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Metabolic Costs of a 58-minute Multi-Intensity Exercise Session with and Without Music and Cueing

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ABSTRACT

International Journal of Exercise Science 13(2): 358-365, 2020. It is unclear if the presence or absence of music and cueing influence total energy expenditure (TEE) during a multi-intensity exercise program. The purpose of this study was to determine the difference between TEE with or without music and cueing during a 58-minute exercise session using heart rate estimation (HRe) and indirect calorimetry (IC). Using a randomized crossover design, 22 participants (6 males; 16 females; 27.64 ± 10.33 yrs.) were randomized into two groups (Group A = 11; Group B = 11). All participants performed the same 58-minute exercise session under two conditions: with music (WM) and without music and cueing (WOM). TEE was obtained through the Activio heart rate system for all 22 participants. TEE and excess post-exercise oxygen consumption (EPOC) were also obtained in a subset of eight participants (4 males; 4 females; 28.25 ± 5.9 yrs.) via IC through a ParvoMedics metabolic cart. Paired samples t-tests were performed to compare TEE between conditions using HRe and IC. Statistical analysis was performed using IBM Analytics, SPSS v24 with significance set at $p < 0.05$. A significant difference ($p = 0.008$) was found between TEE WM and WOM using IC (475.74 ± 98.50 vs. 429.37 ± 121.42), but not between TEE WM and WOM using HRe ($p = 2.04$; 482.67 ± 151.79 vs. 452.90 ± 164.59). The presence of music and cueing increased TEE when monitored via IC, but not when measured via wearable heart rate technology. Music and cueing does aid in additional caloric expenditure.

KEY WORDS: Group fitness, heart rate, VO_2max, multi-intensity interval training

INTRODUCTION

The use of music during group fitness is commonplace and is often associated with enhanced performance. Several studies argue that aerobic dance and step formats, which choreograph exercise routines to music, produce intensity levels and caloric expenditures comparable to those of running and cycling (6, 7, 11). Research has demonstrated that individuals listening to synchronous audio-playlists during structured exercise achieve higher amounts of total weekly physical activity than non-music exercisers, suggesting that music can affect exercise adherence and performance (1).

Music-related research in the exercise domain has primarily focused on individual based activities such as cycling and treadmill running. These studies have analyzed the effects of music on various psychological (e.g. enhanced emotional responses) and ergogenic (e.g. time to exhaustion) variables. Studies evaluating the effects of music on psychological measurements such as rating of perceived exertion (RPE) have found mixed results during cycling and treadmill running. Higher RPE and enjoyment scores were observed during high-intensity cycling sessions accompanied by non-preferred and preferred music (4, 8). However, neutral and motivational music produced lower RPE scores during submaximal treadmill running (9). Studies evaluating the ergogenic effects of music also found that distance and time to exhaustion increased during high-intensity cycling, submaximal treadmill running, and maximal treadmill running performed with various forms of music (preferred, motivational, and synchronous) (2, 4, 9). It appears that music aids performance via a "higher acceptance of effort and discomfort" during individual based activities (10).

Studies analyzing the effects of music on physiological measurements, such as heart rate and blood lactate, have also found mixed results. Heart rate increased during low-to-moderate intensity cycling sessions accompanied by fast tempo music, contradicting studies finding no significant difference in heart rate during submaximal or supramaximal cycling performed after music-based warmups or during music-based conditions (3, 8, 10). Blood lactate concentration increased during a high-intensity treadmill run with motivational music and video, but not during submaximal treadmill running with synchronous music (2, 9). It appears that the physiological benefits of music during exercise may not transfer to high-intensity exercise. Transfer of these studies during group-based exercise is also questionable, considering the limited amount of research in this field.

Few studies have evaluated the effects of music and cueing on exercise performance during group-based activity. Studies that evaluate group-based activities often compare heart rate response and metabolic costs of multiple aerobic formats performed with music, but not without music and cueing. Wickham et al., for example, compared heart rate response and metabolic costs of three commercial group exercise formats commonly performed with music - step aerobics, indoor stationary cycling, and BodyPump (an aerobic exercise session that incorporates resistance training exercises via barbells) (11). Rixon et al. also compared heart rate response and metabolic costs of music-based formats such as step aerobics, cycling, BodyPump, and Bodycombat (6). Collectively, these studies found that music-based group-exercise formats were associated with higher an average heart rate and caloric expenditure than jogging without music at 8.05 km/h (6,11). Although the use of music and cueing during group-exercise is commonplace, it remains unclear whether the presence or absence of synchronous music and cueing influences total energy expenditure (TEE).

