

# **The Effect of Varying Musical Tempo on Exertion During Exercise in College Students**

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## **Abstract**

*This experiment explored the effect of tempo of music plays on one's exertion during exercise. Participants were asked to exercise for two 8-minute sessions, with and without music. Music was played to participants based on slow (60 bpm), medium (100 bpm), or fast (160 bpm) tempi. Physiological responses to exercise and music were measured and compared to one another to find relationships between tempo and exerted effort. Results suggested participants who listened to music while exercising increased their average heart rate (10 bpm), exerted more effort (burned 7% more calories), and increased perceived exertion by 5%. Specifically, fast and medium tempi increased perceived exertion, while slow music decreased mean arterial pressure during exercise. Future research should continue to focus on personal musical preferences in genre and tempo so as to further investigate how music affects the body physiologically.*

## **Introduction**

Americans are constantly bombarded by music – whether they know it or not. Music is played in grocery stores, gyms, commercials and movies. From the advent of the boom-box on the shoulders of kids in Brooklyn, music has been a companion of the pedestrian for decades. Today, mp3 players and cell phones provide a constant source of music, tuning out the sounds of everyday nature and traffic alike. But how does music and its varying components affect athletic physiology?

Music is composed of a vast number of facets ranging from rhythm to mode to genre to tempo. Tempo, one of our study's main focuses, can be defined as the speed of a musical piece as measured to a metronome. This speed is often described in terms of beats per minute (bpm),

with 100 bpm being the average tempo for most music. In this study, we aim to investigate the effect tempo plays on one's physiology when exercising.

Provided the pervasiveness of fast-paced music in exercise facilities, there is reason to believe that there may be a connection between the pace of music and the physiologic response. In 2007, Carpentier and Potter chose to look at how tempo affects arousal from a physiological perspective. Their goal was to determine whether tempo could be connected to increased activation of the autonomic nervous system, which would correspond to elevation in the listener's arousal. The study also focused on whether the tempo could act in the same manner as other auditory features known to cause increased activity in the sympathetic nervous system. Carpentier and Potter hypothesized that there would be a significant effect of tempo on the sympathetic nervous system's level of activation, and believed tempo would be positively correlated with arousal. The results of the data supported their hypothesis and showed that fast-paced music (high bpm) induced a greater activation of the sympathetic nervous system than slow-paced music.

Studies have also examined the relationship between the tempo of music listened to during exercise and the blood plasma concentrations of the stress hormone epinephrine. Epinephrine, also commonly known as adrenaline, is a key hormone in the body's stress response and is critical in preparing the body for exercise or activities of endurance. Yamamoto et al. (2003) found that listening to different music for 20 minutes before exercise can affect the plasma epinephrine level but it did not affect the short term (45 seconds) cycle power output. The interesting finding was that fast tempo music increased the plasma epinephrine level whereas slow tempo music decreased the plasma epinephrine level compared with baseline. This indicated that the tempo of music can affect the physiological function of human body.

Another study (Karageorghis, Jones, and Low, 2006), found that participants had different preferences for musical tempi when they were working out at different levels of maximal heart rate reserve (HRR;  $HRR = \text{max HR} - \text{resting HR}$ ). The study had 29 undergraduate students walk on a treadmill at three different exercise intensities while listening to music with different tempi. The results showed that most participants preferred medium (120 bpm) or fast (140bpm) tempo music to slow tempo (80 bpm) when they work out at 40% and 60% HRR and preferred fast tempo music to both medium and slow tempo when they work out at 75% HRR.

This study attempted to determine the affect of exercise on physiologic responses, as measured by mean arterial pressure (MAP) and heart rate. It was a goal of the study to determine the effect music would have on work, exertion, and the physiologic response. Finally, an understanding of how increasing tempo would affect work, MAP, and heart rate was sought. We hypothesized that participants who exercised would have higher MAPs and heart rates than those who did not exercise. We hypothesized that while exercising, participants would perform more work and perceive greater exertion when listening to music. We expected to find the heart rates and MAPs to be significantly affected during exercise when participants listened to music compared to when they exercised without music. We expected to find that participants who listened to fast paced music would experience the greatest increase in work, MAP, and heart rate compared to those who exercised with moderate- or slow-tempo music.

