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Metabolic Equivalent Determination in the Cultural Dance of Hula

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Abstract

Ethnic minorities share an unequal burden of cardiometabolic syndrome. Physical activity (PA) has been shown as an important factor to improve the health outcomes of these diseases. Metabolic equivalents (METs) have been calculated for diverse activities; however, most cultural activities have not been evaluated. Hula, the traditional dance of Native Hawaiians, is practiced by men and women of all ages but its MET value is unknown. To our knowledge, this is the first scientific evaluation of energy expenditure of hula.

Nineteen competitive hula dancers performed two dance sets of low and high intensity hula. METs were measured with a portable indirect calorimetry device. Mean and standard deviations were calculated for all the variables. A two-way ANOVA was conducted to identify differences for gender and intensity.

The mean MET were 5.7 (range 3.17 – 9.77) and 7.55 (range 4.43 – 12.0) for low intensity and high intensity, respectively. There was a significant difference between intensities and no significant difference between genders.

This study demonstrates the energy expenditure of both low and high intensity hula met the recommended guidelines for moderate and vigorous intensity exercise, respectively and that hula can be utilized as a prescribed PA.

INTRODUCTION

Ethnic minorities in the United States have an unequal burden of the cardiometabolic diseases of diabetes, heart disease, and obesity compared to the general population [10, 12, 22, 24, 25, 27]. It is well established that physical activity (PA) significantly improves health outcomes for these diseases. If culturally-related PA can be quantified as physiologically appropriate, health professionals would have more options to promote exercise, especially PA that could appeal to these at-risk populations. While energy expenditure has been calculated for a wide range of activities, many culturally-based PA have yet to be scientifically evaluated. Ainsworth et al. have compiled the most comprehensive list of activities and metabolic equivalents (MET) [1-3]. Recent updates included a limited number of cultural activities, but many were based on self-reported

exertion levels or unpublished thesis dissertations, and not direct measurements of oxygen uptake [2, 3]. Therefore, the MET values and energy expenditure of culturally-related activities merit further investigation.

A recent review reports that Native Hawaiians (NH) experience among the highest prevalence of cardiometabolic disease in the US [22]. Health improvements could be achieved through increased PA given that Asian, NH and other Pacific Islanders, 64.1% of women and 59.1% of men did not meet recommended levels of PA [8].

Hula, the cultural dance of NH, the indigenous people of Hawai'i, is commonly practiced by men and women of all ages, and is globally known. Ethnic dances are increasingly popular as a PA, paralleling the growth of a multicultural US population [17]. Cultural dancing bonds communities or groups through "traditional practices, cultural transmission, social acceptance, or connectedness." [18, 23] Performance of an advanced dance routine requires complex movements, an expert knowledge of technique and aesthetics, and the physiological capacity to execute the dance to its completeness [20]. While NH may have a natural affinity to hula it is popular with all ethnicities. Hula is performed at family gatherings and school events, and is viewed worldwide through televised and webcast competitions. There are two main forms of hula, the older, *hula kahiko* (Form 1) and the contemporary *hula 'auana* (Form 2). Both forms use the same low impact aerobic lower body movements and foot patterns and similar upper body movements [6, 19]. We sought to establish the physiological requirements of this cultural practice as a form of exercise as part of a study to develop and evaluate a hula-based cardiac rehabilitation intervention [21]. To our knowledge, there has been no scientific evaluation of the energy expenditure of hula.

METHOD

Subjects

Participants were recruited from a Native Hawaiian cultural education school in Hawai'i that specializes in dance and language arts. Participant characteristics for age, height, body mass, BMI, years dancing and years of competitive dancing are shown in Table 1. All 19 participants were adults (18-50 yr) and were free of chronic diseases or conditions that could affect metabolism or daily PA for the past year and were elite dancers who performed in at least one formal hula competition within the past 2 years. All had extensive hula training (2-19 yr) and were able to properly perform both styles of hula continuously for at least 20 minutes. Elite competitive dancers were chosen to standardize the level of dance skill [4, 5, 7, 26, 28].

Before testing, participants completed demographic and a physical functioning questionnaire (Duke Activity Status Index form) to screen for contraindications to participation in the study [16]. Signed consent was obtained and approval for the study was received by an Institutional Review Board for Studies on Human Subjects. Furthermore, the study was performed in accordance with the ethical standards of the International Journal of Sports Medicine [15].

