.
- g. List all procedures/questionnaires participants already do regardless of research.

16. Informed Consent:

Are you requesting Waiver or Alteration of Informed Consent? Yes | No

If yes, please provide the following information:

- a. Fill out and attach the waiver of informed consent.
- b. Briefly describe your process to obtain consent:
All subjects will be asked to read the informed consent form. Prior to signing the informed consent form, all subjects will receive verbal explanation. Prior to participation, written consent will be obtained.

Part B: Research Study Synopsis (continued)

17. Confidentiality:

- a. Are the subjects' social security numbers, BYUH ID numbers or any identifiers (other than study numbers and initials) being sent off site?

Yes | No

If yes, describe and explain reasons.

- b. Will any entity other than the investigative staff have access to medical, health or psychological information about the subject? Yes | No

If yes, please indicate who?

- c. Briefly describe provisions made to maintain confidentiality of data, including who will have access to raw data, what will be done with the tapes, etc.

Data will be filed in a locked cabinet in Joel Reece's office with access to him and primary researchers only. At the time of participation subjects will be given a subject number to identify any data linked with them. Any students involved will only have access to data with an identifying subject number.

Any additional data will be stored on the Viasys metabolic system computer software; this software is accessible by password only.

Will the raw data be made available to anyone other the PI and immediate study personnel? Yes | No

If yes, describe the procedure for sharing data. Include with whom it will be shared, how and why.

If data is published and peers would like to do follow-up studies. Raw data may be sent, but no identifying names will be given, only subject numbers.

Part C:

The attached investigation involves the use of human subjects. I understand the university's policy concerning research involving human subjects and I agree:

1. To obtain voluntary and informed consent of subjects who are to participate in this project.
2. To report to the IRB any unanticipated effects on subjects which become apparent during the course of, or as a result of, the experimentation and the action taken.
3. To cooperate with members of the committee charged with continuing review of this subject

4. To obtain prior approval from the committee before amending or altering the scope of the project or implementing changes in the approved consent document.
5. To maintain the documentation of consent forms and progress reports as required by institutional policy.
6. To safeguard the confidentiality of research subjects and the data collected when the approved level of research requires it.

Signature* of the Principal Investigator: Joel Reece
Date: 10/7/15

Faculty Sponsor Signature Necessary for All Student Submissions

"I have read and reviewed this proposal and certify that it is ready for review by the IRB Board. I have worked with the student to prepare this research protocol. I agree to mentor the student during the research project."

Committee Chair/Faculty Sponsor (Please sign and print):

Thesis/Dissertation – Date of Approval by the Proposal Review Committee:

If submitting by email, please check this box to verify that you are the PI listed on this application and agree to follow the items listed above.

Part D: Synopsis of the Proposal

Part D, 1-9, should only be 5 pages or less (not including instruments, consent forms, etc.). Please use 12pt font, page numbers and the headings noted below.

1. Specific Aims

- 1) Determine the average metabolic cost of Polynesian dance using 6 different cultures (i.e., Hawaiian, Tongan, Fijian, Samoan, Mauri, Tahitian).
- 2) Determine the average metabolic cost for each type of Polynesian dance and if there are metabolic differences among cultural dances.
- 3) Determine the specific metabolic cost of different dances for each cultural Polynesian dance where applicable and if there are metabolic differences among dances.
- 4) Determine if there is a metabolic cost difference between males and females while performing their respective cultural dances.
- 5) Collect electronic activity monitor data at the wrists, ankles, and the hip, for use

in predicting the metabolic rate during Polynesian dance for future dance studies.

2. Hypothesis

It is hypothesized that Polynesian dance will have a similar metabolic cost across cultures.

3. Background and Significance

The popularity of dance is growing (2, 9, 16, 18), along with the knowledge of its potential health benefits (3-6, 10, 12-14, 17). This popularity can be seen in elite levels, such as Dance Sport being considered as an addition to the summer Olympic Games (18) and at the beginner level in the streets (9). According to Bauknecht (2), ballroom dancing has been revived in America with such shows as, *So You Think You Can Dance* on Fox and *Dancing with the Stars* on ABC. Health benefits from dance have included increased bone density (13), fitness (3, 5, 10, 12), happiness (4), and psychological wellbeing (14). With this increasing interest around dance it is important to evaluate metabolic demands of dance to determine potential health benefits associated with unique types of dance.

