Original Research

The Effect of Metronome Use on Heart Rates and RPE for Drum Corps Percussionists

DANIELLE M. DYE*[1], VAUGHN W. BARRY‡[2]

[1]Department of Health and Human Performance, Middle Tennessee State University, Murfreesboro, TN, USA; [2]Department of Health and Human Performance, Middle Tennessee State University, Murfreesboro, TN, USA

*Denotes undergraduate, ‡Denotes professional author

ABSTRACT

International Journal of Exercise Science 9(4): 412-418, 2016. The purpose was to evaluate if playing a musical selection without a metronome would affect the heart rates and rate of perceived exertion for drum corps percussionists. Heart rate and RPE values were collected from 11 battery and 12 front ensemble members from one drum corps. The music consisted of two portions of the show at different tempos of 96 and 176 beats per minute. The music was performed at "standstill" with the battery members lined up behind the front ensemble marching, but not moving around or carrying their instruments. The participants performed each show tempo, with and without a metronome—three times with a one-minute rest period between each rep. Participants recorded RPE values for the two show tempos, with and without a metronome. There was no significant difference in heart rate when playing without a metronome at both tempos. RPE values were higher for the slower (11.83 ± 1.61 vs. 12.65 ± 1.72, $p<0.05$), and the faster selections (13.87 ± 2.34 vs. 14.48 ± 2.33, $p<0.05$) when playing without a metronome. The front ensemble heart rates were higher than the battery during the faster selection with (104.39 ± 6.93 vs. 129.19 ± 17.40 bpm, $p<0.05$) and without a metronome (105.03 ± 8.03 vs. 128.58 ± 18.84 bpm, $p<0.05$). Playing without a metronome requires more effort, psychologically, but does not affect heart rate. The physical demands of the faster selection are most likely the cause of the significant difference in heart rate between the battery and front ensemble.

KEY WORDS: Physiology, percussion, marching band, synchronization, music performance

INTRODUCTION

Studies have measured the effects of music on heart rates, but the results remain inconclusive. The study by Ellis and Brighouse (6) showed non-significant results from music's effect on heart rate. Some studies conclude that music does not have a significant effect on heart rate and could be more relaxing than arousing (5, 6). The difference may be in performing an action to the rhythm of the music. In a study by Barbosa et al. (2), participants performed certain aquatic aerobic exercises to music with varying tempos. A significant change in heart rate probably occurred because participants performed aquatic exercise in time with the tempo, causing an increase in heart rate with an increase in exercise intensity. A study by Bernardi et al. (3) resulted in heart rates lower than the resting baseline when silence was

intermittently placed within musical tracks, suggesting that music and sound could have an arousing effect on heart rate. ESPN recorded an experiment in 2005 conducted by an exercise physiology professor, Dr. Edwards. Dr. Edwards measured a Drum Corps, elite marching band, percussionist's heart rate and energy expenditure during rehearsal. Data from Edwards' measurements showed that the member's heart rate jumped to 180 bpm when the corps started playing—while the member wasn't actually on the field playing (1). This testimony relates the effects of music and sound to the marching population and questions the degree of physiological response during rehearsal. In contrast to Dr. Edwards' experiment, data will include heart rate and RPE measurements from multiple percussionists within the battery and front ensemble rather than measurements from one percussionist in the battery. The battery consists of the marching snare, tenor, and bass drums; the front ensemble consists of non-marching marimba, vibraphone, xylophone, glockenspiel, and auxiliary instruments.

Fewer studies have distinguished the effects of certain sounds or tempi without music. A study by Yanagihashi et al. (11) concluded that a mechanical sound in comparison to a synthesizer and birds tweeting induced alertness and sympathetic nervous dominance in the participants. These results suggest that a mechanical sound, such as a metronome emitting repetitive beeps, creates alertness and could increase heart rate. A study by Repp (8) assessed finger tapping synchronized with repetitive sound. The response to tempo change was used as a means to quantify internal neural processes. Repp concluded that detection of change caused a quicker correction response in finger tapping than undetected change (8). Drum corps percussionists consciously make tempo adjustments in response to the metronome and to each other during rehearsal. However, no studies have assessed whether the use of a metronome affects heart rate. Internalizing tempo without a metronomic correction may or may not affect heart rate.