## **Methods**

### **Participants**

Study participants included 20 individuals (9 females, 11 males), recruited by the experimenters as a class requirement for Physiology 435 at the University of Wisconsin –

Madison. To be considered eligible, participants were required to be English speakers, at least 18 years of age, healthy enough to partake in moderate exercise, and without prior knowledge of the experiment and its hypotheses. Ages ranged from 19 to 26 ( $M = 21.1$  years,  $SD = 1.4$  years). Participants were run individually and were treated in congruence with standard ethical consideration. It should be noted that two participants had data omitted from the study for their exercising with music condition due to a glitch in the fast tempo music clip. Non-music data from these participants was still included in the data analysis.

## **Materials**

Our experiment implemented several instruments, including one cycle ergometer (Schwinn Airdyne Model#3016443), a digital pulse oximeter (Nowin Medical Inc. Model#9843), a digital blood pressure cuff (Walgreens SSN-414W), and one set of computer speakers. The Borg perceived exertion scale was also used during our experiment to help participants relate their exertion levels to the researchers.

A cycle ergometer was used to measure the pedal rate, total distance, and kilo-calories burned by the subject. The pedal rate indicated the change of power output over time (one minute). The total distance and kilo-calories burned measurements displayed the amount of effort the participant exerted during the period of exercise. In using kilo-calories burned, we found how many Joules of energy were consumed through exertion by means of the cycle ergometer. A pulse oximeter measured the heart rate of the subjects. It allowed for resting and exercising heart rates to be measured in one minute intervals. The heart rate while exercising was used to help indicate how much effort the subject put forth during exertion. A digital blood pressure cuff allowed our group to measure blood pressure once while the subject continued to exercise and once at the completion of exercise. The Borg perceived exertion scale allowed the

participants to communicate their perceived effort levels to the researchers. Previous research had found that music could lower subjects' perception of exertion when they work at the same moderate exercise intensity (Boutcher, 1990). Thus, participants may have worked at a higher intensity when they listen to music while they perceive the exertion is same. Finally, one set of computer speakers was used to play our tempo-controlled music.

## **Procedure**

Participants exercised individually in a quiet location on a cycle ergometer. Participants were asked to read and sign a consent form that explained the general logistics of the experiment and were given the opportunity to ask any questions prior to the start of the experiment.

Participants' sex and age was recorded. The participants resting blood pressure was measured with a digital blood pressure cuff secured around the left wrist. A pulse oximeter was clipped and secured to the left-hand pointer finger to measure the heart rate at rest.

Participants were shown a 15-grade scale of perceived exertion (RPE) (Borg, 1982) to familiarize themselves with it prior to the beginning of physical exercise. The Borg scale was taped over the digital counter of the cycle ergometer so participants remained unaware of their peddle rate and amount of time peddling. Participants were asked to exercise moderately over eight minutes in accordance with their ability to ambient sounds (no music). Active heart rate was recorded every minute and blood pressure was recorded after four minutes and immediately following eight minutes of exercise. Perceived exertion was recorded at four and seven minutes based on the feeling of the participants. Peddle rates were also recorded at the four and seven minute marks. The ergometer's estimated amount of calories burned and total distance peddled

over eight minutes was recorded. Participants were then allowed a rest period of ten minutes to sit, stretch and/or drink water.

The second trial was separated from the first by at least 10 minutes to reduce the effect of fatigue on the participants' performance. Participants were randomly assigned to a music condition with one of three tempi (slow 60bpm, medium 100bpm, or fast 160bpm). Music played as soon as participants started exercising and lasted throughout the 8 minutes exercise period. The music in each tempo category was same for all participants. Heart rate, blood pressure, RPE, total distance, and caloric recordings were taken identically to the first trial. Mean arterial pressure was calculated from the systolic and diastolic measurements. Participants were debriefed, allowed to ask questions, and permitted to leave.

A paired t-test was used to compare the average heart rate, perceived exertion, MAP and total calories burned between exercising with and without music. These variables were also compared among exercising without music and exercising to one of three different musical tempi. A  $p$ -value  $< 0.05$  was considered to be significant.

## **Results**

To begin, it was predicted that MAP and heart rate would increase in participants who exercised with music compared to those who did not. Participants were found to have higher heart rates and MAPs when exercising, compared to baseline ( $p < 0.01$ , Figures 1 and 2). Additionally, it was hypothesized that participants who listened to music would show an increase in number of calories burned when listening to music than when in silence. 7% more calories were burned when participants listened to music than when they did not ( $p = 0.023$ , Figure 3B). Regardless of tempo, music was also observed to increase perceived exertion by 5% ( $p = 0.018$ ,

Figure 3A) and increased the heart rate by 10 beats per minute ( $p = 0.015$ , Figure 1). No difference was found in average MAP between music and no music exercises ( $p = 0.1$ ).

