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The Energy Expenditure of Heavy Metal Drummers

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THE ENERGY EXPENDITURE OF HEAVY METAL DRUMMERS

A Thesis
Presented to
The Faculty of the School of Kinesiology, Recreation, and Sport
Western Kentucky University
Bowling Green, Kentucky

In Partial Fulfillment
Of the Requirements of the Degree
Master of Science

By
Joshua T. Brown

August 2016

THE ENERGY EXPENDITURE OF HEAVY METAL DRUMMERS

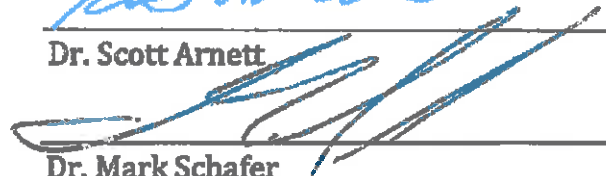
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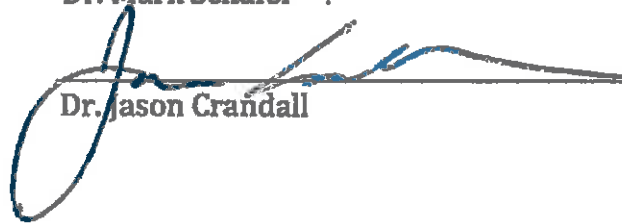
Dr. Gina Cabrero, Chair of Thesis



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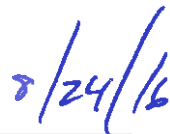
Dr. Mark Schafer



Dr. Jason Crandall



Dean, Graduate School



Date

DEDICATION

I dedicate this work to Lars Ulrich, the drummer for the monster, better known as Metallica. Without him and Metallica, I wouldn't have the exciting life I have today. Thank you for the inspiration and the great songs I have been banging my head to for almost two decades!

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Lastly, and certainly not least, I would like to thank my Mom and Dad for their constant support throughout my entire life. Everything I have done and continue to do is for you and is made possible by you.

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22 Pages

Directed by: Gina Sobrero, Jason Crandall, Scott Arnett, and Mark Schafer

School of Kinesiology, Recreation, and Sport

Western Kentucky University

The purpose of this investigation is to examine the energy demand of heavy metal drummers during rehearsal in order to understand the physiological responses. This information may lead to a better understanding of energy expenditure and add to the compendium of physical activity.

The investigation consisted of eight apparently healthy 20 to 37-year-old males were recruited for this investigation. Information gathered during the drum test was average VO_2 , VO_{2peak} , HR in beats per minute (bpm), metabolic equivalents (METs), and energy expenditure (EE) expressed in calories (kcal) per minute and per hour. Rating of perceived exertion (RPE) was used in addition to VO_2 and HR values to assess physical demand. The Bruce Protocol maximal treadmill test was administered to compare the participants VO_{2max} to their VO_{2peak} while drumming.

The EE during the 40-minute drum test was 387.05 ± 83 kcal with an estimated hourly EE of 567.33 ± 111.7 kcal. VO_2 , VO_{2peak} , V_E , and HR was 21.4 ± 4.1 ml/kg/min, 33.9 ± 8.1 ml/kg/min, 63.5 ± 19 L/min, and 150.4 ± 13.6 bpm respectively. The average MET level reached was six. RPE was 13.8 ± 1.2 and is expressed as “somewhat hard” in difficulty according to the ACSM. Those categorized as having an average level of fitness reached 50-59% of their VO_{2max} while the two individuals categorized as having an excellent level of fitness reached 42-45% of their VO_{2max} .

In conclusion, heavy metal drumming is a form of physical activity that is of moderate intensity and can be compared to other forms of recreational and work related physical activity.