Metabolic demands for dance have previously been evaluated in general dance, ballroom dance, Anishinaabe Jingle dance, and Caribbean dance (1). The metabolic cost of dance has a wide range depending on the type of dance. For example, slow ballroom dance (e.g., foxtrot) is measured at 3.0 metabolic equivalent tasks (METs) compared to 11.3 METs in competitive ballroom dance. With the wide variability of intensities in dance, it is important to understand the metabolic cost of various cultural Polynesian dance. By understanding the metabolic cost of Polynesian dance, potential health benefits and appropriate training programs for performers can be identified. For example, besides potentially improving dance performance, knowing the metabolic cost of dance may encourage healthier behavior change to decrease sedentary time, increase physical activity with dance, and lead to a decrease of disease in areas where Polynesian dance can be practiced.

4. Description of Subjects

Approximately 75 volunteer participants (18 years and older) that are experienced in performing at least one cultural routine to music from the *Breath of Life* Ha show at the Polynesian Cultural Center will be recruited. Prior to participation, dancers will complete a physical activity readiness questionnaire (PAR-Q) to screen for contraindications to moderate-to-vigorous exercise, as well as sign a consent form. A questionnaire evaluating dance experience, demographic statistics, and perceived functional ability will be completed.

5. Confidentiality

All participants will be assigned a subject ID number. Only consent forms will include the names of participants. All other data will be kept in a locked filing cabinet or password protected software.

6. Method or Procedures

All data will be collected on the campus of BYU-Hawaii in the ballroom dance hall with hardwood flooring. Prior to dancing, ethnicity, height, age, gender, and weight will be recorded. Each participant will then be fitted for two types of measurement devices: 1) Portable metabolic measurement system (Oxycon Mobile), and 2) five electronic physical activity monitors (Actical).

Metabolic System: The Oxycon Mobile has been validated through concurrent studies with the Douglas bag method. It is commonly accepted that the Douglas bag method is the gold standard for obtaining accurate oxygen consumption (11). The Oxycon Mobile has been tested against the Douglas Bag method in studies such as Hans Rosdahl (15). The study indicates that with the Oxycon Mobile oxygen uptake is obtained through breath-by-breath analysis and can be determined with a high degree of validity. The portable metabolic system is worn on a vest with two analyzers mounted to the back of the vest. A mask with straps fastening it around the head is also worn with a sample tube attached to the analyzers.

Physical Activity Monitors: The Actical is an accelerometry-based physical activity monitor that can be worn on the wrist, ankle, or hip of the participant to quantify body movement. The Actical is very small (the size a small wrist watch) and light weight (<20 grams), and has been validated for use in predicting the energy cost of many activities (including total daily energy expenditure). However, the Actical has never been validated for predicting the energy cost of Polynesian dance. Use of the Acticals in this study will allow us to evaluate the energy cost of Polynesian dance in the future with the need for the portable metabolic system.

After fitting the participant with these devices, participants will sit quietly for 5 minutes to measure sitting resting metabolic rate. Next, the participants will spend another 5 minutes engaging in self-directed warmup activities that may include walking around dance hall, flexibility exercises, as well as dancing. Next, the first piece of dance music will begin and the participant, along with up to 2 other research participants, will begin the first dance routine (as a group or individually depending on participants). After 5 minutes of continuous dancing, the music will stop and the participants will be instructed to sit on a chair for another 5 minutes. The participants will then repeat this process (i.e., 5 minutes of dance followed by 5 minutes of quiet sitting) for as many cultural dances as they know. Participants who cannot dance to a

specific culture dance will continue to sit until the beginning of the next culture they are familiar with. If no other culture dances are known, participants can be dismissed or can wait until all the routines are completed. Finally, immediately following each 5-minute dance routine, a fingertip blood sample will be drawn for lactate analysis using standard sampling methodology. In combination with measures of oxygen uptake and heart rate, measures of blood lactate are used to characterize the intensity of the dance exercise.

Dance Routine: Each cultural dance routine is made up of dance moves from a specific culture. While a typical dance routine lasts between 3 and 5 minutes, all dance routines in this study will last 5 minutes to ensure that all the physiological measures of interest (e.g., oxygen uptake, heart rate, blood lactate) achieve a physiological plateau. The music played for each dance routine will be played to the Breath of Life show to ensure a consistent tempo.

Body Composition: Subjects will be asked to complete a body composition test using the Bodpod, within 2 weeks of dance testing. This is a noninvasive measurement using air displacement lasting approximately 15 minutes. Standard protocol of not eating or exercising 2 hours prior to testing will be followed.

7. Data Analysis

Descriptive statistics of height, age, weight, and BMI will be presented by gender. Descriptive statistics of metabolic costs for each cultural dance routine and type of dance within cultural routine will also be presented by gender. Repeated measures ANOVA will be employed to determine if differences in metabolic cost exist among cultural dance routines with follow-up post hoc tests when necessary. Independent sample t-Tests will be employed to determine if differences exist between males and females for each cultural dance routine. Reliability of Actical measurements compared to the Oxycon Mobile measurements will be determined with regression analysis. Finally, standard step-forward multiple regression procedures will be used to determine the best prediction of dance energy cost using the Actical monitors.

