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# What are the ergogenic effects of music during exercise?

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## A Synthesis of the Research Literature

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A Synthesis Project

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A Synthesis of the Research Literature.

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# Abstract

This synthesis demonstrates the positive effects of music on exercise. It focuses on the potential benefits of listening to music during exercise. It uses a theoretical framework focusing on the dissociative effect of music resulting in reduced perceived exertion, accompanied by greater output, enhanced performance, improved skill and improved mood. It also looks at the effects of variable intermediaries of the tempo and the volume of the music being used. It uses twelve, peer-reviewed, quantitative research journal articles published within the past forty years as the "critical mass." Using the theoretical framework the synthesis demonstrates that the dissociative effect of music enhances exercise and achieves the potential benefits. It recommends future research over a wider age range and varied exercises.

Table of Contents

## Introduction

Music has been widely used to positively affect exercise performance. Today, many exercisers consider music a very important component in their workout routines. Personal music includes compact disc recordings and various personal audio systems. It has been observed that music is often used to accompany exercise and athletic activity.

The belief that music enhances exercise, is a topic of interest to all who participate in any athletic endeavor – from the professional athlete who is training to someone who simply exercises to maintain health or fitness. While the term "ergogenic effect" may not be a common one, the results of a synthesis exploring the ergogenic effects of music on exercise would be of interest to all who exercise.

### Theoretical Framework

It has long been thought that music may enhance exercise. The common belief is that it does this by altering the psychological state of the participants. It also may establish an effective mindset to sustain motivation and to resist emotional fatigue. It may even enhance physical and athletic performance (Mohammadzadeh, Tartibiyan & Ahmadi, 2008).

Users report that music puts their minds at ease, thus helping them exercise at a greater intensity level. It is possible that they may be utilizing the distracting and emotional qualities of music to avoid focusing attention on internal feelings associated with discomfort. (Boutcher and Trenske, 1990).

These commonly held beliefs will be examined in the synthesis to explore whether or not there is data to demonstrate the validity of these beliefs that music does indeed enhance

performance in exercise. Also to be examined are some of the qualities of the music that is used on various forms of exercise.

The framework this synthesis will use to examine the available literature is as follows (adapted from C.I. Karageorghis and D.-L. Priest, 2012, p. 48)

| Antecedents | Intermediaries | Potential Benefits |
|---|---|---|
| Personal Factors (pre-existing) | Effects of Tempo | Dissociation |
| Situational factors (surroundings) | Effects of Volume | Reduced perceived exertion |
| | | Greater output |
| | | Enhanced performance |
| | | Improved skill |
| | | Improved mood |

We will examine the two antecedents of personal factors, which we note are pre-existing, and situational factors. The personal factors include examining who is being studied – the make-up of the cohort or people included in the study. The situational factors include the type of exercise being used as well as the type of music being used.

There are also intermediaries to be considered – these are variable. These include how the tempo and volume of music effect exercise.

The synthesis will ultimately look toward the potential benefits of listening to music while exercising. These potential benefits have wide ranging significance for anyone who exercises. This synthesis therefore is meant for anyone who exercises from the professional athlete training for his or her sport or upcoming important game to the person who exercises occasionally. It is also important for coaches and trainers, who armed with the information on the potential benefits of using music to enhance exercise. The ultimate goal would be for all who exercise to understand what music, with all the variable taking into consideration, is the best

choice to enhance their exercise regimen. These potential benefits include the effects cited in the table above.

Looking at these individually demonstrates how significant these can be to exercise. Dissociation means that the one who is exercising is distracted by the music he or she is listening to and is able to exercise through small aches and pains, or how tired one is while exercising. In other words, it allows one to concentrate on the music and not on the exercise. Reduced perceived exertion is coupled with dissociation to a certain extent, but it is different in that the one who is exercising is able to dissociate through the use of music that he or she perceives that he or she is not working as hard as without music. For example, it is this reduced perceived exertion that allows one listening to music to run faster or to run farther without the feeling of being exhausted or even delaying the point of feeling tired or exhausted. This results in the next potential benefit of greater output – running farther or faster. This results in the potential benefit of enhanced performance and the possibility of achieving a greater skill level. Finally, an improved mood while exercising is a great benefit to carry away from the regimen.