To our knowledge, no other studies have evaluated the effect of music and cueing on metabolic costs during a multi-intensity, group-exercise format. Thus, the purpose of this study was to estimate the TEE of a multi-intensity group-exercise session with music and cueing (WM) and without music and cueing (WOM), using heart rate estimation (HRe) and indirect calorimetry (IC). Based on the effects of music on physiological measurements for

individual-based activities, it was hypothesized that HRe and IC measurements of TEE would be greater in a multi-intensity group-exercise session performed WM when compared to a session performed WOM. Information obtained during this study could support the efficacy of using music and cueing to increase caloric expenditure.

METHODS

Participants

Twenty-two physically active individuals (Table 1) between the ages of 18 and 40 formed a convenience sample from the University community. Inclusion criteria required that all participants be self-reported healthy with no injuries or chronic health conditions. Subjects were excluded from this study if they: were a current competitive athlete; had self-reported musculoskeletal problems in the upper or lower extremity; or were pregnant. All interested participants were given verbal explanation of the testing procedures and signed an informed consent approved by the Institutional Review Board at California State University, Long Beach. This research was carried out fully in accordance with the ethical standards of the International Journal of Exercise Science (5).

Table 1. Descriptive statistics of individuals participating in a 58-minute multi-intensity exercise session performed with and without music and cueing.

	Age (yrs)	Height (cm)	Weight (kg)	Body Fat (%)	VO2max (mL/kg/min)
Hre Group (22)	27.63 ± 10.33	167.41 ± 8.33	64.62 ± 10.46	20.14 ± 5.75	-
IC Group (8)	28.25 ± 5.9	169.55 ± 7.89	71.34 ± 10.02	18.79 ± 5.59	50.34 ± 6.38

Note: Data are expressed as: Mean ± Standard Deviation. HRe = Heart rate estimation. IC = Indirect calorimetry.

Protocol

This study utilized a crossover design, whereby 22 participants were randomized into two groups (Group A = 11 and Group B = 11). All participants performed the same 58-minute video-led exercise session (Table 2) under two conditions: WM and WOM. Sound was muted during the WOM condition. Conditions were counterbalanced between groups, took place at approximately the same time of day, and were separated by at least 48 hours. Group A performed the WM session first and WOM session two days later, while Group B performed the WOM session first and WM session two days later. Occasional rest and water breaks were taken as needed by the participant during each session.

The program utilized during this study combines kickboxing and bodyweight exercises (ex: squats, lunges, and burpees) with music and cueing. The program specifically choreographs variable intensities to upbeat music, providing a multi-intensity workout via muscle conditioning and plyometric training. Digital marketing for this program suggests that the synchronous effect of movement to music increases TEE.

Table 2. Program design, including training focus and example exercises, of the multi-intensity exercise session utilized during this study.

	Approx. Time (mins)	Training Focus	Exercises
Warmup	8	Dynamic stretching & heart rate elevation	Multi-directional stepping & reaching; shoulder rolls, hip rotations, core rotations
Quarter 1	13	Quadriceps & Chest	Squat & lunge variations (ex: skaters, curtsey lunge); Pushups & Punches of varying paces
Quarter 2	11	Dynamic Core & Cardiorespiratory Endurance	Mountain climbers; Knee drive to punch; running in place; jumps
Quarter 3	11	High Intensity Cardiorespiratory Endurance	Broad jumps; burpees; plyometric pushups
Quarter 4	10	Low Intensity Core	Plank; swimmers; leg levers
Cool-down	5	Low Intensity dynamic & static stretching	Arm circles; hip flexor stretch; spinal flexion & extension

Participant's height, weight, and body fat percentage were assessed prior to the start of the first session. Height was obtained on a Detecto Balance Scale (Webb City, MO). Weight and body fat percentage were measured via the InBody Body520 Composition Analyzer (InBody, Seoul 06313 KOREA). All participants were then fitted with an Activio Heart Rate monitor (Activio Smart Belt, Stockholm, Sweden), which recorded heart rate in real time. TEE was obtained via HRe during both conditions for all 22 participants.