The final hypothesis presented the idea that faster music may cause an increase in calories burned and may bring physiological changes, positive or negative. There was a trend in increase in average heart rate at moderate and fast tempo (Figure 4) but the increase was not significant ( $p=0.14$  &  $p=0.11$  respectively). Both fast and medium temps increased perceived exertion (Figure 5A,  $p = 0.05$  and  $p = 0.030$  respectively), while slow music did not ( $p = 0.88$ ). Slow music decreased MAP when compared to exercising without music (Figure 6,  $p = 0.033$ ). Fast and medium music did not cause significance change in MAP ( $p = 0.79$  and  $p = 0.16$ , respectively). Fast and medium music had a trend of increase calorie burned during exercise although not significant (Figure 5B,  $p= 0.12$  and  $p=0.13$  respectively), whereas slow music did not change calorie burned ( $p=0.52$ ).

## Discussion

Although results did not support all of the hypotheses in this study, several significant findings were discovered. When compared to participants' baseline (at rest) vitals, an increase in MAP and heart rate was observed when they exercised, as hypothesized. Data also supported the hypothesis that among those who exercised, those who listened to music performed more work (calories burned) and perceived greater exertion. While listening to music, MAP and heart rates were significantly affected when compared to participants who exercised without music, as hypothesized. The relative affects of differing tempi did not support any of our hypotheses. There was no significant increase in work between slow, medium, and fast tempi; there was, however, a significant increase in work between no music and music trials. Another unsupported

hypothesis suggested that fast, medium, and slow tempi would cause the participant to perceive that more work is being done when compared to the trial without music. We found that only fast and medium tempi increased perceived exertion. Slow music had no measurable effect on perceived exertion. Finally, MAP decreased when listening to slow music when compared to no music. Neither fast nor medium tempo music significantly increased MAP when compared to the no music trials.

This study confirmed that exercise increases MAP and heart rate. Haslam et al (1988) and Bertovic et al (1999), among many others, have found similar results. As the body performs work, the heart rate and MAP increase in order to deliver oxygen to the working muscles.

It is possible that a correlation between the presence of music during exercise and an increase in work and exertion were observed when compared to the no music trial. As participants listened to music, they were motivated by the pace of the music to pedal faster. Because the participant was pedaling faster, they perceived that they were working harder, as reflected in the increase in Borg scale score as compared to the exercise trial without music. As the participant pedaled relatively faster than he or she would have without music, the heart rate increased as compared to the trial without music.

The effect of the presence of music tended to have significant effects for the exercising body, however, the tempo, whether fast, medium, or slow, tended to have a lesser effect. In understanding why work was not positively correlated with tempo, it is possible that the mere presence of music was stimulating enough to cause the participant to work harder, but the differences between tempi was not as pronounced. Music was found to significantly increase heart rate over the first four minutes of the 8-minute exercise sessions. However, this data should be discounted as resting periods, though at least 15 minutes between exercising sessions,

may have not been long enough for some participants to return to baseline vitals, resulting in the observed increase in heart rate. An additional explanation for this observation may be that participants may have reached their target heart rate for the amount of effort they put forth within 4 minutes of exercise and thus leveled out, or realized they still had 4-minutes of exercise remaining and subsequently paced themselves.

Interestingly, participants perceived they were working harder while listening to fast and medium tempo music, even though the amount of work done was not significantly different between slow, medium, and fast tempi. Essentially, it seems that listening to music during exercise is correlated with greater work expenditure, but the tempo of music does not make a significant difference in the amount of work done. The participants only feel like they are working harder, however, when they listen to fast paced music, even when they are not.

Fast and medium tempo music did not significantly increase MAP when compared to the no music trial, however, slow music was shown to decrease MAP. It can be inferred that the music was slow enough to relax the exercising participant and decrease MAP, as has been studied with meditative music by Knight (2001). Given a larger sample size, a similar observation may be seen with the slow and medium paced tempi.

Limitations for this study include experiment setting and variance of the participants' familiarity and preference of music. Error could be attributed to inconsistencies of experimental setting. While this study attempted to keep the environment as consistent as possible, inconsistencies may have included, but are not limited to: location of cycle ergometer in lab room, unwanted distraction or sources of noise (i.e. students walking down the hall adjacent to the experiment room, walking through the room, talking about various concepts with professors, etc.), temperature, and time of day. These inconsistencies would be significantly reduced if one

single room with white, soundproof walls and only necessary equipment was employed to control for all outside variables.