In many ways these flow from dissociation – the ability to concentrate on the music rather on the difficulty or the intensity of the exercise to enhance overall performance, results and the personal benefits of achieving a higher skill level and an improved mood.

**Background Information**

Several researchers have addressed the question of whether music positively affects exercise performance. Some believe that listening to music during an exercise workout increases performance by allowing the exerciser to maintain a steady pace; and deflects attention away from feelings of discomfort (Boutcher and Trenske, 1990).There are two assumptions for this: (1) specific music tempos, as well as (2) the volume of the music increase work output. This

assumption is expressed in this way:  it is expected that loud music at a faster tempo will also have an effect on increased heart rate and possibly exercise performance (Edworthy and Waring, 2006).

On the other hand, some researchers are far from convinced that listening to music has a positive influence on exercise performance (Schwartz, Fernhall and Plowman, 1990).  Some exercise enthusiasts do not use any type of music to enhance their workouts. Their motivation to exert maximum effort comes from within.

**Scope of Synthesis**

The purpose of this synthesis is to examine the research available to determine if there is sufficient evidence to support the claim that music enhances the performance of an exercise. This synthesis will examine the available literature that is used to demonstrate the claim that music enhances performance.  It will then draw conclusion as to whether the literature sufficiently demonstrates the claim.

**Operational Definitions**

***Ergogenic*.**  This term is used to show anything that is used to enhance physical performance or stamina (*American heritage dictionary of the English language, 1976*).

***Exercise Performance.***  This means carrying out specific physical routines or procedures by anyone who is performing an exercise (*American heritage dictionary of the English language, 1976).*

**Summary**

The practice of using music to enhance performance is so widespread that many athletes accept it as a foregone conclusion: that music works – in other words it does enhance performance.  This synthesis will examine the actual research that backs up this claim.  It will

critically examine the studies on which it bases its claims. It will examine any opposing opinions. It will ultimately offer suggestions or recommendations regarding the use of music to enhance performance in exercise.

## Methods

The purpose of the section was to describe the ways in which a "critical mass" of peer-reviewed research articles was identified and selected for the synthesis. The section is organized according to *selection of studies*, *results of the search*, and *coding*.

### Selection of Studies

Online databases were searched at Drake Memorial Library located on The College at Brockport campus. They included *SPORT Discus with Full Text, Academic Search Complete*, and *The Physical Education Index*. These three databases were selected because they reference many physical activity, exercise and physical education journals. The following advanced search terms were entered, singly and in combination, into the databases: "music and exercise", "music and motivation and exercise", "music and exercise performance", "music and exercise and perceived exertion."

To help in the selection process, three screening criteria were employed. Specifically, each article chosen had to: (1) focus on how music impacts exercise performance; (2) be published in a peer-reviewed research journal; and (3) be published within the past 40 years.

### Results of the Search

The first descriptor phrase, *music and exercise*, was entered into each of the above databases. This procedure yielded a total of 2,756 articles: *Academic Search Complete* (1,755), *SPORT Discus with Full Text* (508), and *Physical Education Index* (493).

Next, the second descriptor, *music and exercise performance* was entered into the databases and yielded 605 articles: *Academic Search Complete* (364), *SPORT Discus with Full Text* (102), and *Physical Education Index* (139).

The phrase *music and motivation and exercise* was then entered and yielded 175 articles: *Academic Search Complete* (88), *SPORT Discus with Full Text* (43), and *Physical Education Index* (44).

Lastly, the phrase *music and exercise and perceived exertion* was entered into the databases, and yielded 114 articles: *Academic Search Complete* (17), *SPORT Discus with Full Text* (31), and *Physical Education Index* (66).