Chapter 1

Introduction

Physical activity (PA) is defined as any bodily movement produced by skeletal muscles that will result in energy expenditure (Caspersen, Powell, and Christenson, 1985). The national average for regular PA is 51.6% with people of all ages not meeting the guidelines for aerobic and strength training. It is reported that one in three children are physically inactive and spend seven and a half hours daily being sedentary (Gallups-Healthways Wellbeing Index, 2013). Because the percentage of people participating in traditional forms (ex. walking, running, resistance training, etc. of PA) is low, investigating non-traditional methods of PA may be warranted. The purpose of measuring non-traditional PA is that it can contribute to the compendium of PA and be used to properly prescribe exercise for recreation, health, weight management, or rehabilitation (Ainsworth et al. 2011). Some examples of non-traditional PA research is Sell, Clocksin, Spierer, Ghigiarelli's, (2011) investigation that compared the energy expenditure of prusik climbing to Nintendo Wii Boxing and walking. Other examples include measuring the energy expenditure during household and garden tasks (Gunn et al. 2001), the energy expenditure of recreational ballroom dance (Lankford et al. 2014), or the energy expenditure of different types of video games (Lyons et al. 2012).

One non-traditional PA that has been measured and recently categorized as a moderate to vigorous PA is drumming. As drumming is considered to be physically demanding, understanding the metabolic demand and possible health benefits can

add to the compendium of PA research and be used by health care professionals, researchers, and the public.

Heavy metal drumming (HMD) is a style of percussion that involves full body intermittent activity that is done while seated. The musician plays a drum set consisting of two bass drums operated with the feet. The snare, tom toms, and cymbals are played with hand-held sticks. The use of the kick drums is a defining characteristic of the HMD sound and are used to play beats, accents, and syncopate with patterns played by other instrumentalists. These rhythms are performed at high tempos and require a speed and endurance that can be metabolically demanding. As HMD and other styles of drumming can be moderate to vigorous in intensity, drumming may be a mode of PA for individuals to improve and maintain health.

The first reported study of drumming and its energy demands was in the 1920's when German researchers measured the energy cost of orchestral percussionists (Da Le Rue, Draper, Potter, & Smith, 2013). Investigators measured the energy expenditure of one 58 and one 65-year-old male orchestral percussionists via indirect calorimetry. The researchers found that the 58-year-old participant burned .0004 kcals/min and the 65 year old burned approximately .0042 kcals/min (Passmore & Durnin, 1955). The level of intensity of the orchestral drummers' PA expressed in metabolic equivalents (METs) was less than 3.0-6.0 (Passmore & Durnin, 1955). Therefore, orchestral drumming would not be considered moderate intensity and is not comparable to the possible metabolic demand of a heavy metal drummer. In addition, the two orchestral percussionists

played with only the limbs of the upper body and were much older than average heavy metal drummers. As such, these results cannot be generalized to modern rock/pop or HMD musicians.

Additional studies involving energy expenditure of drumming are not found in the literature again until 2008. Smith, Burke, Draper, and Potter (2008) analyzed the energy cost of rock drumming with a single participant. The participant's energy expenditure was measured during both an incremental drumming test and a live performance test. Energy cost during the test was measured using maximal oxygen uptake (VO_{2max}), respiratory exchange ratio (RER), and maximal heart rate (MHR) via portable metabolic analyzer. The participant played four 4-min stages with a fifth stage to volitional exhaustion. For each stage during the incremental test, the drummer chose what to play for the allotted time. During the live performance (82 min. 27 s), energy expenditure was estimated using a portable heart rate monitor. Immediately following the performance, blood was drawn to assess lactate levels. During the test, the participant's peak heart rate reached 191 beats per minute (bpm) and VO_{2peak} reached 2.02 L/min (24.2 ml/kg/min). The concert performance elicited an average heart rate of 145 ± 13 bpm (range 110-179 bpm), peak blood lactate value of 3.6 mmol, and average energy expenditure of 412 kcal/hour and 0.082 kcal/min. Researchers concluded that rock drumming was a form of intermittent full body PA, utilizing both the aerobic and anaerobic energy systems.

This preliminary research contained various methods of estimating energy expenditure. During the incremental test, energy expenditure was measured with a portable metabolic analyzer, while the live performance test only utilized a heart

rate monitor (Montgomery, Green, Etxebarria, Pyne, Saunders, & Minahan, 2009). As researchers have found that HR monitors alone tend to underestimate VO_2 and energy expenditure, it is possible that the calories burned during the performance may have been higher than reported.