TEE and EPOC were also obtained via IC through four ParvoMedics metabolic carts (ParvoMedics Inc., Sandy, UT) in eight (4 males, 4 females) of the 22 participants during each condition. Out of the 11 people tested at a time, all were wearing the Activio heart rate monitor and four were wearing metabolic carts. All 11 participants from each group participated in the same 58-minute video-led group exercise session together, regardless of the data collection method. For those using the metabolic cart, a maximal oxygen consumption (V02max) treadmill test was completed prior to the first session. Treadmill speed and grade, which began at a walking pace with no incline, were gradually increased until the participant stepped off the moving belt, indicating volitional fatigue. HR, RPE, and VO2max data were collected at regular intervals throughout the assessment. Verbal encouragement was provided when appropriate.

Following anthropometric measurements and Activio set-up, participants were connected to the metabolic cart using a 2-inch diameter tubing and facemask. The metabolic cart was calibrated according to the manufacturer's instructions prior to data collection. Baseline values of oxygen consumption (VO2), carbon dioxide production (VCO2), and ventilator equivalent (VE) were collected in a seated position for 5-10 minutes prior to exercise. Individual breath-

by-breath data points for VO2 (L/min), VCO2 (L/min), and respiratory exchange ratios (RER) were collected for 1-minute, every 5 minutes of activity during each condition. Continuous breath-by-breath VO2 and VCO2 measurements were collected over a 40-minute period immediately following exercise and were used to calculate TEE during EPOC.

Statistical Analysis

RER were averaged during each 1-minute data collection point. Non-protein RER conversion charts were used to identify kcals/L02 obtained during each collection point, which were then used to extrapolate TEE over a 5-minute interval. TEE was calculated as the sum of the energy expenditure obtained over eleven data collection points. Post-exercise TEE was calculated by averaging RER obtained over the 40-minute period immediately following exercise. Non-protein RER conversion charts were used to identify kcals/L02 obtained during this period, which was then used to calculate TEE during EPOC.

Paired samples t-tests were performed to compare tee (throughout and post-exercise) between conditions using hre and ic. Statistical analysis was performed using ibm analytics, spss v24 with significance was set at $p < 0.05$. Individuals with missing data were excluded from statistical analysis.

RESULTS

TEE obtained by HRe and IC during a multi-intensity exercise session, WM and WOM, are expressed in Table 3. A significant difference was found when comparing WM and WOM TEE using IC ($n = 7$; $p = 0.008$). On average, participants burned an additional 46.37 ± 31.60kcals during a multi-intensity exercise session WM when using IC. There was no significant difference in: HRe WM vs. HRe WOM ($n = 21$; $p = 2.04$); HRe WM vs. IC WM ($n = 8$; $p = 0.91$); or HRe WOM vs. IC WOM ($n = 6$; $p = 0.563$).

Table 3. Total energy expenditure (kcals) obtained by HRe and IC during a multi-intensity exercise session, with and without music and cueing.

	HRe	IC
With Music and Cueing	482.67 ± 151.79 ($n = 21$)	475.74 ± 98.50 ($n = 7$)
Without Music and Cueing	452.90 ± 164.59 ($n = 21$)	429.37 ± 121.42 ($n = 7$)

Note: Data are expressed as: Mean±Standard Deviation (N). HRe = Heart rate estimation. IC = Indirect calorimetry. Individuals with missing data were excluded from statistical analysis.

There was no significant difference in TEE during EPOC using IC following either condition ($n = 8$; $p = 0.533$).

DISCUSSION

Although the use of music during group-exercise is commonplace, it is unclear if the presence or absence of synchronous music and cueing influences tee. Therefore, the purpose of this study was to determine tee of a multi-intensity exercise session wm and wom using hre and ic. This study found that the presence of music and cueing significantly increases tee during a 58-minute multi-intensity, group-exercise format. To our knowledge, this is the first study to demonstrate the effects of music and cueing on tee of physically active individuals participating in group-based exercise.