An additional limitation was variance of the participants' familiarity and preference of music. This limitation became apparent after several participants commented on the musical selection during the musical session of exercise. As stated by Kellaris and Kent (1994), certain music may just elicit a certain response to genres such as pop or rock, as participants have an expectancy of what it should sound like as opposed to classical or other less known genres, which may not have the same familiarity. Additionally, it is a matter of personality. Just as there are nearly seven billion people on earth, there are just as many ways to interpret any one song. Taking this fact into account, we made a musical track list that focused more so on tempo than genre. Tempo is much less time-consuming than preparing music based on individual musical preferences. If genre was selected for, each participant could react differently. They may run slower when they are more comfortable with a song based only on personal preference and habit. To control for this variable a matched-pairs design should be implemented and participants would be required to complete a test indicating their level of prior musical experience and preference at the start of the experiment. Error may also be attributed to caffeine or other physiological arousing factors as most were participants partaking in other studies occurring synonymously with this study as they were part of a larger convenience sample.

A final limitation can be attributed to equipment. Certain equipment (ex. pulse oximeter and digital blood pressure cuff) was unreliable and faulty at times (not recording constantly or needing to be rerun). Specifically, the cycle ergometer used in the experiment was "one-of-a-kind". It was both a great control and a great hindrance in collecting and receiving our data. The main hindrances were that there was only one cycle ergometer of its kind in the lab and that the

pedaling resistance was not adjustable. The blessing in disguise came with the realization that, rather than having to calculate BMI and other personal information for each participant, the “calories burned” reading could be generalized across our pool of participants. In this case, the amount of work the bike recognized was a general measure. This allowed for easily comparable data for “calories burned” across subjects without the need to adjust calculations for error. However, actual calories burned may have differentiated significantly from the observed digital readout as a result of individual participant’s BMI.

Ideally, this study should be conducted again in a more standardized fashion. In this standardized study, it is recommended that participants would all complete the experiment in the same room with the same experimenter giving the prompts. Additionally, the experimenter and environment should strive to control for as many confounding variables as possible (i.e. distraction, musical familiarity, equipment failure, etc.). Another recommendation for future research would be to increase the size of the participant population. This change alone could significantly alter the results seen, because while random selection was implemented, it is difficult to see differences with such a small convenience sample. Additionally, it would be interesting to explore individual genres while still controlling for tempo, mode, and instrumentation.

## **Addendum**

### **Introduction**

After the original study was sent for review, it was suggested that an order effect may have been incurred as all participants listened to music in the second exercise condition. As a result of this procedural shortcoming, the data obtained may be affected in one direction if the subjects were tired from the first session, or if the first session served as a “warm-up” for the

second session. In an attempt to correct this potential order effect, three additional participants were run with a modified procedure and results are discussed below. It is hypothesized that no differences will be observed from this study's original hypotheses.

## **Methods**

### **Participants**

Study participants included 3 individuals (2 females, 1 males), recruited by the experimenters as a class requirement for Physiology 435 at the University of Wisconsin – Madison. To be considered eligible, participants were required to be English speakers, at least 18 years of age, healthy enough to partake in moderate exercise, and without prior knowledge of the experiment and its hypotheses. Ages ranged from 22 to 23 ( $M = 22.6$  years,  $SD = 1$  years). Participants were run individually and were treated in congruence with standard ethical consideration.

### **Materials**

Our experiment implemented several instruments, including one cycle ergometer (Schwinn Airdyne Model#3016443), a digital pulse oximeter (Nowin Medical Inc. Model#9843), a manual blood pressure cuff (MedSource International #MS-BP100 Adult) and one set of computer speakers. The Borg perceived exertion scale was also used during our experiment to help participants relate their exertion levels to the researchers.