The Borg RPE scale is a numerical and descriptive scale ranging from 6 to 20, and "no exertion at all" to "maximal exertion," respectively. This scale was created to predict heart rate with the equation, HR = RPE x 10 bpm, and used to predict intensity for dynamic exercise (9). In a study by Chen et al. (4), dynamic, partially dynamic, and static exercises (i.e. running, dumbbell curls, and an isometric curled position while holding a dumbbell, respectively) were performed to validate the relationship between RPE and heart rate. Chen et al. (4) validated the modified regression equation for an RPE range of 11-16 (HR = RPE x 10 + 20 ~ 30 bpm) and concluded that RPE could not accurately predict heart rate for partially dynamic and static exercise. Therefore, the relationship between heart rate and RPE is dependent on full-body, aerobically demanding work. Because standing and playing would be considered a partially dynamic exercise, RPE cannot accurately predict the heart rate response for this study. The RPE scale will be used to evaluate perceived exertion while playing. The study by Barbosa et al. (2) resulted in a strong linear relationship between cadence tempo and RPE, suggesting that the participants' perceived exertion increased as they performed a motion at a faster pace. However, no research has evaluated perceived exertion in response to playing an instrument without a metronome.

Table 1. Characteristics of Participating Drum Corps Members (mean ± *SD*)

	BATTERY (*n*=11)	FRONT ENSEMBLE (*n*=12)	TOTAL (*n*=23)
Age (y)	19.91 ± .90	20 ± 1.15	19.96 ± 1.07
Male	10	6	16
Female	1	6	7
Resting Heart Rate (bpm)	63.27 ± 7.01	70.03 ± 6.05	66.80 ± 7.51

The purpose of this study is to evaluate if playing a musical selection without a metronome would affect the heart rates and RPE values of drum corps percussionists. It is hypothesized that heart rate and RPE will not vary when playing musical phrases without a metronome as these are highly trained individuals and playing without a metronome should not be more difficult.

METHODS

Participants

Data were collected from 23 percussionists from one drum corps (see table 1). The drum corps director was emailed for approval before recruiting the percussionist members. The mean age among 16 males and seven females was 19.96 ± 1.07 years. Percussionists (11 battery and 12 front ensemble) were evaluated, varying in the specific instrument played. Based on the AHA/ACSM Health/Fitness Facility Preparticipation Screening Questionnaire, all participants were able to participate in physical activity, and were free of heart problems. After explaining the protocol and purpose, consent was attained. The University Institutional Review Board approved this study.

Protocol

Roughly 26 hours before data collection day, participants were emailed and/or texted a list of foods and supplements containing caffeine that were to be avoided. On the morning of data collection, participants were assigned monitors, ate breakfast, and completed a daily group stretch regimen. After stretching, all 23 participants assumed supine positions for roughly 15 minutes. Resting heart rates were recorded for five minutes, afterwards. Participants followed a regular morning rehearsal schedule once the resting heart rate measurement was complete. Rehearsal was spent outside where the front ensemble learned and practiced music, while the battery learned and practiced marching formations on a field. After an hour lunch, the percussion sections lined up in standstill in an air-conditioned gym to complete the heart rate assessment with and without the metronome.

The metronome setup consisted of a Boss DB-90 Dr. Beat digital metronome (Roland Corporation US, Los Angeles, California) on the quarter note, non-accented setting and connected to a Long Ranger portable speaker (Lectrosonics, Rio Rancho, New Mexico). Heart rate was measured using Polar RS800 heart rate monitors (Polar Electro, Kempele, Finland). Each monitor strap was lubricated with water and placed on the skin over the sternum and below the chest muscles. The members were allowed

to wear the sensor watches or keep them in mallet bags while playing. The music consisted of two portions of the 2014 Phantom Regiment Drum and Bugle Corps production, *Swan Lake* (3). The first selection was picked from the first movement of the show—an arrangement of *Swan Lake* by Peter Illyich Tchaikovsky, and was played at 96 bpm. The second selection was the percussion feature in the third movement of the show—an arrangement of *Dracula* by Philip Feeny, and was played at 176 bpm. The show selections were chosen based on moments that both percussion sections played and that both sections were comfortable with, while providing a tempo variety. The time elapsed for each repetition included the first tap or beep of the metronome to the last not played; the metronome was stopped with the last note played. The slower, majestic selection lasted approximately 50 seconds, while the faster, aggressive selection lasted approximately one minute and 13 seconds. The music was performed at "standstill" where the battery members were lined up behind the front ensemble; the battery was marching in time but not moving around and not carrying their instruments. The repetitions with a metronome included four quarter-note beeps before the cues and continuous beeping until the last note played. All repetitions included the center snare player tapping two half-note cues followed by four quarter-note, vocal "duts" or cues from the entire battery. Participants performed each show section (with and without a metronome) three times with a one-minute rest period between each rep in order to allow physical and mental rest. Once they finished playing completely, participants recorded RPE values for the two show tempos, with and without a metronome.