To summarize, a total of 3,650 articles were initially identified for the synthesis. Following application of the three screening criteria, 18 articles were retained for further evaluation. Subsequently, 14 articles were deemed appropriate and included in the "critical mass." By placing the articles into an article grid and looking for commonalities in cardiovascular endurance, muscular endurance, and perceived exertion. Two additional articles were selected for the synthesis as a result of the ancestry method. The latter involved carefully perusing the reference lists of each of the articles previously selected for additional studies. Thus, a total of 14, peer-reviewed, quantitative research journal articles published within the past 40 years formed the "critical mass" for the synthesis.

**Coding Variables**

Critical information from each of the fourteen articles was extracted and categorized as follows: (1) author's name(s); (2) publication date; (3) subjects; (4) independent and dependent variable(s) measured; (5) method of data collection; and; (6) major findings (see Appendix A).

The author's name was considered because of other research studies the author may have published as well. Publication dates are significant because they raise the concern about which research is more reliable? Is the most recent study necessarily "the best," or is an older study more exhaustive and therefore more reliable? The participants are important because of demographic data – such as the number of participants as well as their gender and age. A larger number of participants with both genders and a wide range of ages would be preferred over a small number of participants within a single age range who are all of one gender.

An examination of how independent and dependent variables is measured is very significant. In looking for solid objective research, it is important to take this into consideration. How data is collected is among the most significant for this synthesis. This raises the concern with objective vs. subjective collection of data. The preferred is objective which are more reliable, but many of the studies consulted appear to be more subjective leaving questions about the reliability of these studies when arriving at a general conclusion.

Finally taken into account are the major findings of each of the studies. This raises questions not only about whether or not the conclusion is valid for the study, but also about whether or not the study can be applied to only the specific area of the study, or if it can be applied to a general conclusion for everyone. This is important to this synthesis because the goal is to find an answer that would be valuable to many people and not just a group limited by age or gender.

These studies were then coded into themes based on the independent and dependent variables. The first theme looks at the effects of music on perceived exertion. The second theme looks at the effects of music on cardiovascular endurance. The third theme is muscular

endurance and groups the studies that look at this. The final grouping or theme is the mediating variables which look at the tempo and the volume of the music.

## Results

After a careful review of the relevant literature, a total of 14 peer-reviewed research studies were chosen for the synthesis. The dates of publication ranged from 1978 to 2012. Presentation of the major findings is organized in line with the theoretical framework found the in the chart in the previous section titled Theoretical Framework with the exception of the personal factors and situational factors which are factored into the context of the studies that demonstrate the two right columns of the chart.

### Intermediary Valuables

There are two mediating variables considered in this synthesis: (1) music tempo (2) music volume. Each of these is a variable because music can have a fast or slow tempo and soft or loud volume. The literature examined in the critical mass for these examines whether tempo and volume have an effect on perceived performance.

***Music tempo.*** Three studies included in the critical mass investigated the effects of music tempo on exercise performance. The effects of both fast and slow tempo music were compared in terms of their influence on exercise performance. Fast tempo music is defined as music that has a steady fast beat, while slow tempo music is much more calming to the ear. The general hypothesis is that music with a faster tempo will prove to enhance exercise because it is more motivational than music at a slower tempo.

Edworthy and Waring (2006) had 30 adult male and female volunteers run at their own continuous comfortable pace on a treadmill for 10 minutes while listening to music that was fast on some trials and slow on others. Participants who ran while listening to faster tempo music

covered more distance on the treadmill than participants who ran to slower tempo music. Karageorghis, Jones and Low (2006) found similar results. The study began with a survey of 128 undergraduate students to establish their three favorite musical artists. Then a separate group of 29 undergraduate participants selected the music of a single artist from the three highest-rated artists from the earlier survey. They reported their preference for slow, medium and fast tempo selections from each artist for three treadmill conditions of 40, 60, and 75 percent of their maximum heart rate. The music that accompanied their walking was 80, 120, and/or 140 beats per minute. The results showed that faster music, medium and fast tempos (120 and 140 beats per minute), resulted in better treadmill performance than slower beat music (80 beats per minute). The results of this study demonstrate that faster tempo increases exercise performance. This demonstrates this mediating variables have a positive effect on performance.