A cycle ergometer was used to measure the pedal rate, total distance, and kilo-calories burned by the subject. The pedal rate indicated the change of power output over time (one minute). The total distance and kilo-calories burned measurements displayed the amount of effort the participant exerted during the period of exercise. In using kilo-calories burned, we

found how many Joules of energy were consumed through exertion by means of the cycle ergometer. A pulse oximeter measured the heart of the subjects. It allowed for resting and exercising heart rates to be measured in one minute intervals. The heart rate while exercising was used to help indicate how much effort the subject put forth during exertion. A digital blood pressure cuff allowed our group to measure blood pressure once while the subject continued to exercise and once at the completion of exercise. The Borg perceived exertion scale allowed the participants to communicate their perceived effort levels to the researchers. Previous research had found that music could lower subjects' perception of exertion when they work at the same moderate exercise intensity (Boutcher, 1990). Thus, participants may have worked at a higher intensity when they listen to music while they perceive the exertion is same. Finally, one set of computer speakers was used to play our tempo-controlled music.

## **Procedure**

Participants were asked to read and sign a consent form that explained the general logistics of the experiment and were given the opportunity to ask any questions prior to the start of the experiment. Participants' sex and age were recorded. The participants resting blood pressure was measured with a digital blood pressure cuff secured around the left wrist. A pulse oximeter was clipped and secured to the left-hand pointer finger to measure the heart rate at rest.

Participants were shown a 15-grade scale of perceived exertion (RPE) (Borg, 1982) to familiarize themselves with it prior to the beginning of physical exercise. The Borg scale was taped over the digital counter of the cycle ergometer so participants remained unaware of their peddle rate and amount of time peddling. Participants were asked to exercise moderately over eight minutes. Participants were randomly assigned to a music condition with one of three tempi

(slow 60bpm, medium 100bpm, or fast 160bpm). Music played as soon as participants started exercising and lasted throughout the 8 minutes exercise period. The music in each tempo category was same for all participants. Active heart rate was recorded every minute and blood pressure was recorded after four minutes and immediately following eight minutes of exercise. Perceived exertion was recorded at four and seven minutes based on the feeling of the participants. Peddle rates were also recorded at the four and seven minute marks. The ergometer's estimated amount of calories burned and total distance peddled over eight minutes was recorded. Participants were then allowed a rest period of ten minutes to sit, stretch and/or drink water.

The second trial was separated from the first by at least 10 minutes to reduce the effect of fatigue on the participants' performance. Participants exercised again, for 8 minutes, but without music. Heart rate, blood pressure, RPE, total distance, and caloric recordings were taken identically to the first trial. Mean arterial pressure was calculated from the systolic and diastolic measurements. Participants were debriefed, allowed to ask questions, and permitted to leave.

A paired t-test was used to compare the average heart rate, perceived exertion, MAP and total calories burned between exercising with and without music. These variables were also compared among exercising without music and exercising to one of three different musical tempi. A p-value < 0.05 was considered to be significant.

## **Results**

Results were very similar to those found in the original experiment. Due to having such a small subset of participants, all p-values were deemed insignificant (all  $p > 0.05$ ). Raw data showed that MAPs were, on average, very close to the same during exercise as they were at rest

( $p > 0.8$ ). Heart rates spiked during exercise with music compared to exercising without ( $p = 0.09$  for the first 4 minutes,  $p = 0.89$  for last 4 minutes, and  $p = 0.26$  for total average HR). The amount of calories burned did not appear to be higher with music when compared to no music like in our original experiment ( $p = 0.36$ ). Perceived exertion was not found to be significantly different between music and no music ( $p = 0.74$  at the 4<sup>th</sup> minute of exercise,  $p = 0.58$  at the 7<sup>th</sup> minute of exercise).

## **Discussion**

The correctional aspect of this experiment should be taken with a grain of salt. Limited time in-lab allowed for only three additional participants, one in each music condition, and this did not allow for standard deviations to be found for each specific tempo. With a sample size this small, the results obtained can only be based on a single individual. Further, paired t-tests could not be calculated as they depended on the existence of a standard deviation. These limitations eliminated any validity when making inferences on whether or not order played a role in the results observed. Raw data may have suggested there was a majority of information that benefited the integrity of the original results, yet all of the paired t-tests disagreed. Hence, though our data from the three participants appeared to be generally in line with our original study, we cannot determine whether or not the order effect affected past participants.