De La Rue et al. (2013) observed 14 professional and semi-professional rock drummers. Similar to the previous case study, this investigation had both an incremental drumming test (laboratory test) and a live performance test. During the test, participants' energy cost was measured with a portable metabolic analyzer that reported VO_{2max} , RER, and MHR. Participants played a four bar sequence made up of a selected rhythm played for three measures, followed by a selected fill played for one measure. During the live performance, energy expenditure was measured with heart rate values. Unlike the previous study, blood lactate levels were assessed following the incremental drumming test as opposed to the live performance test. During the incremental drumming test, HR reached 178 ± 17 bpm with a VO_{2peak} of 35.6 ± 5.7 ml/kg/min. Lactate levels averaged 3.7 ± 1.5 mmol. The live performance test produced a peak heart rate of 186 ± 16 bpm and an average heart rate of 166 ± 19 bpm. Energy expenditure of the live performance was found to be 0.203 ± 0.121 kcals/min (range 0.041-0.423 kcal/min.) with a mean energy expenditure of 623 ± 168 kcals/hour. The VO_{2max} , HR, and blood lactate values for the incremental drumming test and the HR values for the live performance test were higher than the results of Smith and colleagues (2008). De La Rue et al. (2013) found that the mean value of energy expenditure was more than double that of the previous literature and would be characterized by the American College of Sports Medicine (ACSM) as a

hard/vigorous physical activity. This activity, therefore, can be compared to the metabolic demand of other intermittent exercises such as interval cycling, hockey, and volleyball (De La Rue et al. 2013).

The energy cost of HMD was not measured until 2014 (Romero, 2014). Unlike the previous rock drumming studies (De La Rue et al. 2013; Smith et al. 2008), Romero (2014) measured the energy cost of four HMD drummers in the lab while performing four songs selected by the researcher and four songs chosen by the participant. In addition to the drumming test, each participant had submaximal and maximal VO_2 measured. Energy expenditure for all testing was measured using a stationary metabolic cart. Romero (2014) concluded that heavy metal drumming is an activity that is done at 6 METs or higher and can therefore be classified as a vigorous activity. This appears to be the only peer reviewed study measuring the metabolic demand of heavy metal drummers. As the means of measuring energy expenditure was a stationary metabolic cart instead of a portable metabolic analyzer that is worn by the individual, the participants' ability to move freely may have been restricted. This restriction could have resulted in extra effort by the drummer to keep the upper body stable, thus compromising performance and increasing energy demand. In addition, participants were only tested in the lab setting and were not tested with the external influence of a live audience and other distractions that can occur at a live concert.

Another avenue of research involving the physiological responses of musicians is exploring the difference between the rehearsal setting and the live concert setting as opposed to comparing a lab test to a concert test. Mulcahy and

colleagues (1990) measured 48 orchestral musicians with ages ranging from 22-59. Instruments played included the tympani, organ, tuba, oboe, horn, bassoon, clarinet, trombone, trumpet, flute, double bass, cello, viola, and violin. During both the rehearsal and concert setting, participants wore electrocardiograms that measured cardiac activity. The concert setting yielded maximal heart rate values of 97.7 bpm, compared to 91.1 bpm seen in the rehearsal venue. Based off of the HR values observed, these results suggest that the energy demands of a concert setting may be greater than the rehearsal setting.

Inesta et al. (2008) also measured the energy demands of the rehearsal compared to the concert setting in musicians. This study consisted of 62 orchestral musicians with an age range of 15 to 71 years who were grouped according to type of instrument played. The instruments included strings, winds, piano, and percussion. Each musician wore a HR monitor during rehearsals and concerts that were both one hour in length. During the live concert setting, musicians reached average HR values that were 76.8% of their MHR value. The researchers reported that the HR values during the concert were significantly higher than the values for the rehearsal setting, and suggest that cardiac demand of musicians may be higher than what has been previously reported by Mulcahy et al. (1990).

As drumming is a physical activity, the use of drumming as a means to improve health and manage stress has also been measured. Smith, Viljoen, and McGeachie, (2014) measured African drumming. This style of drumming is different than the styles previously mentioned in that the drummer does not use a drum set but a single drum that rests between the person's legs and is played by the hands.