In a somewhat related study, Birnbaum, Boone and Huschle (2009) reported that their participants burned more calories during an exercise routine done to faster tempo music. While jogging on a treadmill, participants listened to four fast-paced and four slow-paced songs. Jogging performance as determined by a heart rate monitor was far better when accompanied by faster- paced music (140 beats per minute).

***Music volume.*** Just one study included in the critical mass investigated the effects of music loudness on exercise performance. This was conducted by. Edworthy and Waring (2006) and the objective of discovering if an increased volume of the music demonstrated a parallel increase in performance. This study had 30 adult male and female volunteers run at a comfortable pace on a treadmill for 10 minutes while listening to music through a set of headphones. The loudness of the music varied from 60 to 80 decibels. The participants noted their perceived exertion as the volume of the music was increased. They further noted that as

the volume of the music was increased their perceived exertion decreased. That as the loudness of the music increased in volume participants felt their output in the workout decreased.

**Dissociation**

As noted above this is a critical part of the use of music in exercise. To a certain extent all that follows flows through this. It has the effect of distracting the one who listens to music to perform at a more intense level and allow for greater output resulting in greater performance. This is most especially found in perceived exertion and cardiovascular endurance.

**Perceived Exertion**

A few of the studies included in the critical mass investigated the effects of music on perceived exertion, which is how hard the exerciser feels his or her body is working. This is customarily measured on the Borg Rating. The Borg Rating is a scale from one to ten that relates to the phases of how easy or difficult a participant finds the activity. Mixed findings were noted across the studies.

In one study, Mohammadzadeh, Tartibiyan, and Ahmadi (2008) observed the effects of music on perceived exertion and performance during a running exercise. A total of 24 participants, 12 untrained and 12 trained healthy female college students performed the *Bruce Test* until exhaustion. The test requires the subject to run on a treadmill in two different sessions where the speed and incline increased every three minutes. Participants were randomly chosen to listen to music during the first session and then switched for the second session. After each three minute period, participants indicate their perceived exertion. The results showed that those participants who exercised to music had a lower perceived exertion on the Borg Scale than those who did not.

There were three cycling tests, these were done in 1990, 2005 and 2009.

The first cycling study used a bicycle ergometer. It was done by Boutcher and Trenske (1990) and observed the effects of music on perceived exertion. A total of 24 female undergraduates cycled at 60, 75, and 85 percent of their maximum heart rate. These volunteer participants performed three eighteen minute sessions at light, moderate and heavy workload, during which perceived exertion and heartrate were monitored. Each participant also experienced a control condition of depravation of music and music included. The results showed that music positively and significantly affected the participants' rate of perceived exertion. That is, those participants who listened to music indicated less physical stress while cycling.

The second cycling study, this one done by Elliott, Carr and Orme (2005) pre-tested 18 male and female undergraduate college students in order to assess their workload level, a popular measure of fitness. Specifically, the participants peddled a bicycle ergometer at their own comfort level for 20 minutes. During each of three 20 minute sessions, they were required to partake of three experimental conditions: no music, music and motivational music. During each trial, they indicated their state of perceived exertion. The results showed that bicycling to music increased the distance participants were able to cycle and lowered the participant's perceived exertion. No significant differences were observed between the two music conditions and increased exercise intensity associated with the musical accompaniment. Both music conditions elicited increased impact effect and generated equally positive attitudes toward the exercise experiment.

The third and somewhat more detailed cycling study by Lim, Atkinson, Karageorghis, and Eubank (2009) observed the effects of music introduced and removed during a cycling time trial. Eleven physically active males completed a 10 kilometer (km) time trial on a bicycle ergometer. There were three different conditions: (1) No music was played at all, (2) Music was

played initially and then removed between five and ten kilometers, and (3) music played between five and ten kilometers only. After every kilometer, the subject's time to completion, cadence, and speed were calculated. At 2.5 km, 5.0 km, 7.5 km, and 10.0 km each subject's rate of perceived exertion was assessed. The results showed that the introduction of music was unrelated to the amount of time needed to complete the task.