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## Appendix

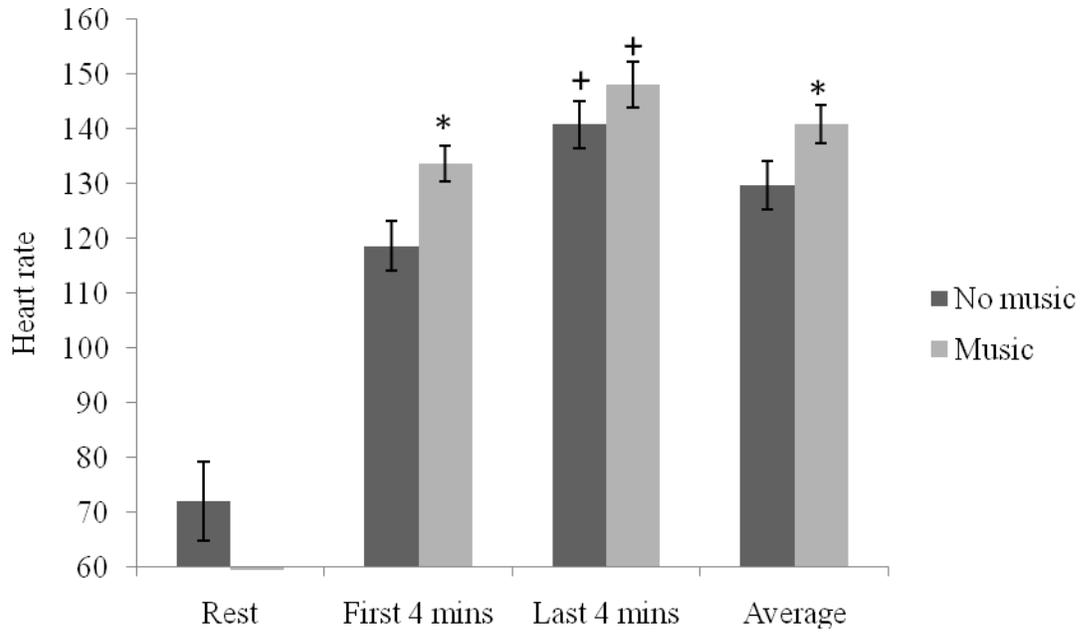


Figure 1. Comparison of average heart rate during exercise with music and without music. + Significantly different from the first 4 minutes average ( $p < 0.05$ ); \* significantly different from no music ( $p < 0.05$ ).

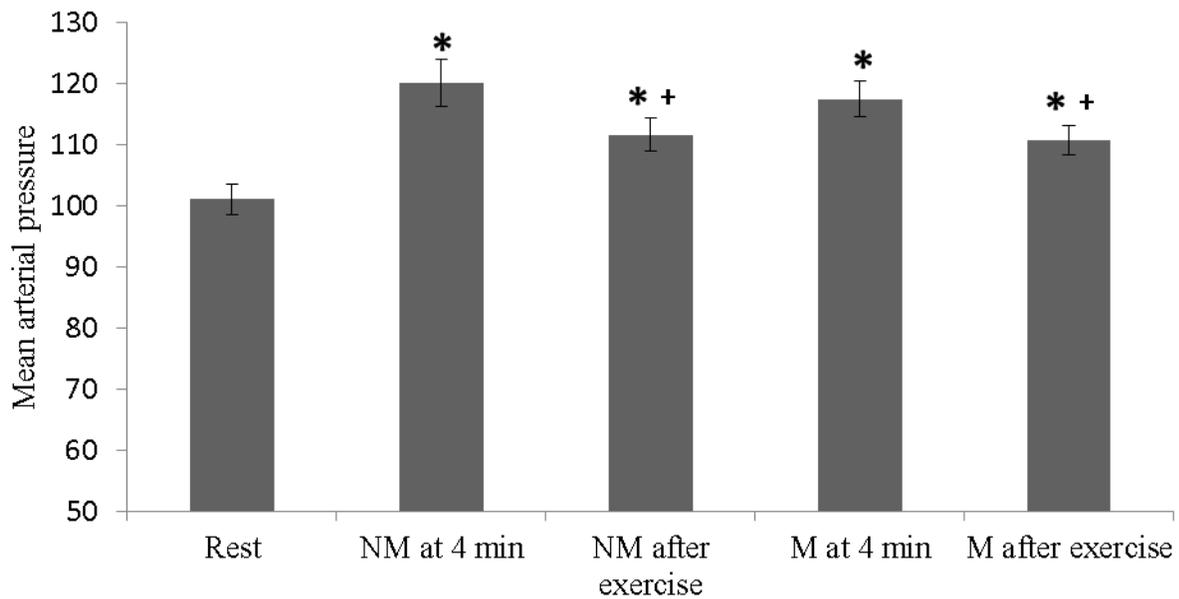


Figure 2. The average MAP at rest, at 4 minute during exercise, and immediately after exercise. \* significantly different from resting value ( $p < 0.01$ ); + significantly different from average blood pressure at 4 minute ( $p < 0.05$ ); NM, no music; M, music.