For this investigation, two populations were measured and compared. A group of young adults who were inexperienced players (average age 23.4 ± 3.3 years; $n=17$, 13 females and four males) and a group of older adults that were experienced players (average age 53.1 years, $n=17$, 12 women and five men). All participants regularly engaged in physical activity. The drumming intervention consisted of a 40-minute instructor led drum circle that began with a low-intensity warm up phase then progressed to a phase of higher intensity, and ended with a low-intensity cool down phase. Prior to the intervention, both groups had blood pressure and blood lactate measurements taken. During the 40-minute intervention, participants wore heart rate monitors to assess the physical demand.

Following the intervention, the older population experienced a more significant decrease in systolic blood pressure (SBP) than the younger population, with no significant alteration in diastolic blood pressure (DBP) in either group. Heart rate values during the intervention indicated that the older population spent 50% of the time at 55-70% of their heart rate max where as the younger participants spent the same amount of time at 45% of their maximal heart rate. Blood lactate values for both groups were well below 4 mmol/l.

After reviewing the literature, it appears that drumming requires a certain degree of aerobic and anaerobic capacity and may be categorized as an intermittent hard-to-vigorous PA. The level of demand, however, differs depending on musical style and environment. Authors in the aforementioned studies have analyzed the energy cost of various percussionists with varying results. Rock/pop drumming, the closest in style to HMD, typically requires the use of one foot to play the bass drum.

HMD requires the use of both feet to play the bass drum(s) and is typically performed at faster tempos, and therefore may require a higher level of aerobic and anaerobic capacity.

Drumming has the potential to be used as a non-conventional mode of physical activity. However, the physical demand that is placed on an individual that participates in HMD is not fully understood. Therefore, the purpose of this investigation is to measure the energy expenditure of heavy metal drummers. This information can add to the compendium of physical activity and be available for professional or recreational use. It is hypothesized that heavy metal drumming will be classified as vigorous physical activity and will elicit a higher metabolic demand than previous rock drumming research.

Chapter 2

Manuscript

Physical activity is defined as any bodily movement that results in energy expenditure (Caspersen, Powell, and Christenson, 1985). Half of adults and adolescents in the United States do not meet the guidelines for regular physical activity. In addition, it is estimated that one in three children spend seven and a half hours being sedentary (Gallups-Healthways Wellbeing Index, 2013). Finding alternative methods of movement, beyond the traditional exercise prescription, may be an effective way to increase weekly physical activity. The reason for studying a non-traditional form of PA is that it can add to the compendium of physical activities and be used by researchers, clinicians, and the public to properly prescribe exercise.

Some examples of non traditional PA research are Determining Energy Expenditure During Some Household and Garden Tasks (Gunn et al. 2002), Energy Expenditure and Enjoyment During Video Game Play: Differences by Game Type (Lyons et al. 2012), The Energy Expenditure of Ballroom Dancing (Lankford et al. 2014), and the Energy Expenditure during Non-Traditional Physical Activities (Sell, Clocksin, Spierer, Ghigiarelli, 2011). One activity that has been recently investigated for this purpose is performing music and its metabolic demand.

Research on this topic dates back to 1920 with the analysis of energy expenditure of orchestral drummers (Da Le Rue, Draper, Potter, & Smith, 2013). However, there is a dearth of research until 2008 and 2013 when the first studies measuring energy expenditure of a drum set percussionist were conducted (Smith, Burke, Draper, & Potter, 2008; De La Rue et al. 2013). Researchers observed energy

expenditure of pop/rock drummers in the laboratory as well as in live concert settings in both of these studies. Investigators concluded that rock drumming can be considered a form of vigorous intermittent physical activity, utilizing both the anaerobic and aerobic energy systems.

Although physiological responses to playing percussion have been studied, and evidence exists that this activity has a high degree of metabolic demand, heavy metal drumming (HMD), a style that is vigorous in nature, has not been thoroughly investigated. The metabolic demand of HMD may be higher than pop/rock drumming, as HMD utilizes both legs as opposed to one. Salvalaio, Silva, Pinho, and Pohlmann (2011) measured the effort of lower limbs in double bass drummers with thermography, concluding that there was an increase of blood flow in ankle dorsiflexors and quadriceps musculature resulting in fatigue, and perhaps leading to greater metabolic demand.