Statistical Analysis

After data collection, the resting heart rates for the second through fourth minutes of rest were averaged. The fifth minute was not included as many participants moved during this minute. Analysis involved downloading the heart rate information through Polar ProTrainer 5 (Polar Electro, Kempele, Finland). Lap markers were manually placed at the recorded start and stop times for each repetition to average the heart rates for the metronome and non-metronome repetitions. Statistical analysis was completed using SPSS version 20 software (IBM, Armonk, New York), to compare metronome vs. non-metronome heart rates and RPE values for the entire group, and between the battery and front ensemble. Paired-sample and independent T-test analyses measured significance at a p value of ≤ 0.05.

RESULTS

There was no significant difference between heart rates with and without a metronome for each tempo. RPE values were significantly higher for the first musical selection at 96 bpm ($p<0.05$), as well as the second selection at 176 bpm ($p<0.05$) without a metronome compared to with a metronome (See table 2). The front ensemble heart rates were higher than the battery only during the 176 bpm selection with ($p<0.05$) and without a metronome ($p<0.05$) (See table 3 and table 4).

DISCUSSION

The primary purpose of this study was to evaluate if playing a musical selection without a metronome would affect the heart rate of drum corps percussionists. The

Table 2. Total Heart Rate and RPE* Values When Playing With and Without a Metronome at Different Tempos (mean ± *SD*)

	96 M	96 NM	176 M	176 NM
Heart Rate (bpm)	105.49 ± 9.00	104.96 ± 9.43	117.33 ± 18.27	117.32 ± 18.75
RPE	11.83 ± 1.61	12.65 ± 1.72†	13.87 ± 2.34	14.48 ± 2.33‡

*RPE=Rate of Perceived Exertion; M=with a metronome; NM=without a metronome; *n*=23; †*p* =.000 96 NM vs 96 M for RPE; ‡*p* =.003 176 NM vs 176 M for RPE

secondary purpose was to evaluate the psychological effort using RPE during the same scenario. Results showed no significant difference in heart rate between playing with and without a metronome at the slower tempo (105.49 ± 9.00 vs. 104.96 ± 9.43) and faster tempo (117.33 ± 18.27 vs. 117.32 ± 18.75), respectively. However, RPE was significantly different when playing with and without a metronome at the slower tempo (11.83 ± 1.61 vs. 12.65 ± 1.72, $p< 0.05$) and faster tempo (13.87 ± 2.34 vs. 14.48 ± 2.33, $p< 0.05$). In addition, the front ensemble had significantly higher heart rates than the battery while playing with (104.39 ± 6.93 vs. 129.19 ± 17.40, $p< 0.05$) and without a metronome (105.03 ± 8.03 vs. 128.58 ± 18.84, $p< 0.05$) at a tempo of 176 bpm.

Most likely, the lack of effect from playing without a metronome is due to the percussionists performing the same motions regardless of a metronome. Percussionists are trained to perform the same motions without a metronome, so the heart rate remains consistent in order to maintain consistent actions. Furthermore, the significant difference in heart rate between the battery and front ensemble seems contradictory. Studies by Barbosa et al. (2) on aquatic aerobic participants and Bernardi et al. (3) on musicians and nonmusicians show a linear relationship between tempo and heart rate. Therefore, as percussionists move at a faster speed, heart rate should increase. One would think the battery would have similar heart rates to the front ensemble as the battery is not marching and wearing their instruments, yet the heart rates were lower at the faster tempo. One reason could be that battery members are more fit, indicated by a lower average resting heart rate and greater stroke volume, causing a less dramatic rise in heart rate with intensity. The study was completed a week after the beginning of full-day rehearsals requiring the battery to march and carry their drums. Some physiological adaptations to training could have occurred. However, the average

