



Metabolic Demands of Heavy Metal Drumming

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Received: 01-05- 2016

Accepted: 28-06- 2016

Published: 31-07- 2016

doi:10.7575/aiac.ijkss.v.4n.3p.32

URL: <http://dx.doi.org/10.7575/aiac.ijkss.v.4n.3p.32>

Abstract

Background: The drum set involves dynamic movement of all four limbs. Motor control studies have been done on drum set playing, yet not much is known about the physiological responses to this activity. Even less is known about heavy metal drumming. **Aims:** The purpose of this study was to determine metabolic responses and demands of heavy metal drumming. **Methods:** Five semi-professional male drummers (mean \pm SD age = 27.4 ± 2.6 y, height = 177.2 ± 3.8 cm, body mass = 85.1 ± 17.8 kg) performed four prescribed and four self-selected heavy metal songs. Oxygen consumption (VO_2), minute ventilation (V_E) and respiratory exchange ratio (RER) were measured using a metabolic cart. Heart rate (HR) was measured using a heart rate monitor. $\text{VO}_{2\text{max}}$ was determined using a graded cycle ergometer test. **Results:** The results indicated a metabolic cost of 6.3 ± 1.4 METs and heart rate of 145.1 ± 15.7 beats \cdot min $^{-1}$ ($75.4 \pm 8.3\%$ of age-predicted HR_{max}). VO_2 peak values reached approximately 90% of the drummer's $\text{VO}_{2\text{max}}$ when performing at the fastest speeds. According to these results, heavy metal drumming may be considered vigorous intensity activity (≥ 6.0 METs). The relative $\text{VO}_{2\text{max}}$ of 40.2 ± 9.5 mL \cdot kg $^{-1}\cdot$ min $^{-1}$ leads to an aerobic fitness classification of "average" for adult males. **Conclusions:** The metabolic demands required during heavy metal drumming meet the American College of Sports Medicine guidelines for the development of health related fitness.

Keywords: Drum set, Exercise physiology, VO_2 , Music

1. Introduction

Repetitive movement is not only seen in sport, it is seen in workplaces, schools, leisure activities, and in entertainment. Musicians can encompass all these areas with some performing for a living, others teaching and learning in a school setting, and some simply playing instruments for fun. Musicians generally possess athletic similarities, with repetitive movements and high oxygen consumption (VO_2) demands. Oftentimes they require a high metabolic demand in order to perform their specific instruments in a fast-paced, long duration, and intermittent environment (De La Rue, Draper, Potter, & Smith, 2013; Holmes & Redding, 2001; Iñesta, Terrados, Garia, & Perez, 2008; Mulcahy et al., 1990; Nietzsche, Stutzig, Walther, & Siebert, 2015; Robertson, Federoff, & Eisensmith, 2010; Salvalaio, Silva, Pinho, & Pohlmann, 2011; Smith, Burke, Draper, & Potter, 2008). Due to the increased beats \cdot min $^{-1}$ of their genre's songs, a heavy metal musician must presumably sustain a particularly high metabolic rate when playing. Drummers require stamina, speed, and quickness within varying bouts of time with simultaneous use of the arms and legs (De La Rue et al., 2013, Salvalaio et al., 2011, Smith et al., 2008). Drumming has been classified as an intermittent movement activity with varying bouts of intensity (De La Rue et al., 2013; Tigerstedt & Olin, 1924).

While upper limbs are important for percussion and drumming, the legs are just as important in the drum set. The feet can play multiple bass drums or percussion instruments with multiple foot pedals. One study used thermography to

study lower limb movement during double bass drumming. More specifically, the study examined the muscle groups affected by double bass drumming (Salvalaio, et al., 2011). Thermography showed a concentration of heat (associated with muscle activity) in the lower extremities.