Researchers have shown that drumming is a physical activity that can vary in intensity. As the style of drumming changes, so does the physical demand. Heavy metal drumming may be the most intense method of play based off of previous research cited above, suggesting that it may be an activity that elicits the same health benefits as other modes of vigorous physical activity. Therefore, the purpose of this experiment was to examine the metabolic demand of heavy metal drumming to add to the compendium of research on non-traditional physical activity.

Methods

Eight apparently healthy (Pescatello, et al., 2014), 20-50 year old male (mean height: 71.2 ± 2.9 and weight: 90.7 ± 22.8) drummers were recruited for the investigation. Inclusion criteria consisted of experienced or professional drummers, and having played heavy metal drums for a minimum of five years. The investigation consisted of three separate sessions for measurement that lasted approximately 60-180 min each and were separated by ≥ 24 hours to ensure optimal recovery. Before each session, participants were instructed to be well hydrated and to eat no less than three hours prior to testing. Participants were also asked to abstain from tobacco, drugs, alcohol, and caffeine no less than 24 hours prior to each testing session. For each testing session the participants wore loose fitting clothing that was appropriate for obtaining accurate HR and VO_2 measurements. All procedures were reviewed and approved by the Western Kentucky University Institutional Review Board (IRB).

Procedures

Session 1:

Participants reported to Belmont University's physiology laboratory to complete informed consent, Par-Q, medical history, and baseline testing. The participants weight was measured with shoes off on a Detecto Medic Scale (Detecto Scales Inc., NY), resting heart rate by palpating the radial pulse, and maximal VO_2 was assessed using the Bruce Protocol (Bruce, 1972) treadmill test with a Parvo Medics metabolic analyzer (Sandy, UT).

Session 2:

The investigator reported to the participant's rehearsal space to assess energy expenditure in a controlled setting. Oxygen consumption was analyzed via Cosmed K42b Metabolic Analyzer (Concord, CA), while the drummer rehearsed with songs selected by the drummer. The 40-minute time limit was chosen because it is a typical length of time a drummer practices. Having a set time limit over a song limit ensured that each test would be identical in time length as songs differ in duration. The drummer selected the songs played during the drum test to save time as learning songs is time consuming and the investigator did not have time to allow each drummer to learn the same songs. The draw back to this is that each heavy metal song was played at different tempos. This difference in tempo is believed to affect the intensity of each drum test. The drummer was only measured in the rehearsal space as measuring the drummer while playing a concert was not achieved due to space for the equipment as well as permission from the university. The information gathered from each 40-minute test included volume of O₂ inhaled vs. CO₂ exhaled, HR, RER, and calories per minute. Between each song, the drummer was asked to give the investigator his rating of perceived exertion (RPE) to measure physical demand.

Statistical Analysis

All data were analyzed with Microsoft Excel Software and expressed in means and standard deviations. Variables measured during the 40-minute drum test was mean VO₂ (ml/kg/min), Peak VO₂ (ml/kg/min), percentage of VO_{2max}, mean

heart rate, percentage of age predicted heart rate, maximal heart rate, ventilation (L/min), METs, RER, RPE, and Kilocalories/40-minute drum test.

Results

This investigation consisted of eight participants that completed a 40-minute drum test and Bruce Protocol Maximal Treadmill Test. All nine participants completed the drum test and only eight participated in the maximal treadmill test. The energy expenditure (EE) during the 40-minute drum test averaged 387.05 ± 83 kcals with an estimated hourly EE of 567.33 kcals. The average VO_2 , VO_{2peak} , V_E , and HR was 21.4 ± 4.1 ml/kg/min, 33.9 ± 8.1 ml/kg/min, 63.5 ± 19 L/min, and 150.4 ± 13.6 bpm, respectively. The MET level reached was six. The RPE was 13.8 ± 1.2 .