In summary we are looking to see how music effects perceived exertion with an eye toward the ability of music to allow us to dissociate from the intensity level we are experiencing. The studies cited above demonstrate this effect. The participants have a lower perceived exertion while at the same time achieving a higher level of performance.

**Greater Output**

This is a significant benefit of using music to dissociate the stress of exercise and showing greater performance benefits. Here we will review cardiovascular endurance and muscular endurance.

**Cardiovascular endurance**

A small number of studies included in the critical mass investigated the effects of general music on cardiovascular endurance. In these studies it was generally found that music had a positive influence on the dependent variable. For example, Anshel and Marisi (1978) investigated the effects of general music on the physical performance of 32 male and female undergraduate college students ranging from 19-22 years of age using a bicycle ergometer. All participants were pre- and post-tested to determine level of physical fitness. All participants who listened to music while bicycling demonstrated greater aerobic endurance than a control group that didn't listen to music. This was calculated by a physical work capacity test and used as the criterion for exercise intensity on repeated conditions: participants were assigned in each of the

three conditions synchronous movement to music, asynchronous movement to music, and a control condition. The study indicated that music, particularly if synchronized to physical movement, had a positive effect on the ability to endure the task and that males participants endured longer than female participants.

Another cycling study done by Elliott, Carr and Savage (2004) had18 participants listen to music through a set of headphones while riding a bicycle ergometer. Each participated in three separate 12 minute trials: no music, non-motivational music and motivational music. Motivational music has a high tempo and volume. Non-motivation music is slower with a softer volume. Participants were instructed to perform at a pre-determined rate of exertion throughout the exercise bout. The results showed that music positively affected the subject's work output; that is, participants who listened to music while pedaling were able to endure longer and perform at a higher intensity level.

Karageorghis, and colleagues (2009) observed the effects of general music on cardiovascular endurance using a walking test. A total of 100 volunteers all between the ages of 19 and 21 participated in two experimental conditions. In the first condition, participants walked at a pace that was 75 percent of their maximum heart rate while listening to music provided through a set of headphones. In the second condition, participants walked without the assistance of music. The results showed that participants who walked with music performed longer before becoming exhausted.

**Muscular endurance**

Muscular endurance is also a potential benefit from using music in exercise. This also ties into the dissociation that comes from listening to music – music allows the listener to concentrate on the music which allows greater intensity and duration.

Muscular endurance is an important aspect of exercise. Two articles included in the critical mass investigated the effects of general music on this aspect. Razon, Basevitch, Land, Thompson and Tenenbaum (2009) randomly assigned 60 participants, 33 male and 27 female, into four groups of fifteen. The exercise is performed using hand grips that are squeezed. After establishing the maximal squeezing value they performed 30% max squeezing task under one of four assigned conditions: (1) full vision and preferred music, (2) full vision and no music, (3) blindfolded and preferred music, and (4) blindfolded and no music. The blindfold was used to eliminate outside distractions while listening to music or not. The test was to see if outside environmental distractions were removed does music have the effect of dissociation and enhance muscular endurance as it does for the perceived exertion. Each participant was asked to hold the grips until volitional fatigue while listening to a music selection of their own choosing. The rate of perceived exertion and attention strategies were administered at 30 second intervals. Results from a repeated measures analysis showed that participants who held the squeeze while not blindfolded and were listening to music were able to do so for a longer time than when no music, or music while blindfolded. This indicates that the dissociate effect of music does have the effect of increasing muscular endurance.

In another study, the findings were similar, but the exercise was different. Crust and Clough (2006) had 58 physically active participants hold a 1.1 kg dumbbell for as long as possible while listening to music provided through a set of headphones. Participants who listened to music were able to hold the weight for a significantly longer time than when no music was involved.

This section on greater output demonstrates that music does enhance output. The dissociated effect of music allows the participants to experience greater output accompanied by the reduced perceived exertion cited in the section above.

**Summary**

The studies in the critical mass reach a conclusion that music enhances exercise performance. Music provides a dissociative distraction that allows the one performing the exercise to concentrate on the music rather than the intensity or duration of the exercise.

