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Energy Expenditure in Rock / Pop Drumming

Abstract

Despite the vigorous nature of rock / pop drumming, there are no precise data on the energy expenditure of this activity. The aim of this study was to quantify the energy cost of rock / pop drumming. Fourteen male drummers (mean ± SD; age 27 ± 8 yr, height 1.78 ± 0.07 m and mass 76.6 ± 12.6 kg) completed an incremental drumming test to establish the relationship between energy expenditure and heart rate for this activity and a ramped cycle ergometer test to exhaustion as a criterion measure for peak values [oxygen uptake and heart rate]. During live concert performance heart rate was continuously measured and used to estimate energy expenditure (from the energy expenditure vs. heart rate data derived from the drumming test). During concert performance, estimated energy expenditure (mean ± SD) was 623 ± 168 $kcal \cdot h^{-1}$ (8.1 ± 2.2 METs) during performances of 38.6 ± 15.6 minutes, and drummers achieved a peak heart rate of 186±16 $b.min^{-1}$ During the drumming test participants attained 78.7 ± 8.3% of the cycle ergometer peak oxygen uptake. Rock / pop drumming represents a relatively high-intensity form of physical activity and as such incurs significant energy expenditure. Rock / pop drumming should be considered as a viable alternative to more traditional forms of physical activity.

Key words: Exercise physiology, physical activity, heart rate, music

Introduction

The rates of energy expenditure for various forms of physical activity have received considerable attention and comprehensive compendia have been compiled [1,2]. These compendia may be used by exercise practitioners to identify physical activities with specific rates of energy expenditure for exercise prescription or research [11]. However, despite appearing to be a physically demanding activity, rock / pop drumming has received very little attention. Rock / pop drumming is a seated activity that involves all four limbs, is intermittent in nature, and combines high levels of energy output over an extended period of time. Accurate quantification of energy expenditure during such activities could be of interest to health professionals working with clients not inspired by conventional sports or physical activities.

Contemporary compendia of physical activities include values for drumming of 4.0 [1] and 4.2 [8] METs. All current estimates of the rate of energy expenditure for drumming are referenced to a single article published in 1955 by Passmore and Durnin [10]. Primary data for drumming in this article were from two German research papers published in 1924 [15] and 1926 [7]. The age of these studies is problematic, not because of the quality of the data (procedures to quantify energy cost were appropriate and thorough), but the drumming performed. The participants for the studies were orchestral percussionists performing a style of drumming very different to modern rock / pop drumming. Orchestral percussion is generally more intermittent, less vigorous and rarely involves the legs. The type of drumming used, together with low subject numbers (one per instrument measured in some cases) mean that the findings of Tigerstedt and Olin [15] and Loewy and Schroetter [7] should not be considered as a useful reference point for estimating energy expenditure during contemporary rock / pop drumming. Furthermore, Passmore and Durnin [10] also misquoted the results from the primary research, reporting the maximum values as mean values for energy expenditure in drumming. It is clear therefore that an investigation into the energy cost of contemporary rock / pop drumming is warranted.

Recently Smith and colleagues [13] presented case study data on Clem Burke, drummer with the band Blondie. Using indirect calorimetry, it was estimated that 412 $kcal \cdot h^{-1}$ were expended during a live concert performance. This figure is higher than those previously published for seated drumming (240 $kcal \cdot h^{-1}$) [10]. A limitation of the data of Smith and colleagues [13] was that no set drum pattern was used for estimating energy expenditure during the consecutive test stages. Instead, the drummer performed self-selected drum patterns at the prescribed tempi [13], making replication difficult. In spite of this limitation, a striking finding was that extremely high peak heart rates (HR_{peak}) were reported; 191 and 179 $b \cdot min^{-1}$ for the drumming test and the concert performance respectively [13]. The participant also attained a peak oxygen uptake ($\dot{V}O_{2peak}$) of 24.2 $ml.kg^{-1}min^{-1}$ during an incremental drumming test, but since a standard laboratory determined $\dot{V}O_{2peak}$ was not recorded, it was not possible to contextualise the drumming test peak value. Whether a high maximum heart rate and energy cost of this magnitude are common during rock / pop drumming is at present unknown and further investigation using a larger cohort and repeatable methods is needed.

The aims of this study were twofold: firstly, to quantify the energy cost and HR_{peak} of drummers during live performance; and secondly, to compare maximal oxygen uptake ($\dot{V}O_{2peak}$), derived from a conventional cycle ergometer ramp test and the $\dot{V}O_{2peak}$ attained during an incremental drumming test.