The Bruce Protocol Maximal Treadmill Test yielded a VO_{2max} , age-predicted max HR, and V_E of 43 ± 9.9 ml/kg/min, 184.1 bpm, and 124.8 L/min. The MET level was 11.6 ± 3.6 with an EE of 109.1 ± 52.4 kcals/min. When comparing the maximal VO_2 and HR values during the treadmill test to the drum test, the participants were working at $52 \pm 6.2\%$ of their VO_{2max} and $78.5 \pm 7.9\%$ of their max HR.

Summary

Prior to the investigation, the researcher suggested that like rock/pop drumming, heavy metal drumming would be categorized as vigorous physical activity, but would elicit higher VO_2 and HR values compared to rock drumming. This assumption was made as heavy metal drumming is played at higher tempos (compared to rock drumming) and requires the use of both legs to play the bass drum pedals. Similar to previous research done by Romero (2014), EE was

measured using indirect calorimetry and HR monitor, while the drummer played to music. The results of this investigation supports the previous analysis of heavy metal drumming done by Romero (2014). Romero (2014) suggested that heavy metal drumming can be classified as a form of physical activity that is moderate to vigorous in intensity based off of the EE, VO₂, HR, RPE, and MET values when compared to the other research done on rock/pop drummers.

Although the previous investigations on drumming were measuring EE, the types of drum test, equipment, values reported, setting, and aerobic fitness assessments, were different. Both Smith et al. (2008) and De La Rue et al. (2013) had the drummers engage in an incremental drumming test where the bpm of the rhythm played was increased every four minutes until the drummer reached exhaustion and could not continue. Although this is a good representation of the peak energy expenditure a drummer can achieve while playing, it is not a good representation of how a drummer plays, in that drummers do not purposely play to exhaustion. The concert test was a good representation of the energy expenditure of rock/pop drumming as playing a concert is a typical activity for rock/pop drummers and generally require the same rhythms played during rehearsal or while the drummer plays for fun. The investigators, however, measured energy expenditure with HR monitors during the concert test. The current investigator used a portable metabolic analyzer with a HR monitor as HR monitors alone are known to under estimate energy expenditure (Montgomery et al. 2009). The heavy metal drum study done by Romero (2014) required the drummer play to recorded songs in a laboratory, while EE was measured with a stationary metabolic cart. The

current investigation utilized a similar drum test with participants playing to recorded music of their choice, but wore a portable metabolic analyzer instead of a stationary metabolic analyzer. Although both instruments are valid for measuring energy expenditure (Cochrane and Gaskill, 2014), the portable metabolic analyzer is believed to be more appropriate for this activity. The reasoning behind this belief is when using a stationary metabolic analyzer, the individual's head is connected to a cart that is separate from the individual. This may have restricted the drummer's movement and made the act of drumming more difficult. The portable metabolic analyzer consists of a mask and oxygen analysis unit worn on the torso of the participant. This design allows the drummer to move freely, without restriction, and feel more comfortable while playing.

All four investigations reported calories burned per hour and average heart rate. The current investigation yielded a caloric expenditure of 567.33 kcals/hour where as Romero (2014) reported a caloric expenditure of 518.51 kcals/hour. These values are similar to values reported by Smith et al. 2008 with 412 kcals/hour and De La Rue et al. (2013) with 623 ± 168 kcals/hour (see Table 4). However, it is difficult to compare the caloric values of the previous three investigations as the devices used to estimate EE were different. Researchers Smith et al. (2008) and De La Rue et al. (2013) measured EE with HR monitors where as Romero (2014) and the current investigator estimated EE with indirect calorimetry.

Within the past decade, the energy expenditure of drummers has been examined in different environments using various instruments to measure EE. The

current investigation, as well as the study conducted by Romero (2014), measured the EE of drummers while playing songs that contained rhythms commonly used by heavy metal percussionists and is believed to be a good representation of the average EE of this activity. However, Romero (2014) measured the participants in a laboratory where the current investigator measured the participants in their personal rehearsal space. It was believed that measuring the drummer in the space where they typically play would allow the drummer to feel more comfortable and better represent an environment that is typical for a drummer to play in. Another difference in methodology for the current investigation is that the drum test for each participant was 40-minutes long. Romero (2014) did not have a set time for the drum test, but instead had the participants play eight songs. The reason the current investigator chose a 40-minute time limit as opposed to a song limit, is that 40-minutes is a typical length of time a drummer rehearses and/or performs a concert. The time limit was also chosen to keep the time of each drum test consistent as songs have different time lengths and would result in each drum test differing in time.