Dance sets

Participants performed a pre-selected set of low intensity and high intensity dances that included traditional and contemporary forms of hula. Intensity level was identified based on tempo and complexity of choreography. Lower intensity dances generally have slower tempo and less complex sequences of foot patterns and movements of the upper body, lower body, and hands. Choreography for men and women were identical. Dance sets of 12-16 minutes in duration were developed for each of the two hula forms and included both high and low intensity dances. In order to establish a steady state of PA, each intensity level of dance was performed for a minimum of six minutes. Dancing was continuous within each set. Commercial or pre-recorded accompanying songs, music or chant was used to accompany the dancing. A portable sound system was used to play the recordings (Bose® SoundDock® Portable digital music system, Bose Corporation, Framingham, Massachusetts).

Metabolic analysis

The Oxycon Mobile system is a portable, wireless metabolic system measuring gas exchange in each breath which has been demonstrated as valid for obtaining metabolic data during exercise [9, 13]. The main components of the system are a sensor box for the gas and flow signals, a data exchange and storage unit, a calibration and receiver unit and a computer. The total mass of the unit attached to the participant is approximately 950 grams or 33.51 ounces, which researchers considered to be negligible and would only minimally hinder the movements of the participants. The Oxycon Mobile system was calibrated in accordance with manufacturer instructions prior to each test.

Experimental design

Each participant reported to the testing location for a 2 hour testing session and was instructed to arrive in a rested, normally hydrated state. Anthropometric data consisting of self-reported height and body mass were collected. Body mass was recorded to the nearest 0.1 pound using a digital scale (Tanita® Model BWB-800A Professional Digital Scale, Tanita, Tokyo, Japan). A heart rate monitor (Polar®, T31 Coded Transmitter, Polar Electro Inc., New York, USA) that transmitted data to the metabolic system was attached to the participants. A portable cardiopulmonary stress test system (OxyCon Mobile® CardioPulmonary Stress Test System, Erich JAEGER, Hoechberg, Germany) was used to collect heart rate (beats/min), VO_2 ($\text{ml}\cdot\text{kg}^{-1}$), respiratory exchange ratio (RER) and energy expenditure (kcal/hour). Ambient temperature level during each session was collected through the same system.

Before beginning the dance set, participants were familiarized with the testing protocol including instruction as to the importance of dancing to their best ability. Every dancer sat in a chair for 10 minutes to establish a resting, baseline heart rate with the OxyCon and face mask attached. Then each dancer completed a 5-10 minute self-directed warm-up of sitting and standing stretches. At the completion of the warm-up, participants performed a dance set of either of the two hula forms in a randomized order. After the dancer completed the first set, they rested in a chair for 20-30 minutes in a sitting position with the face mask removed.

Once their heart rate returned to within 10% of their baseline, the dancer repeated the testing session and performed the other dance set.

METs, VO_2 , heart rate (beats/min), RER and energy expenditure (kcal/hour) values were taken directly from the Oxycon system. The Oxycon system utilized the Weir equation to calculate energy expenditure. Heart rate maximum was calculated based on age [11] and % of heart rate maximum achieved during each dance set and intensity was calculated. Heart rate, percent of heart rate maximum, MET values, VO_2 , RER and energy expenditure were recorded as the mean value during the sixth minute of each of the four conditions to represent a steady state: Low intensity – Form 1, high intensity – Form 1, low intensity – Form 2, and high intensity – Form 2. The mean values for all variables were pooled between dance forms (Form 1 and Form 2) for each intensity (Low and High) during final analysis.

Data analysis

All statistical procedures were completed using SPSS v. 19 (IBM, Armonk, NY). Mean and standard deviations were calculated for all the variables at each intensity level. A two-way repeated measures ANOVA, with gender as the between group variable and intensity level as the within group variable, test was conducted to identify differences for gender and intensity. Normalcy of distribution and homogeneity of variance for the dependent variable were assessed using the Kolmogorov-Smirnov test and Hartley's Fmax test, respectively which were both non-significant. Significance was set at $p < .05$.

Results

Summary statistics for all variables by low and high intensity and by gender are presented in table 2. The mean MET values were 5.7 (range 3.17 – 9.77) and 7.55 (range 4.43 – 12.0) for low intensity and high intensity, respectively. The mean oxygen uptake values were 19.9 $\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ (range 11.07 – 34.40 $\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$) and 26.4 $\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ (range 19.6 – 42.0 $\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$) for low and high intensity hula, respectively. The two-way ANOVA revealed a significant main effect for the repeated measured variable of intensity in METS ($F=5.476$, $p=.025$) but not for gender ($F=.261$, $p=.631$) (Figure 1). There was no significant interaction between gender and intensity in METS ($F=.330$, $p=.570$).