In the 1920's, German researchers looked at energy expenditure during many activities, including musical instrument playing (Loewy & Schroetter, 1926; Tigerstedt & Olin, 1924). These studies only looked at using one drum or cymbal and the results were later used to encompass the entire drum set. A later study looked more specifically at the oxygen cost (VO_2) of Rock/Pop drumming and the energy expended while performing on a drum set (De La Rue, et al., 2013). They reported a large percentage of VO_2 peak was reached while playing rock/pop music. Furthermore, heart rate reached a high level, with most drummers coming very close to or even exceeding their age-predicted HR_{max} . This paralleled the case study where a rock drummer also exceeded his age-predicted HR_{max} many times during his performance (Smith et al., 2008).

While recent studies have begun to investigate the physical demands of previously neglected sports and physical activities (Serrano-Huete, Latorre-Román, García-Pinillos, Morcillo Losa, Moreno-Del Castillo, & Párraga-Montilla, 2016), few studies have been done on the physiology of drumming. Further studies of drumming are needed to improve our understanding of how a drummer's body reacts to the full-bodied nature of modern rock drumming, and whether or not there is a sufficient stimulus for the development/maintenance of aerobic fitness. Therefore, it was our desire to investigate metabolic responses to heavy metal drumming. We hypothesized that due to the increased speed and repetitions in all four limbs compared to other methods of drumming, heavy metal drumming would demonstrate a metabolic cost sufficient to meet ACSM guidelines for the development of aerobic fitness.

2. Methods

2.1 Experimental approach

Each participant visited the exercise physiology laboratory at California State University, Fullerton once for two tests. The first test performed by each participant was a drum performance using a metabolic cart (Parvo Medics, model 2400, Sandy, UT). VO_2 , minute ventilation (V_E), respiratory exchange ratio (RER), and heart rate (HR) were measured during drumming. After 20 minutes of rest, an incremental cycle ergometer test was used to determine VO_{2max} .

2.2 Subjects

Five male semi-professional drummers (musicians who play their instruments in a professional setting part time; 27.4 ± 2.6 y, 177.2 ± 3.8 cm, 85.1 ± 17.8 kg) participated in the study. They were asked to eat a light meal the day of testing, and that caffeine and alcohol intake be kept normal the day before and day of testing. Participants were also instructed to avoid intense exercise, including drumming, for the 24 hours before visiting the lab. Two subjects reported resistance training three to four days per week, one trained two days per week in long distance running or biking, one trained in sprints on a bike, and one subject reported he biked long distances to work every day. The years drumming and years double bass drumming were 11.70 ± 5.19 and 10.10 ± 1.14 , respectively. Subjects reported that they practiced 2.40 ± 0.89 hours per day, 3.6 ± 1.14 days a week, and rated the vigor of practice at 6.6 ± 0.55 on a scale of 1-10.

Subjects completed a health status questionnaire to confirm they were free of any injury, medications, or health-related issues that could have prevented them from participating in the exercise protocol. All participants signed a statement of informed consent, which was approved by the Cal State Fullerton Institutional Review Board.

2.3 Drum performance test

After written informed consent was obtained and anthropometric data was taken, subjects were asked to set up the drum set, provided by the lead investigator, per their liking. Subjects then warmed-up on the drum set as they would normally do for a performance. Calibration of the metabolic cart was also completed before attaching a HR monitor and mask. Subjects were then fitted with a Polar Heart monitor (Polar Electro, Inc., Lake Success, New York.). The drummers then performed for 3 minutes unmonitored for familiarization while wearing the metabolic cart mask. Once familiar, the test began and the drummers performed their set. Each set included four predetermined "metal standards": Metallica's "Fight Fire with Fire," Lamb of God's "Walk with Me in Hell," Dethklok's "Thunderhorse," and Slayer's "Raining Blood," along with four songs of their choosing. Between songs, the testing was paused to allow for a water break or to fix/rearrange the drum set. These times varied from 5 seconds to 20 seconds, mimicking the intervals of a professional heavy metal show. Data were collected by the metabolic cart every 15 seconds, with these values averaged over the entire duration of the test.