The preponderance of evidence found in the literature examined allows this synthesis to reach this conclusion. It is significant that even though various exercises were used with a wide variety of participants the conclusion remains consistent. Although there is not a longitudinal study found in the literature, there is a span of years between the various studies that shows the same conclusion. Whether on a bicycle, a treadmill, a handgrip or dumb bells, it was found that music enhanced cardiovascular endurance and perceived exertion.

The studies examining the mediating values of tempo and volume demonstrated a positive effect for each: respectively faster tempo and louder volume were found to enhance the perceived performance.

The general overall conclusion is that music does indeed enhance performance. The dissociative value of music allows the one who is exercising to either be distracted by the music or concentrate on the music rather than the exercise. This dissociation from the exercise and toward the music results in music enhancing exercise performance.

## Discussion

The purpose of the research synthesis was to determine the ergogenic effects of music on exercise performance. Given the popular trend of people exercising while listening to music, the

results of a synthesis of the most relevant research literature available could prove very informative for anyone who exercises. This would range from the person who does casual or regular exercise to those who are professional athletes or coaches.

The synthesis was based on 14 peer-reviewed research journal articles. The discussion below will review and comment on the major results of the synthesis, identify and discuss some of the limitations of the research reviewed, identify some of the weaknesses associated with this research endeavor, and offer some recommendations for researchers interested in the subject of the synthesis.

The majority of the research articles included in the synthesis reported that music had a positive effect on exercise performance. This demonstrates that music does reward the exerciser with the potential benefits outlined in the theoretical framework.

Focusing first on the potential benefit of dissociation the literature demonstrates that other potential benefits flow from this first one. Once again, dissociation is seen as a distraction from the difficulty or intensity of the exercise. This occurs when the person who is exercising is concentrating on the music more than the exercise. The other potential benefits can be seen to flow through this first one.

The literature demonstrates that music had a positive and significant effect on perceived exertion. It's quite possible that the distraction of the music put the subject at ease during exercise; music deflects the subject's concentration away from pain that was experienced during the exercise performance. Untrained participants showed effects due to the fact that they focused on the external stimulus (music).

The literature also shows that has a positive influence on both cardiovascular and muscular endurance. This is parallel with the widely held belief among those who exercise that

music selections increased such physiological factors as heart rate and perspiration which, in turn, contributed to better exercise performance. Participants were able to focus their attention on a positive auditory stimulus (music) rather the grueling physical task at hand which allowed them to exercise for longer amounts of time.

This dissociation value of music also demonstrates positive and significant effects of music on sub-maximal exercise in the research literature that was reviewed. In two studies involving cycling performance, traveled further and faster on an ergometer while listening to music (Boutcher and Trenski, 1990; Elliott, Carr, and Savage, 2004). Again, the argument can be made that motivational music distracts the participant's from paying attention to the physical challenge they were confronted with.

Turning to the mediating values of music tempo and volume we again see that music has a positive effect. These also show the potential benefits of the dissociative value of music to be significant.

Taking the first mediating value, music tempo was positively related to exercise performance. Faster tempos were beneficial, while slower tempos were not. Participants were able to endure longer and with less reported discomfort when they listened to faster tempo music. Faster tempo music may have been motivating than slower tempo music. Secondly, if the fast tempo music had a lyrical statement relating to motivation such as "move your body," it reported higher exercise performance.

The second mediating variable, music volume was also positively related to exercise performance. The louder the music, the greater it's positive effect on exercise performance. It may well be the case that louder music increases your heart rate which in turn allows the exerciser to perform at a higher intensity level.

When looking at these in the framework of the potential benefits of music it is concluded that tempo and volume have this effect on exercise performance – faster tempos and louder volumes have a greater effect than their opposites. The dissociate value of music in this case become not only a distraction from the intensity or endurance of the exercise being performed, but may become a motivating factor as well.

**Limitations**

A number of limitations were noted in the research literature that was reviewed for the synthesis. Researchers noted in their studies that a limitation was that they focused a very narrow age range. Participants were typically between the ages of 18 and 30. Since this synthesis is meant to be used by everyone, it would be very beneficial if older adults were included in future studies. The premise would be that we do not stop exercising at the age of thirty. A study to demonstrate that the potential benefits of music on exercise at every age would be an added incentive to continue exercising no matter a person's age.