Table 3. Heart Rate and RPE* Values by Section When Playing With and Without a Metronome at 96 bpm (mean ± *SD*)

	M BA	M FE	NM BA	NM FE
Heart Rate (bpm)	102.72 ± 7.55	108.03 ± 9.77	101.64 ± 7.13	108.00 ± 10.52
RPE	11.55 ± 1.86	12.08 ± 1.38	12.73 ± 1.90	12.58 ± 1.62

*RPE=Rate of Perceived Exertion; M=with a metronome; NM=without a metronome; BA=Battery (*n*=11); FE=Front Ensemble (*n*=12)

Table 4. Heart Rate and RPE* Values by Section When Playing With and Without a Metronome at 176 bpm (mean ± *SD*)

	M BA	M FE	NM BA	NM FE
Heart Rate (bpm)	104.39 ± 6.93	129.19 ± 17.40†	105.03 ± 8.03	128.58 ± 18.84‡
RPE	12.82 ± 2.27	14.83 ± 2.04	13.82 ± 2.52	15.08 ± 2.07

*RPE = Rate of Perceived Exertion; M = with a metronome; NM = without a metronome; BA = Battery (*n* = ll); FE = Front Ensemble (*n* = 12); †*p* = .000 M Front Ensemble vs Battery for Heart Rate; ‡*p* = .001 NM Front Ensemble vs Battery for Heart Rate

resting heart rate in the front ensemble could be higher due to a greater number of females in that section. Although the AHA-ACSM questionnaire contains a question regarding physical inactivity, activity levels before the study were not assessed. The most probable cause is the musical demands particular to the front ensemble compared to the battery. Even though both sections may be playing at the same tempo and using mainly upper body motion to play, the differences in playing motion (e.g. pronating, supinating and flexing the wrist once vs. twice within the same amount of time, and playing in one area of the drum vs. reaching for notes) support the significant heart rate differences between the battery and front ensemble.

The significant change in RPE when playing without a metronome suggests that more psychological effort is needed to play without a metronome. The goal of maintaining tempo is to maintain the space between each beat, not necessarily maintaining a beat. In order for the entire percussion section to play together and sound like one musician, personal adjustments must be made in order to play each beat of music with the correct space corresponding to tempo. A metronome provides a constant and consistent checkpoint that can be heard by all percussionists. Playing without a metronome removes this checkpoint, causing tempo to fluctuate, and members to adapt more often. Repp (8) recreated previous finger tapping experiments to validate awareness of tempo change. The study concluded that a conscious effort is required to detect tempo change quickly. An internal timekeeper controls motor activity. The difference in space between the audible tones and the pace controlled by the timekeeper must be acknowledged and diminished for synchronization. This involves a higher-level cognitive response, which could correlate to the change in perceived exertion when playing without a metronome.

Several limitations accompany this study. Although the battery playing in standstill and not carrying their drums allows a comparison to the front ensemble, this formation is not indicative of typical performance setup. Normally, the battery is marching and carrying drums around a field while the front ensemble stays in the same area the entire performance. The difference in energy demand would be interesting to compare. A potential bias in the study includes participants not understanding how to correctly rate perceived exertion, which was minimized with verbal instructions and stress on individual perception. Another potential bias could be practicing outside before the

study, which could elevate heart rates prematurely. Performing the study inside after an hour-long lunch break helped minimize this by allowing the body to rest before the assessment. One of the biggest limitations would be relating the battery vs. front ensemble analysis to other marching groups. Drum corps shows are constantly evolving and none are completely alike. Because the difference between the battery and front ensemble heart rates was most likely dependent on the music played, other corps may have different outcomes. Possible future research includes measuring the heart rates and RPE during a performance day, comparing the effects between different corps, comparing the heart rates of battery members when marching and in standstill, and measuring the metronomic effects on the heart rates of less experienced high school marchers.

In conclusion, playing without a metronome requires more effort psychologically, but may not affect heart rate. Therefore, when learning music, rehearsing with a metronome may reduce psychological effort and allow musicians to focus on other aspects of the music or the show. In addition, more emphasis on rehearsing without a metronome prior to performance may allow percussionists to adjust to the elevated perceived effort associated with playing without a metronome.

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