2.4 VO_{2Max} Test

Subjects were given a 20 minute rest post drum performance test. They then performed a graded exercise test to exhaustion on a calibrated cycle ergometer (Monark 894E; Country Technology, Inc., Gay Mills, Wisconsin) at a pedal cadence of 60 revolutions \cdot min⁻¹. Seat height was adjusted so that each participant's knees were near full extension at the bottom of each pedal revolution, with the same heart rate monitor used for the drum test. After a three minute period of rest, the participants pedaled at 50 W for two minutes. Power output was then increased 20 W every minute until the test was completed. A test was considered maximal if the subject met at least two of the following: 1) inability to maintain the pedal cadence; 2) 90% of age-predicted max heart rate; or 3) RPE scale rating over 17 (Malek, Coburn, & Tedjasaputra, 2009). As with the drum performance test, data were sampled every 15 seconds using the metabolic cart.

Ratings of perceived exertion (RPE) scores were recorded every minute using the Borg Scale of Perceived Exertion (Borg, 1998).

2.5 Statistical Analysis

Data analyses were completed using SPSS 20 software (IBM, Armonk, NY, USA). All descriptive statistics were expressed as means \pm SD.

2.6 Variables Analyzed

Average VO_2 , VO_2 peak, HR, RER, and V_E were determined from the drum performance test. Maximal oxygen consumption was determined from the $\text{VO}_{2\text{max}}$ cycle ergometer test, and compared to the VO_2 average and peaks for each subject during the drum performance test.

3. Results

Five subjects completed the drum performance test, while four completed the $\text{VO}_{2\text{max}}$ test (one was unable to perform the $\text{VO}_{2\text{max}}$ test due to a time limitation). The metabolic and physiologic data for the drum performance test are presented in table 1. Drum performance speeds had a mean of 179 ± 33 beats \cdot min $^{-1}$, with songs ranging from 110-255 beats \cdot min $^{-1}$. Song lengths had a mean of 3 minutes and 59 ± 11 seconds.

Table 1. Drum Performance Test Metabolic Data (Mean \pm SD)

Mean VO_2 (mL \cdot kg \cdot min $^{-1}$)	22.2 ± 4.7
Mean Peak VO_2 (mL \cdot kg \cdot min $^{-1}$)	33.5 ± 8.4
Percentage of $\text{VO}_{2\text{max}}$	91 ± 14
Mean Heart Rate (beats \cdot min $^{-1}$)	145.1 ± 15.7
Percentage of Age Predicted HR $_{\text{max}}$	75.4 ± 8.3
METs	6.3 ± 1.4
V_E (L \cdot min $^{-1}$)	56.1 ± 6.1
RER	0.87 ± 0.0
Kilocalories \cdot hr $^{-1}$	518 ± 46.5

The maximal cycle ergometer test showed subjects to have a mean $\text{VO}_{2\text{max}}$ of 40.2 ± 9.5 mL \cdot kg \cdot min $^{-1}$. The mean $\text{VO}_{2\text{peak}}$ for the drum performances was 33.5 ± 8.4 mL \cdot kg \cdot min $^{-1}$, indicating that the percentage of $\text{VO}_{2\text{max}}$ on the drum performance test was $90 \pm 14\%$.

4. Discussion

With a mean $\text{VO}_{2\text{max}}$ of 40.2 ± 9.5 mL \cdot kg \cdot min $^{-1}$, the results of the present study indicate that these drummers would have an aerobic fitness classification of “average” for adult males, while their average MET value of 6.3 ± 1.4 would be classified as vigorous intensity activity according to the American College of Sports Medicine (Pescatello & American College of Sports Medicine, 2014). Mean drum performance VO_2 peaks reached about 90% of the drummers $\text{VO}_{2\text{max}}$ when performing at the fastest speeds.