Participants in the present study obtained a tee of 475.74 kcals ± 98.50 when completing the 58-minute exercise session wm and ic. This is comparable to the tee obtained during the "added resistance aerobic" program known as pump, which is characterized by "compound resistance exercises using adjustable barbells and bodyweight exercises" performed at high repetitions and choreographed to music (6, 11). When analyzing tee of three commercial group exercise formats performed with music, wickham et al. Found that 52.8-minutes of pump burned 1385.1 kj/kg/min or approximately 331.05 kcals (11). Rixon et al. Also analyzed tee of multiple group exercise formats performed with music, and found that 60-minutes of pump burned 8 kcals/min or approximately 440 kcals (6). Although our program did not incorporate barbells, the use of kickboxing and compound bodyweight exercises did burn 475.74 ± 98.50 kcals when performed wm. This suggests that our program, when performed wm and when compared to pump, can burn a similar number of calories without equipment. It must be noted, however, that the data collection and reporting methods of these studies vary. While the present study used hre and ic to calculate total calories burned, rixon et al. Used heart rate monitors to report kcals/min and wickham et al. Used ecg electrodes to report kj/kg/min (6, 11). The differences in these methods makes it difficult to compare results between studies.

Although participants burned significantly more calories when completing the exercise session wm, music during a multi-intensity exercise session may not produce a tee comparable to those achieved during other modes of aerobic activity. When analyzing tee of commercial group exercise formats performed with music, rixon et al. Found that pump (8 kcals/min or 440 kcals) had a significantly lower tee than step aerobics (9.6 kcals/min or 576 tee), bodycombat (9.7 kcals/min or 582 tee), and cycling (9.9 kcals/min or 594 tee) (6). Wickham et al.'s study obtained similar results, where pump (1385.1 kj/kg/min or 331.05 kcals) also burned significantly less calories than step aerobics (2107.7 kj/kg/min, or 503.75 kcals) and cycling (1880.4 kj/kg/min or 449.43 kcals) (11). Considering the similarities between our program and pump, it can be assumed that the tee of a multi-intensity exercise session performed wm would also be less than other aerobic formats. As stated earlier, the differences in the data collection and reporting methods makes it hard to accurately compare tee between studies

Although a muscle-based multi-intensity exercise session may not produce a tee comparable to other forms of aerobic activity, it may be useful to fitness professionals looking to improve class participation and exercise adherence. A study by alter et al. Found that individuals

demonstrated greater adherence to a steady-state interval training program when provided music (1). In fact, individuals listening to a synchronous music playlist during exercise achieved "greater amounts of weekly physical activity" and experienced "lower declines in weekly physical activity than their non-music counterparts" (1). Changes in exercise adherence due to music may be a result of increased enjoyment of exercise (8). Including synchronous music, especially when stylized around personal preferences, may therefore be an effective strategy to increase exercise participation, adherence, and caloric expenditure over the long-term.

Lastly, the authors acknowledge several limitations in this study. When compared to ic, hre can produce differing results in tee. Although ic and other techniques can be more accurate, they can be more expensive and problematic when administered in a group-setting. Although significance was observed when comparing wm and wom tee using ic, the small sample size (n = 7) may be a limitation. Volunteers also formed a convenience sample of primarily college-aged adults. Thus, the results of this study might not be applicable to older populations. Additionally, researchers did not verify authenticity of self-reported measures, which may affect the results of the present study.

In conclusion, the results of this study indicate that the presence of music and cueing significantly increase tee during a 58-minute group-based multi-intensity exercise session. Music and cueing can, therefore, be used as a supplemental tool to aid in caloric expenditure. Future studies can expand on these data by calculating tee of a multi-intensity group-exercise session led by a group fitness instructor wm and wom (as opposed to video) in different populations such as competitive athletes and older adults. Related studies can determine the tee of other multi-intensity exercise sessions, such as high-intensity interval training, performed wm and wom. Lastly, future studies can investigate the effects of this multi-intensity exercise session performed wm on long-term physiological adaptations, such as aerobic capacity, and physical activity adherence.

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