8. Risks

This study will have no more than minimal risk. To ensure this, participants will all be screened with a physical activity readiness questionnaire and be accustomed to the cultural dance they will perform.

9. Benefits

Benefits of the study will be increased knowledge of the cardiovascular benefits of Polynesian dance.

10. Compensation

No compensation will be given by the researchers for participating in this study.

11. References

1. Ainsworth, Barbara E., et al. "2011 Compendium of Physical Activities: a second update of codes and MET values." *Medicine and science in sports and exercise* 43.8 (2011): 1575-1581.
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15. Rosdahl, H., Lindberg, T., Edin, F., & Nilsson, J. The Moxus Modular metabolic system evaluated with two sensors for ventilation against the Douglas bag method.

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17. Ward, S. Health and the power of dance. *Journal of Physical Education, Recreation & Dance*, 79(4), 33 (2008).
18. World Dance Sport Federation. The aspirations. Retrieved August 8, 2015 https://www.worlddancesport.org/About/Olympic/The_Aspirations.
19. Qualifications
20. Four qualified professionals with experience in energy expenditure, dance, physical activity, body composition, and accelerometry.

Include the following information as necessary in the appropriate appendix.

Appendix I – Consent Document

Appendix II – Questionnaires, Surveys, Instruments, Interview question, etc.

Appendix I

Consent to be a Research Subject for the Polynesian Dance Study

Introduction

This research study is being conducted by Dr. Joel Reece (BYUH), Dr. Eli Lankford (BYUI), Dr. Daniel Heil (Montana State University), and Wei Zhu (Montana State University) at Brigham Young University – Hawaii to determine the metabolic demands of dance from 6 different Polynesian cultures. You were selected to participate because you are abilities in Polynesian dances.

Procedures

You will be asked to participate for 60-90 minutes. First you will be screened for participation by completing a Physical Activity Readiness Questionnaire (PARQ). Next you will complete a second brief demographic questionnaire, be measured for height and weight, and be fit for the equipment.

The questionnaire will include gender, ethnicity, date of birth, dance experience, and perceived functional ability. Other data will include accelerometer data (wrist, ankle, and hip monitors), oxygen uptake, CO₂ output, heart rate. Blood lactate measurements will be taken after dancing using a finger prick. Within two weeks after testing you will be asked to complete a body composition test.

Risks/ Discomforts

There are no more than minimal risks for participation in this study. However, you may feel physical discomfort from the finger prick to measure blood lactate and/or performing the dances.

Benefits

There are no direct benefits to subjects. However, it is hoped that through your participation researchers will learn more about the metabolism that occurs during Polynesian dancing.

Confidentiality

All information provided will remain confidential and will only be reported as group data with no identifying information. All data will be kept in a locked storage cabinet or password protected and only those directly involved with the research will have access to them. The results of this study will likely be published, but no identifying variables of individual participants will be released.

Compensation

No compensation for participation will be awarded.

Participation

Participation in this research study is voluntary. You have the right to withdraw at any time or refuse to participate entirely at any time.

Questions about the Research

If you have questions regarding this study, you may contact Dr. Joel Reece at (808)-675-3353 or Joel.reece@byuh.edu.

Question about your Rights as Research Participants

If you have questions you do not feel comfortable asking the researcher, you may contact Dr. Boyd Timothy, IRB Chair, (808) 675-3931, boyd.timothy@byuh.edu

I have read, understood, and received a copy of the above consent and desire of my own free will and volition to participate in this study.

Signature: _____

Date: _____

Appendix II

Questionnaires

Subject ID: _____

Sex		
Birth Date		
Height		
Weight		
Ethnicity		
Dances to perform:		
Fijian	Tongan	Samoan
Hawaiian	Mauri	Tahitian
Dance Experience:		
Beginner	Intermediate	Expert
How many months have you performed Polynesian dance?		

Perceived Functional Ability (PFA)

Suppose you were going to exercise continuously on an indoor track for 1 mile. Which exercise pace is just right for you –not too easy and not too hard?