Drum performance song speeds had a mean of approximately 180 beats \cdot min $^{-1}$, and subjects had mean heart rates of 145 beats \cdot min $^{-1}$. These values are likely due to the increased exercise demands on the upper body, as has been shown to occur in previous studies (Stenberg, Astrand, Ekblom, Royce, & Saltin, 1967). Calories expended were shown to have a mean of 518 kcal \cdot hr $^{-1}$. This was lower compared to the rock/pop drum study, which reported an estimated 600 kcal \cdot hr $^{-1}$ (De La Rue et al., 2013). By comparison, a study which investigated the performance on of various styles of piano playing, found a mean VO_2 of 8.65 ± 2.55 mL \cdot kg \cdot min $^{-1}$ and 55% of the heart rate age predicted max reached. These values were lower than the heavy metal drumming findings of the present study (Clark, Holmes, Redding, 2011). Clearly, different forms of music performance involve different metabolic demands.

The differences between drum studies with regard to VO_2 , heart rate, and other physiologic measures, may be due to differences in muscles utilized and the intensity of drum play. For example, the performance of rock/pop drumming typically consists of slower song speeds and less prevalent use of the left leg (De La Rue et al., 2013). In metal drumming, the left leg is used to work the second bass drum/slave pedal of the double bass pedal in addition to working the “hi hat” pedal. In rock/pop drumming, there is typically no second bass drum or slave double bass pedal. Rather, the left leg typically is holding down the “hi hat” pedal and/or in an isometric hold slightly raising it to create a different sound to the “hi hats” and/or time keeping. Heavy metal drummers will do all of those actions while also including the intense fast, intermittent repetitions of patterns on the pedal. This likely accounts for the greater physiological responses to metal drumming found in the present study.

The previous rock/pop study estimated energy expenditure through heart rate monitoring and extrapolated through the heart rate data of their progressive intensity drum test (De La Rue et al., 2013). This could explain the large differences of VO_2 reached and kilocalories burned while playing between the two studies, especially with the heavy metal having

faster speeds. The aforementioned study also monitored heart rate during actual concerts where other stressors such as nervousness and adrenaline could have had an effect on physiological responses. It is possible that the laboratory environment in which our testing took place led to different physiological responses than would be observed in a true concert performance environment. For example, the subjects of the current study commented how difficult and distracting it was performing with a mask on, this being necessary in order to collect expired air for VO_2 , RER, and V_E determination. This may have prevented them from focusing 100% on performance and may have influenced their playing.

Another study looking at musician's daily stressors noticed a large increase in heart rate during concert performance compared to practicing on their own (Iñesta, et al., 2008). Yet another study looked at an orchestra during practice, recording, and live performances and also saw a large increase in heart rates during live performances compared to practicing and recording (Mulcahy, et al., 1990). The researchers noted on average the instrumentalists reached 50-60% of their age predicted HR_{max} during practice, but reached 60-70% during live performances. More specifically with the percussion group, researchers observed 59% of their age predicted heart rate max during live performance. Comparing professional and semiprofessional to novice musicians this study also reported a difference in heart rate values during the playing of the same piece of music (Mulcahy, et al. 1990). Future research should examine the physiological responses to metal drumming during live professional performances to see if there are even greater physiological responses.

With a mean RER of 0.87 during the drum performance, our study suggested there was a mix of carbohydrates and fats being used as a fuel source, with the emphasis being on the former. To our knowledge, no other studies have examined fuel utilization during music performances. We observed the mean V_E for the drum performance test at $56 \text{ L} \cdot \text{min}^{-1}$, which is normal for "moderate" activity. Since the subjects had a mean experience of almost 12 years drumming and reported to have practiced 3-5 times per week, these numbers for RER and V_E may reflect adaptations resulting from the subject's extensive experience and specificity of training in drumming.

5. Conclusions

The results of the present study suggest that heavy metal drumming meets the ACSM guidelines for the development of aerobic fitness. Further research is needed regarding proper warm up and conditioning methods to increase performance. Furthermore, there are different subgenres in heavy metal, such as death metal, thrash, djent, metalcore, and nu-metal. These subgenres feature similar movements of all four limbs, yet speeds and movement patterns vary from being fast at 240 plus beats $\cdot \text{min}^{-1}$ or slower and more groove oriented. Comparisons could be made to get a better idea how similar and dissimilar the subgenres are among drummers, and how they relate to standards for the development of aerobic fitness.

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