Discussion

The current American College of Sports Medicine (ACSM) and Center for Disease Control (CDC) recommendations for PA and health for adults is 150 minutes of moderate intensity aerobic activity per week or 75 minutes of vigorous activity per week [14]. The study's data on energy expenditure concludes that hula is a valid form of exercise with average MET values for low and high intensity hula meeting the guidelines of moderate intensity (3.0 – 6.0 METs) and vigorous (> 6.0 METs) exercise, respectively [14, 25]. This range of MET and oxygen uptake values are comparable to doubles tennis (7.0), brisk walking (4.0), swimming at a moderate level (8.0), and a basketball game (8.0) which are all well recognized PA [1-3].

The female participants accumulated more years of dancing than their male counterparts. However, this is typically characteristic of hula dancers, where female dancers often begin training at age 5 years, and male dancers usually start in late adolescence or early adulthood. Hula experts agree that participants of this study were of equivalent skill level despite the difference in years of dancing. All dancers had competition experience, which further equalized their ability.

The range of METs was larger in the male participants than in the females. The fewer years of dancing and the larger age distribution for the males decreased their homogeneity which is also reflected in the standard deviation of the MET values. Additionally, two of the male dancers were markedly larger in body mass than the rest of their peers (132.27 and 156.82 kg compared to the rest of the male participants – mean: 97.32 kg; SD: 14.15 kg) with one falling more than two standard deviations above the mean and the other more than three. The larger anthropometric variance of the male dancers was thought to contribute to their greater range of MET values. The female dancers were generally more homogeneous anthropometrically and in terms of skill level than their male counterparts which likely accounted for the greater similarity in MET requirements within females across intensities. The significant difference between low and high intensity hula dances shows that the intensity of hula is modifiable. Physical ability and skill level can also be an important factor when considering this activity for novice, inexperienced dancers. Skilled dancers may be more efficient, but may be capable of reaching higher levels of energy expenditure.

There are some limitations of the current study. The participants were all elite dancers; novice dancers may differ in specific MET levels. However, while the ability of skilled dancers to fully execute hula steps may produce higher oxygen consumption during a given dance compared to novices, the inefficiency of the beginner may also increase the oxygen demand of a given dance performance, compared to an advanced dancer, while still mastering each technique [29]. Additionally, as a dancer improves their skill level, the potential of a graded increase in oxygen consumption is beneficial. This allows for novice dancers to begin dancing at a comfortable pace and increase the intensity over time as they improve their skill and fitness level. Another limitation to the current study is that the fitness level of the dancers before testing was not measured. While fitness level can affect energy expenditure, the elite status of the dancers served as the fitness criteria for participation in the study.

Therefore, the results of this study validate that hula may serve as a legitimate form of exercise for non-elite dancers, although studies on novice dancers are needed. Future studies measuring beginning and advanced dancers should be conducted to determine if there is a significant difference in energy expenditure between these populations.

This study provides important information about the energy expenditure of a culturally important PA for an ethnic population at high risk for chronic conditions that can be improved through increased physical activity. If more culturally relevant PA can be validated as appropriate forms of exercise, then physicians, physical therapists, and other health professionals can prescribe these activities as a means to improve health.