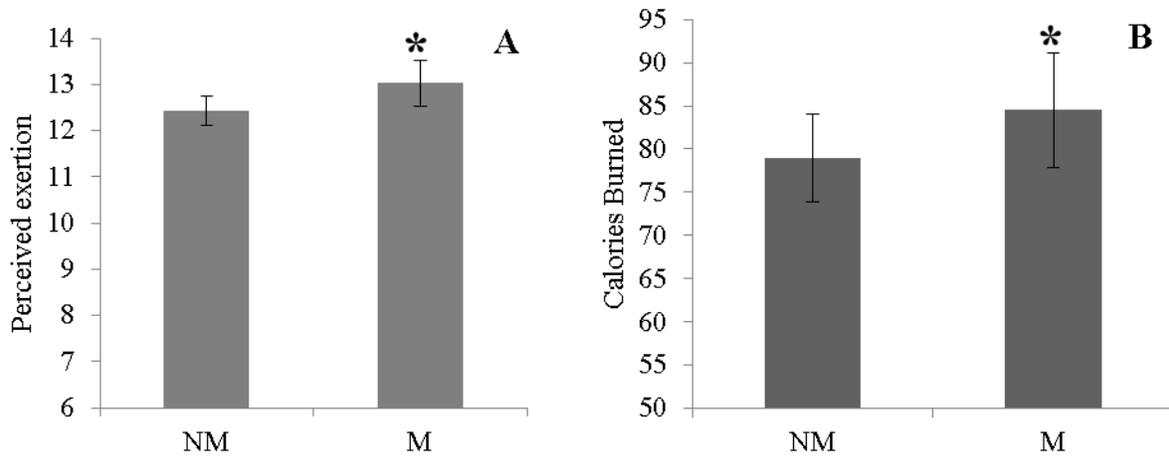


Figure 3. Effect of music on average perceived exertion (A) and calories burned (B) during the 8 minutes of exercise. \* significantly different from exercise without music.

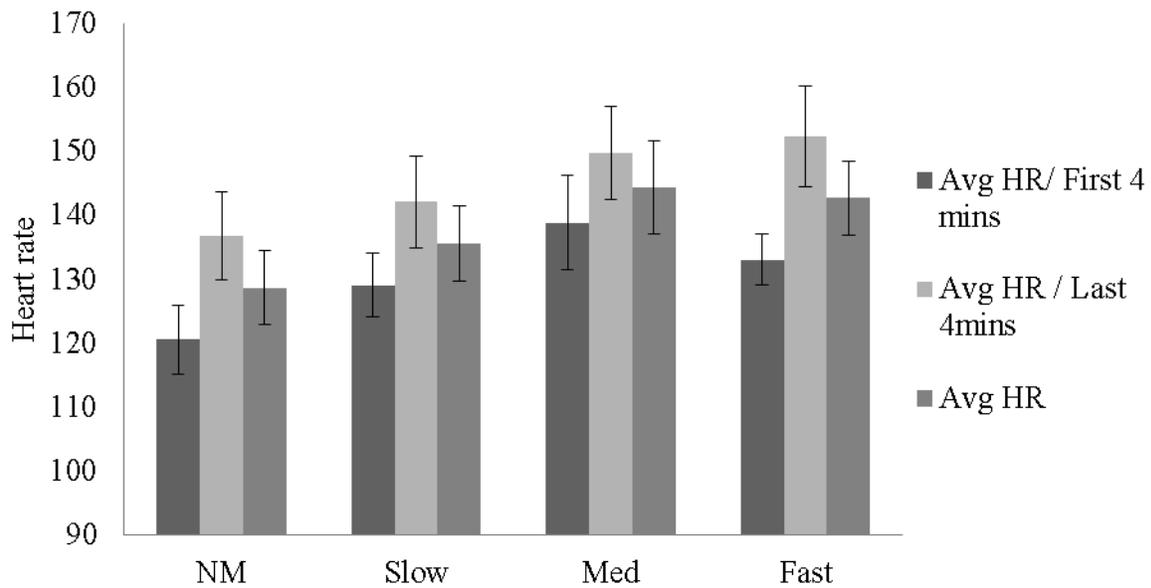


Figure 4. Effect of different music tempo on average heart rate during 8 minutes of exercise.