Methods

Participants

Fourteen healthy semi-professional and professional drummers (mean ± SD; age 27 ± 8 yr, height 1.78 ± 0.07 m and mass 76.6 ± 12.6 kg) volunteered for the study. Participants were instructed to refrain from intense physical activity for 24 hours prior to testing, and to abstain from caffeine and alcohol on the day of testing. Each participant was briefed on the experimental procedures before giving written informed consent. Participants also provided information on how many hours they spent drumming in a typical week and of these hours, which would be considered vigorous (aware of sensations such as elevated heart rate and sweating). All procedures were approved by the University of Gloucestershire Research Ethics Committee and the study fully meets the ethical standards of this journal [6].

Procedures

Participants completed two laboratory tests and were monitored during a live concert performance. Concert performance was always within 1 week of the laboratory tests, but there was variation in whether the concert preceded or followed the laboratory tests, depending on the availability of the participant. The laboratory testing consisted of a novel incremental drumming test to exhaustion and (following a rest period of approximately one hour) a conventional ramp test to exhaustion performed on a cycle ergometer. Since the primary focus of this paper was energy expenditure in drumming, the order of the two laboratory tests was not counterbalanced and the drumming test was always performed prior to cycling. Afingertip capillary blood sample was drawn 1 min post each laboratory test and assayed for blood lactate concentration (Lactate Pro, Arkray TM, Kyoto).

For the drumming test, the participant performed a standard drum pattern and ‘fill’ (Figure 1). The pattern was played three times followed by the ‘fill’ in a four bar sequence, the participant continued to play this sequence continuously throughout each stage. The exercise intensity was controlled by manipulating the tempo at which the pattern was performed. This was provided to the participant through headphones (Vic Firth, Boston US) as an audible cue (cow bell sound) from a percussion sound module (TD9, Roland, Swansea). The starting tempo was 110 $b \cdot min^{-1}$ and was increased by 20 $b \cdot min^{-1}$ every four minutes until the participant could no longer execute the prescribed pattern. (This was considered to be when there were mistakes or alterations in the pattern being played; however often the participants adjudged themselves unable to continue playing at the increased tempo.) Drumming ceased between stages for a short period (typically ~5 s) to allow the tempo to be increased. Once the incremental test was completed, participants were instructed to perform a further four-minute stage, during which they were asked to play as if performing a drum solo in a vigorous fashion. The drumming tests were all completed on the same drum kit (Collector’s Series, Drum Workshop, Oxnard, US), consisting of; 14” snare drum, 14” rack tom, 16” floor tom, 18” floor tom and 20” bass drum (single bass drum pedal), cymbals consisting of a 20” ride, 14” hi-hats, 18” crash, 16” crash, 18” china (A Custom, Zildjian, Norwell, US) and 18” crash cymbals (K dark crash, Zildjian, Norwell, US). Only the ride and hi-hats were used in the prescribed drumming test pattern, but participants were free to use all cymbals in the ‘drum solo’ final stage. Participants were seated throughout the test (9100M, Drum Workshop, Oxnard, US) and allowed to adjust the positioning of the kit as they wished. Drum sticks (5A, Vic Firth, Boston, USA) were supplied although some participants used their own sticks.

[Insert Figure 1 about here]

For the cycle test participants performed a ramp test to volitional exhaustion on an electromagnetically-braked cycle ergometer (Excalibur Sport 2500, Lode, Groeningen NL). Following two minutes of unloaded (0 W) cycling the test began at 30 W and intensity increased continually ($20W{\cdot}min^{-1}$) until exhaustion. Cadence was self-selected by participants but was consistent through the test (the ergometer was set in cadence independent mode).

Concert data were collected at various performance venues in the South and South-West of England, including indoor concerts and outdoor festivals. Heart rate data were collected for the entire duration of the performance, and therefore included breaks between songs and prior to encore.

Data Acquisition

Heart rate was measured throughout all testing using short range telemetry (RS800, Polar, Kempele, Finland) sampling every five seconds and downloaded using manufacturer's software (Protrainer 5 version 5.2, Polar, Kempele, Finland). Both laboratory tests were completed in the same ventilated sound proofed room (2.8x2.8x2.25 m) (Total Acoustic Solutions, Preston). Throughout the laboratory tests subjects breathed through a low dead space (0.90 L), low resistance (5.5 cmH_2O at 510 $L.min^{-1}$) mouthpiece and turbine assembly. Gases were drawn continuously from the mouthpiece through a 2 m sampling line (0.5 mm internal diameter) to a quadrupole mass spectrometer (EX671; Morgan Medical, Rainham, UK), where they were analysed for O_2, CO_2 and N_2 concentration. Expired volumes were determined using a turbine volume transducer (Interface Associates, Alifovieja, US). The mass spectrometer was calibrated before each test using gas mixtures (Linde Gas, Guildford, UK) for which the concentrations of O_2, CO_2 and N_2 were known. The turbine was calibrated before each test using a 3.00 L calibration syringe (Hans Rudolf, Kansas, US). Oxygen uptake ($\dot{V}O_2$) and carbon dioxide output ($\dot{V}CO_2$) were calculated and displayed for each breath.