Compared to the previous research on drumming, the current investigation included assessments that had not been used, such as the Bruce Protocol Maximal Treadmill Test and the Rating of Perceived Exertion scale. The treadmill test was used to categorize the participant's level of fitness as "poor", "average", or "excellent" based off of ACSM's Guidelines for Exercise Testing and Prescription and to compare the participant's average VO_2 while drumming to their maximal VO_2 . The RPE scale was used in conjunction with indirect calorimetry and HR monitor to

compare physical demand to energy expenditure during the drum test. Two participants admitted to engaging in regular physical activity, while the other seven participants did not. The seven participants that did not engage in leisure time PA had maximal VO_2 values that categorized them as having a fitness level of “average” and the other two that regularly engage in PA outside of their occupation had a fitness score of “excellent” according to the ACSM. Those categorized as having an average level of fitness reached 50-59% of their VO_{2max} while the two individuals categorized as having an excellent level of fitness reached 42-45% of their VO_{2max} . This information suggests that level of fitness may determine the metabolic demands of heavy metal drumming.

A limitation to the current investigation is the eight participants did not play the same songs during the 40-minute drum test. As a result, all participants played songs that differed rhythmically and in tempo. These differences may have caused the intensity of each drum test to vary. The reason for this is that although the eight participants were heavy metal drummers, they did not all play the same style of heavy metal. Different styles of heavy metal can result in a difference in rhythms played and tempo of each song and possibly affect the intensity. Having each participant play the same song may have been a better choice in methodology as the rhythms played and tempo of each song during the drum test for this investigation were not identical.

After observing the metabolic data, it was determined heavy metal drumming is a form of moderate to vigorous intensity PA (Table 2) and can be

compared to other forms of recreational and work related physical activity (Table 3). Future research involving the drum set and energy expenditure should analyze and compare the drummer during rehearsal and concert using a portable metabolic analyzer, HR monitor, and RPE scale as both settings have been tested, but were not compared using the same methods of measuring EE. Another avenue of research would be to measure an exercise program that combines percussion with cardiovascular and resistance exercises. As heavy metal and rock/pop drumming can be categorized as moderate to vigorous physical activity, it combined with other exercises that are moderate to vigorous in intensity may improve an individual's fitness and health. This information can add to the compendium of physical activity and be used by professionals interested in non-traditional forms of PA.

Table 1. Mean Anthropometric Data

Age (yrs)	28.8 (5.5)
Height (in)	71.2 (2.9)
Weight (kg)	90.7 (22.8)

Table 2. Mean Drum Performance Metabolic Data (Means \pm SD)

Mean VO ₂ (ml/kg/min)	21.4 (4.1)
Peak VO ₂ (ml/kg/min)	33.9 (8.14)
Percentage of VO _{2max}	52.1 (6.2)
Mean Heart Rate	150.4 (13.6)
Percentage of Age Predicted	
Heart Rate Max	78.5 (7.9)
V _E	63.5 (19)
METs	6 (1.1)
RER	0.96 (.07)
Rating of Perceived Exertion	13.3 (1.2)
Kilocalories/40 minute Drum Session	387 (83)

Table 3. MET comparison of other forms of physical activity

Heavy Metal Drumming	6
Resistance Training (Powerlifting, body building, nautilus)	6
Rowing	6
Running (4 mph)	6
Hunting pheasants	6
Butchering large animal	6
Roofing	6

Table 4. Comparison of Average Energy Expenditure of Previous Research Expressed in Calories (kcal) Per Hour

Brown, 2016	567.33 (111.97) kcal/hour
Smith et al., 2008	412 kcal/hour
De La Rue et al., 2013	623 (168) kcal/hour
Romero, 2013	518.51 kcal/hour

Table 5. Mean Drum Performance Heart Rate (Means + SD)

<i>Brown, 2016</i>	<i>150.4 (13.6)</i>
Smith et al., 2008	145 (13)
De La Rue et al., 2013	166 (19)
Romero, 2013	143.4 (20.8)

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