1. Walking at a slow pace (18 minutes per mile or more)
2. Walking at a slow pace (17-18 minutes per mile)
3. Walking at a medium pace (16-17 minutes per mile)
4. Walking at a medium pace (15-16 minutes per mile)
5. Walking at a fast pace (14-15 minutes per mile)
6. Walking at a fast pace (13-14 minutes per mile)
7. Jogging at a slow pace (12-13 minutes per mile)
8. Jogging at a slow pace (11-12 minutes per mile)
9. Jogging at a medium pace (10-11 minutes per mile)
10. Jogging at a medium pace (9-10 minutes per mile)
11. Jogging at a fast pace (8-9 minutes per mile)
12. Jogging at a fast pace (7-8 minutes per mile)
13. Running at a fast pace (7 minutes per mile or less)

How fast could you cover a distance of 3 miles and NOT become breathless or overly fatigued? Be realistic

1. I could walk the entire distance at a slow pace (18 minutes per mile or more)
2. I could walk the entire distance at a slow pace (17-18 minutes per mile)
3. I could walk the entire distance at a medium pace (16-17 minutes per mile)
4. I could walk the entire distance at a medium pace (15-16 minutes per mile)

5. I could walk the entire distance at a fast pace (14-15 minutes per mile)
6. I could walk the entire distance at a fast pace (13-14 minutes per mile)
7. I could jog the entire distance at a slow pace (12-13 minutes per mile)
8. I could jog the entire distance at a slow pace (11-12 minutes per mile)
9. I could jog the entire distance at a medium pace (10-11 minutes per mile)
10. I could jog the entire distance at a medium pace (9-10 minutes per mile)
11. I could jog the entire distance at a fast pace (8-9 minutes per mile)
12. I could jog the entire distance at a fast pace (7-8 minutes per mile)
13. I could run the entire distance at a fast pace (7 minutes per mile or less)

(George, J.D. et al. Non-exercise VO_{2MAX} estimation for physically active college students. *Medicine and Science in Sports and Exercise*. 29, 415-423, 1997)

PHYSICAL ACTIVITY READINESS QUESTIONNAIRE (PAR-Q)

Name: _____ Date: _____

PAR-Q is designed to help you help yourself. Many health benefits are associated with regular exercise, and the completion of PAR-Q is a sensible first step to take if you are planning to increase the amount of physical activity in your life.

For most people, physical activity should not pose any problem or hazard. PAR-Q has been designed to identify the small number of adults for whom physical activity might be inappropriate or those who should have medical advice concerning the type of activity most suitable for them.

Common sense is your best guide in answering these few questions. Please read them carefully and check the YES or NO opposite the question if it applies to you.

- | YES | NO | |
|--------------------------|--------------------------|--|
| <input type="checkbox"/> | <input type="checkbox"/> | 1. Has the doctor ever said you have heart trouble? |
| <input type="checkbox"/> | <input type="checkbox"/> | 2. Do you frequently have pains in your heart and chest? |
| <input type="checkbox"/> | <input type="checkbox"/> | 3. Do you often feel faint or have spells of severe dizziness? |
| <input type="checkbox"/> | <input type="checkbox"/> | 4. Has a doctor ever said your blood pressure was too high? |
| <input type="checkbox"/> | <input type="checkbox"/> | 5. Has your doctor ever told you that you have a bone or joint problem such as arthritis that has been aggravated by exercise, or might be made worse with exercise? |
| <input type="checkbox"/> | <input type="checkbox"/> | 6. Is there a good physical reason not mentioned here why you should not follow an activity program even if you wanted to? |
| <input type="checkbox"/> | <input type="checkbox"/> | 7. Are you over age 65 and not accustomed to vigorous exercise? |

If you answered "YES" to one or more questions...

If you have not recently done so, consult with your personal physician by telephone or in person BEFORE increasing your physical activity and/or taking a fitness test. Tell him/her what questions you answered YES to on PAR-Q, or show your doctor your copy of this form.

If you answered "NO" to one or more questions...

You have a reasonable assurance of your present suitability for a graduated exercise program or an exercise test.

NOTE: Postpone exercise testing if you suffer from minor illness such as a common cold.

Signature: _____ Date: _____



BRIGHAM YOUNG UNIVERSITY- HAWAII

Institutional Review Board

MEMORANDUM

Application Approval Notification

TO: Joel Reece

FROM: Boyd Timothy, IRB Chair
Brigham Young University – Hawaii
808-675-3931
boyd.timothy@byuh.edu

SUBJECT: IRB Application Number: # (15-11)
The Polynesian Dance Study

Approval Date: October 9, 2015

Expiration Date: October 8, 2016

Application Type: New

Research Type: Non-exempt

Application Review Type: Expedited

The Institutional Review Board (IRB) of Brigham Young University – Hawaii approved your application. The research was approved in accordance with 45 CFR 46 of Federal Policy for the Protection of Human Subjects, and the University's IRB policies and procedures. The IRB approves waiver of signed informed consent as per criteria in 45 CFR 46.116(d). Please reference the IRB application number (above) in any future communication regarding this research.

Recruitment/Consent: For research requiring written informed consent, the IRB-approved and stamped informed consent document is enclosed. The IRB approval expiration date has been stamped on the informed consent document. Please keep copies of the consent forms used for this research for three years after the completion of the research.