Data Analysis

Breath-by-breath respiratory data ($\dot{V}O_2$ and RER) and HR were averaged for the final minute of each fully completed incremental stage to determine a representative value for each work rate. Energy expenditure ($kcal \cdot min^{-1}$) was calculated using indirect calorimetry from the respiratory data according to thermal equivalents of $\dot{V}O_2$ and RER [18]. Linear regression was then used to characterise the relationship between estimated energy expenditure ($kcal \cdot min^{-1}$) and HR ($b \cdot min^{-1}$) for each participant. The resulting individual linear regression equations were used to calculate individual estimated energy expenditures from the live performance mean HRs. To calculate $\dot{V}O_{2peak}$, the $\dot{V}O_2$ data were interpolated (second to second) and the highest 15s moving average was taken to be $\dot{V}O_{2peak}$ for each laboratory test. HR_{peak} was defined as the highest recorded value from each test. The relationship between between age and HR_{peak} (determined from the cycle ergometer test) was investigated using Pearson Product Moment correlation. Differences in HR between the three tests were investigated using one-way repeated measures ANOVA with post-hoc Bonferroni corrected paired *t*-tests. When comparisons were between two tests only, paired *t*-tests were used. Data are presented as mean ± SD (unless stated otherwise) and statistical significance was set at 0.05. Statistical tests were performed using SPSS version 16.0 (SPSS Inc, Chicago).

Results

A typical concert HR trace is shown in Figure 2. The average HR for all participants during concerts (HRmean) was 166±19 $b{\cdot}min^{-1}$ and the mean duration of concert performance was 38.6±15.6 min. Linear regression analyses of the individual energy cost ($kcal{\cdot}min^{-1}$) and HR ($b{\cdot}min^{-1}$) data yielded a mean R^2 of 0.989±0.008 (range 0.968-0.999) and mean SEE of 0.203 ±0.121 $kcal.min^{-1}$ (range 0.041-0.423 $kcal.min^{-1}$). The mean calculated rate of energy expenditure was 623 ± 168 $kcal{\cdot}h^{-1}$ and when expressed as METs this equated to a mean value of 8.2 ± 2.3 METs. All other results from the two laboratory tests and the concert performance are contained in Table 1. No significant correlation existed between age and HR_{peak} (determined from the cycle ergometer test), ($r = 0.051$, $P = 0.861$). Self-report revealed that the subjects typically spent 9.8 ± 6.6 hours drumming per week, and of these 4.1 ± 5.2 hours were reported as vigorous.

[Insert Table 1 and Figure 2 about here]

Discussion

The main findings of the present study are that rate of energy expenditure of rock / pop drumming is greater than previously reported. Furthermore drumming is associated with high exercising heart rates and a high percentage of a conventional laboratory determined $\dot{V}O_{2peak}$ can be realised during drumming. The rates of energy expenditure reported here were in excess of those reported in all previous studies [15,7] and compendia of physical activities [1,2,8].

The present study also demonstrates that the data reported in the only other appropriate work in this area (the case study data of Smith and colleagues) [13] was not exceptional and was typical for drumming in this genre. Clem Burke, the subject of the case study, is known for his flamboyant style of drumming [12] and it was important to investigate how typical his results were. Smith and colleagues [13] reported an energy expenditure of 412 kcal$\cdot$h^{-1} and these data seem to be at the lower end of the normal range for drummers in this genre (although these data were from an older subject and longer concert duration) based on the new data reported in the present study.

Energy expenditure was converted to METs using the recognised value of (1 kcal.kg^{-1}h^{-1}) per MET [3], the mean value was more than double that reported for seated drumming and drumming in contemporary compendia and texts [1,2,8] and would place drumming as a 'hard / vigorous' activity. Drumming is therefore (despite the limitations of the MET as a unit of energy expenditure [5]) clearly a far more vigorous activity than previously reported and assuming accurate calculation / citation of other physical activities, rock / pop drumming is of equal metabolic demand to; running (8 km.h^{-1}), cycling (19 - 22 km.h^{-1}), ice and field hockey and competitive volleyball (beach and gymnasium) [2]. It is clearly possible to incur significant energy expenditure whilst participating in rock / pop drumming. It should be recognised however, that the present study utilised professional and semi-professional drummers and whether such high rates of energy expenditure would be achieved by novice or intermediate drummers requires further investigation. It is worth noting however, that the drum pattern and fill used in the present study is a relatively simple one and could be performed by drummers with limited drumming experience.