A second limitation is there is no consistent type of task over all the studies. Each used a different kind of exercise. The critical mass cites these: handgrip, treadmill and bicycle. The synthesis would be stronger if there were more literature involving only one kind of exercise. This allows us to know the effects of music for the studied exercises, it allows us only to draw general conclusions by assuming if other exercises were studied, and the results would be similar. At the present moment we do not have the literature to determine this.

Another limitation is that most of the studies included in the synthesis used small sample sizes. The average sample size was 30 with only three studies using sample sizes larger than 30. This raises issues about the generalizability of the research, and does not allow for the

calculation of non-parametric statistics (effect size). In turn, reliability and validity of the synthesis is weakened.

Lastly, in several studies, the researcher did not specify the music the subject was asked to listen to. Did the subject listen to classical, hip-hop, or country music? Different music genres may have differential effects on exercise performance unless specific music styles are compared and contrasted to other genres of music.

**Future Research**

With respect to future areas of inquiry, more attention should be given to potential gender differences. This is, some music might be better suited for female exercisers than male exercisers, and vice versa. Males and females may respond differently to different music tempos and styles. This is an area that may be looked at in future research.

The same can be said of more attention to different ages. As stated above it would be very helpful to have studies of older people. We sometimes see anecdotal stories of the benefits of exercising across the age range, or even studies of this. It would be beneficial to have evidence that music enhances exercise no matter the age of the one who is performing the exercise.

Researchers should also consider extending their studies over a longer time interval. Too many of the studies included in the synthesis were of short duration (e.g. 1-day, 1-week, 1-month). Would a 6-month study produce different results? We might see more dramatic changes in endurance if the participants exercised to music for a longer period of time.

Lastly, researchers should investigate the effects of a greater variety of music styles rather than "generic music" that several researchers tested. What about, hip-hop, country and

western or classical music? It may well be the case that every exerciser has a favorite genre of music to perform to. The choice may vary by age, sex, race or social class.

Based on an exhaustive search of several online databases, and a careful analysis of 14 peer-reviewed quantitative research studies, the evidence strongly suggests music positively affects exercise performance. Specifically, individuals who exercise while listening to music are likely to experience positive benefits with respect to cardiovascular endurance, muscular endurance, and sub-maximal exercise. Moreover, exercising to music is also associated with the perception of motivation. Future research may look to studies that include more participants and that may be divided by age and gender. This could result in a more personalized exercise regimen based on age and gender as well as the music style, tempo, and volume. One could imagine an individualized exercise performance enhancement based on listening to a music program that is tailored for each person and for each style of exercise.

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* Included in the critical mass

## Appendix A

| Author | Title | Source | Purpose | Methods & Procedures | Analysis | Findings | Recommendations |
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| Anshel & Marisi (1978) | Effects of music and rhythm on physical performance | Research Quarterly | To investigate the effects of generic music on cardiovascular endurance | 32 participants 16 male and 16 female undergraduate physical education students were | PWC 170 test (Physical work capacity, 170 beats per minute) | Improved endurance | That music had a positive effect on the ability to endure the task at hand |
| Birnbaum, Boone & Huschle (2009) | Cardiovascular responses to music tempo during a steady state exercise | Journal of Exercise Physiology Online | To determine if general music would improve physical performance | 16 males and 16 females undergraduate physical education students completed three 15 minute steady exercise jogging sessions at 5.5 mph | Oxygen consumption (VO2), expired carbon dioxide (VCO2), frequency of breaths (Fb), minute ventilation (VE) | Improved physiological measures | These findings suggest that listening to fast music during steady-state treadmill exercise produces cardiovascular and respiratory responses that are significantly different from how the body responds to the same exercise intensity when listening to slow or no music |
| Boutcher & Trenske (1990) | The effects of sensory deprivation and music on | Journal of Sport and Exercise Psychology | To study the effects of sensory deprivati | 24 volunteer female undergraduate college | Cycle ergometer | Lower perceived exertion | It was concluded that the influence of music and deprivation on perceived |