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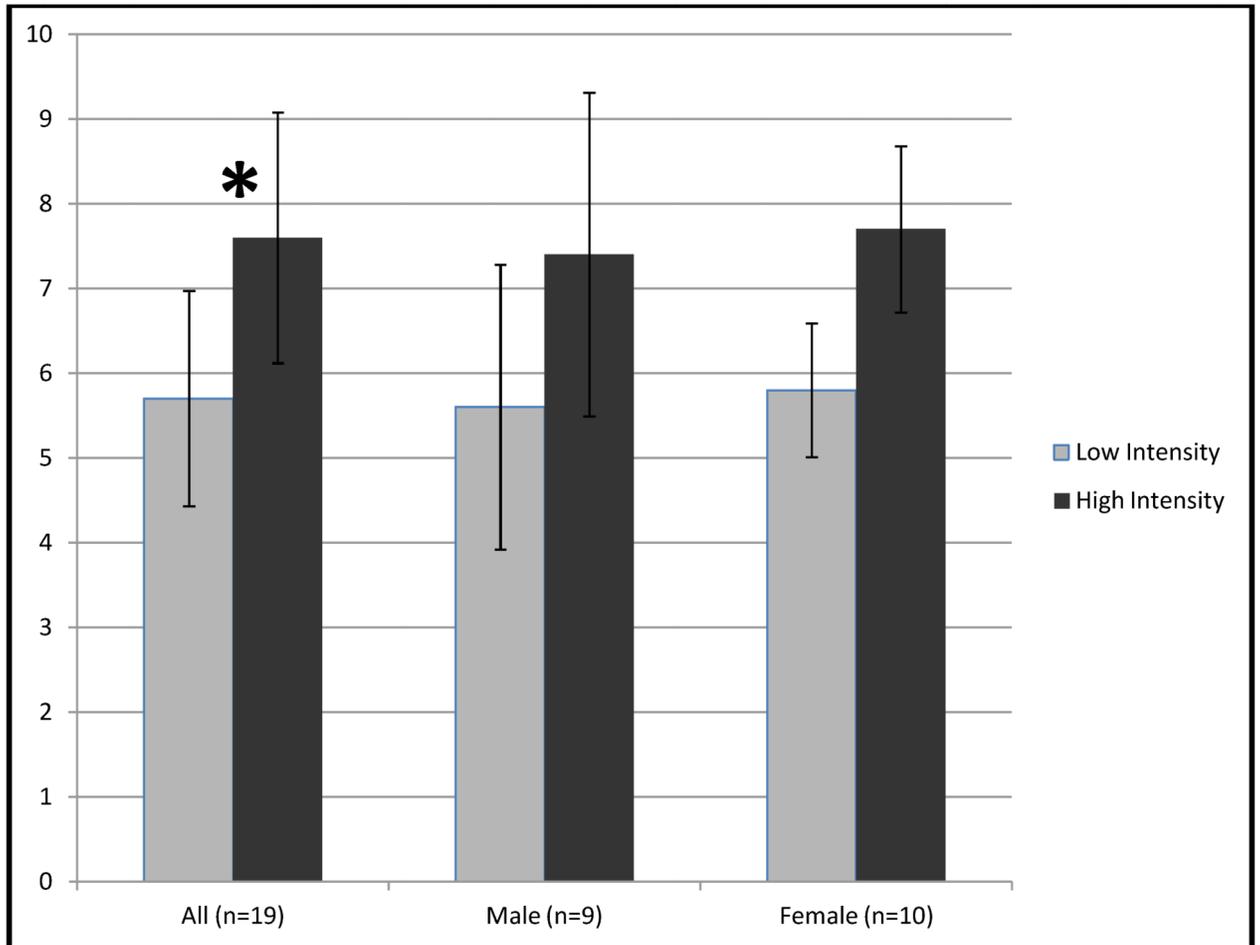


Figure 1. Comparison of MET requirements for high and low intensity hula (mean±SD; * indicates significant difference, p=0.025)

Table 1Descriptive data for participants (mean \pm SD)

Variable	Female (n=10)	Male (n=9)
Age	25.80 \pm 4.80	33.2 \pm 9.10
Height (cm)	164.60 \pm 5.59	169.4 \pm 9.20
Mass (kg)	64.80 \pm 19.04	97.32 \pm 14.15
BMI	23.70 \pm 6.14	30.8 \pm 7.99
Years dancing	19.10 \pm 3.31	3.0 \pm 1.39
Years competitive dancing	10.40 \pm 4.30	2.2 \pm .79

Table 2Metabolic data for participants for high and low intensity hula (mean \pm SD)

	All (n=19)	Male (n=9)	Female (n=10)
Low Intensity			
MET	5.70 \pm 1.27	5.60 \pm 1.68	5.80 \pm .79
HR (beats/min)	147.00 \pm 18.49	137.59 \pm 17.06	155.42 \pm 15.70
% HR max *	79 \pm 9	75 \pm 9	82 \pm 8
RER	.87 \pm .08	.89 \pm .09	.84 \pm .08
Energy expenditure (kcal/hour)	453.60 \pm 137.20	533.30 \pm 133.06	381.80 \pm 96.69
VO ₂ (ml·kg ⁻¹ ·min ⁻¹)	19.90 \pm 4.47	19.70 \pm 5.90	20.20 \pm 2.74
High Intensity			
MET	7.60 \pm 1.48	7.40 \pm 1.91	7.70 \pm .98
HR (beats/min)	170.70 \pm 161.00	160.07 \pm 15.17	180.20 \pm 9.80
% HR max *	92 \pm 8	87 \pm .08	96 \pm 5
RER	.94 \pm .06	.95 \pm .07	.93 \pm .05
Energy expenditure (kcal/hour)	608.00 \pm 158.00	709.93 \pm 145.59	516.30 \pm 104.56
VO ₂ (ml·kg ⁻¹ ·min ⁻¹)	26.40 \pm 5.20	25.80 \pm 6.67	27.00 \pm 3.44

* HRmax calculated as $191.5 - (0.007 \cdot \text{age}^2)$