While we have reported estimated energy expenditure for concert performance here, the overall dose (combination of frequency, intensity and duration) of drumming related activity undertaken by the professional and semi-professional in this study is unknown. The technical and physical nature of expert level drumming requires regular and prolonged practice. The energetic demands of drumming practice were not studied in this investigation but the intensity of such sessions is extremely varied (as revealed by the large SD of vigorous drumming hours). However the average time spent practicing and in particular, the time spent engaged in vigorous activity is sufficient that there are likely to be long term health benefits from prolonged participation [17]. Although, we acknowledge the problems of self-report in populations, such as this one, that may be inexperienced in the perception of physical activity. To date there are no data describing longevity in drummers, and this requires investigation. It has been demonstrated that individuals with an exercise capacity >8 METs have a significantly reduced risk of mortality from cardiovascular diseases [9]. Indeed, it is apparent from the present data that drummers need to maintain an exercise capacity in excess of 8 METs in order to adequately perform, and more than half of the drummers in this study exceeded this value as average energy expenditure during concert performance. Drumming warrants further attention as a mode of physical activity because it has the potential to provide long term health benefits and is perhaps a form of activity that would attract people who are less inclined to participate in traditional forms of exercise such as running or cycling.

The present study sought to determine drumming $\dot{V}O_{2peak}$ for all participants and to provide some context for this value by measuring $\dot{V}O_{2peak}$ in a conventional manner using a traditional laboratory based cycle ergometer ramp test. An important finding of the present study was that a high percentage (78.7±8.3%) of $\dot{V}O_{2peak}$ can be achieved during drumming. Given that this study also demonstrates the possibilities to control work rate by the manipulation of tempo, this raises some interesting possibilities for an alternative form of exercise prescription. It should be noted however, that this would only apply to the drum pattern used in the present study, the use of alternative or self-chosen patterns will require further investigation.

One of the most remarkable findings of Smith and colleagues [13] was the high (in excess of age predicted maxima) HR_{peak} achieved by the 52 year old subject. In the present study this was further investigated to ascertain whether this is a typical response in drummers. However, data from the present study showed mean HR_{peak} during concert performance (186 $b.min^{-1}$) to be very close to the age predicted value (183 $b.min^{-1}$) indicating a high HR_{peak} in Clem Burke. Interestingly there was no significant relationship between age and HR_{peak} in the present study, despite such a relationship existing in the general population [14]. However, the sample in the present study was relatively small and homogeneous for age and therefore this relationship requires further investigation.

The live performances can be characterised as intermittent physical activity; the activity within a song varies (verses, choruses and drum fills), and for the most part there are short pauses between songs. This intermittent activity pattern is shown in the HR trace in Figure 2, where there is no discernible HR steady state. It should also be remembered that the calculations for energy expenditure were based on the total performance (including all breaks between songs) and prior to encore. If these calculations were based on drumming time only rather than the total performance, the peak rate of energy expenditure would be even higher (although ecologically less valid).

A potential source of error in our calculations was introduced by estimating energy expenditure from HR data rather than from measured $\dot{V}O_2$ during concerts (subjects were reluctant to allow us to collect $\dot{V}O_2$ data during concert performance). The size of this potential error source can be quantified using the SEE from the individual linear regression analyses of energy expenditure and HR. The SEEs were small both in terms of mean values and ranges (see Results); indeed, the mean SEE equates to a mere 12 $kcal.h^{-1}$. The HR-energy expenditure relationships were also well characterised by linear regression; the mean correlation was r=0.994±0.089 and residuals were randomly distributed.

We did not measure blood pressure (BP) in the subject while drumming as it was not feasible to do so during live concert performances. Arm cranking has been found to elicit elevated systolic and diastolic BPs relative to leg exercise [4] and a higher mean arterial pressure during arm exercise relative to combined arm and leg exercise [16]. Measurement of the BP responses to drumming will be necessary to determine whether drumming is a form of physical activity that should be recommended for those with cardiovascular disease (CVD) or risk factors for CVD. It may also be useful to measure the BP responses to different forms of drumming, since drumming activity that excludes the legs would be expected to elicit different BP responses to activities recruiting larger muscle beds in the legs [4,16].

Rock / pop drumming represents a relatively high intensity form of physical activity; it incurs significant energy expenditure, induces high HR and requires a high $\dot{V}O_2$. Further research is warranted on both the potential for rock / pop drumming to be used as an alternative to more traditional forms of physical activity and the longevity of those engaged in regular participation.

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