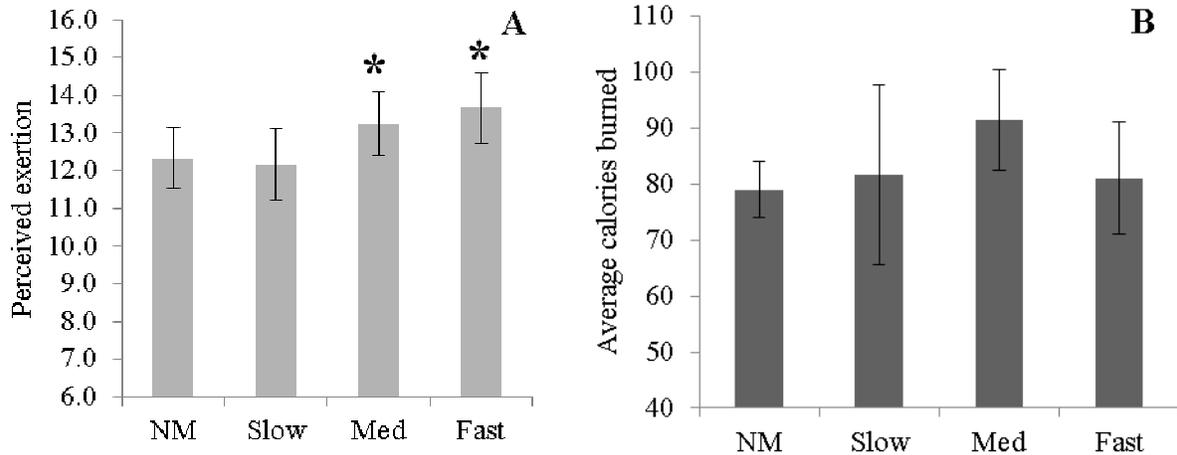


Figure 5. Effect of different music tempo on perceived exertion (A) and average calories burned (B). \* significantly different from no music ( $p < 0.05$ ).

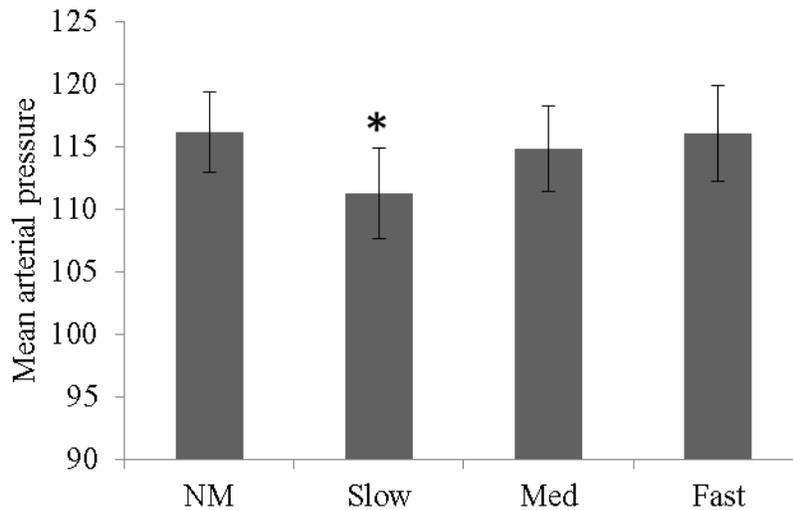


Figure 6. Effect of different music tempo on mean arterial pressure during and immediately after exercise, combined. \* significantly different from no music.

## Discography

Coldplay (2005). *Swallowed in the Sea*. On *X&Y* [compact disc]. USA: Capitol Records.

Iron and Wine (2008). *Flightless Bird, American Mouth*. On *Twilight: Original Motion Picture Soundtrack* [compact disc]. USA: Chop Shop Records.

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Franz Ferdinand (2004). Take Me Out. On *Take Me Out* [compact disc]. UK: Domino Records.

Girl Talk (2010). Jump On Stage. On *All Day* [compact disc]. USA: Illegal Art Records.

Girl Talk (2010). Every Day. On *All Day* [compact disc]. USA: Illegal Art Records.

A Good Fight (2008). The Drama. On *The City Could Be Ours By Morning* [compact disc]. USA: self-published.

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Hans Zimmer (2009). 160 BPM. On *Angels and Demons Original Motion Picture Soundtrack* [compact disc]. USA: Columbia Pictures.