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| | perceived exertion and affect during exercise | | on and music on perceived exertion and affect | students performed three 18 minute sessions on a cycle ergometer at light, moderate, and heavy workloads | | | exertion and affect was load dependent |
| Costas I. Karageorghis & David-Lee Priest (2012) | Music in the exercise domain: a review and synthesis (Part I), | International Review of Sport and Exercise Psychology | To synthesis the prior study to determine if music does enhance exercise | Reviewed all previous studies on ergogenic effects on exercise and musical variables | Varied from each study | The effects of music appear to be at their most potent when it is used to accompany self-paced exercise or in externally valid conditions. | When selected according to its motivational qualities, the positive impact of music on both psychological state and performance is magnified. Guidelines are provided for future research and exercise practitioners |
| Crust & Clough (2006) | The influence of rhythm and personality in the endurance response to motivational asynchro | Journal of Sports Sciences | To determine if asynchronous music will improve muscular endurance | 41 males and 17 females performed isometric weight holding task on three occasions while being randomly | 1.1 kg dumbbell | Improved muscular endurance | These results suggest that responses to motivational music are subtle in nature and are determined by both musical factors and individual characteristics, and potentially an interaction |

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| | nous music | | | exposed to no music, rhythm, and motivational music | | | between the two |
| Edworthy & Waring (2006) | The effects of music tempo and loudness level on treadmill exercise | Ergonomics | To see if music of varying tempos improved the performance | 15 males and 15 females running on treadmills with different tempos of music | Perceived Exertion Scale | Improved performance | That fast, loud music played can enhance optimal exercising, and show how loudness and tempo interact |
| Elliott, Carr & Savage (2004) | Effects of motivational music on work output and affective responses during sub-maximal cycling of a standardized perceived intensity | Journal of Sport Behavior | To determine if motivational music improved performance (sub-maximal) while cycling | 8 males and 10 females undergraduate students subjected to three 12 minute exercise trials in conditions of no music, oudeterous music, and motivational music | Perceived Exertion Scale, cycle ergometer | Improved performance | Music increased not only performance but also showed higher motivational levels than no music |
| Elliott, Carr & Orme (2005) | The effect of motivational music on sub-maximal exercise | European Journal of Sport Science | To determine if motivational music improved performance | 8 males and 10 females untrained undergraduate students participated in a 20 minute | Perceived Exertion Scale, cycle ergometer | Improved performance | Motivational music can significantly increase the distance traveled and increase in-task affect and generate positive post-task attitude towards exercise |

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| | | | (sub-maximal) while exercising | sub-maximal cycle task | | | |
| Karageorghis, Jones, & Low (2006) | Relationship between exercise heart rate and music tempo preference | Research Quarterly for Exercise & Sport | To determine participants heart rates during exercise while varying the tempos of music | 67 women and 61 men walked on a treadmill while different varies of tempos played at different walking conditions | Brunel Music Rating Inventory | Improved performance | Use a low/moderate tempo music for low moderate exercise intensities and a fast tempo music for high intensity |
| Karageorghis et al. (2009) | Psychophysical and ergogenic effects of synchronous music during treadmill walking | Journal of Sport and Exercise Psychology | To determine if synchronous music will increase exercise performance while walking on a treadmill | 50 men and 50 women selected either pop or rock tracks and walked to exhaustion starting at 75% maximal heart rate | Treadmill (GXC200; powerjog) ANOVA MANOVA Recorded at 2 min intervals (RPE) | Improved performance | The present results indicate that motivational synchronous music can elicit an ergogenic effect and enhance in-task affect during an exhaustive endurance task |
| Lim, Atkinson, Karageorghis, & Eubank (2009) | Effects of differentiated music on cycling time trial | International Journal of Sports Medicine | This study was determining the effects of music introduced and removed during | 11 physically active males Differentiated music | Compu-Trainer ergometer | No change in performance | This study results are saying that behavioral influences the exercise and not the music |

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| | | | cycling | | | | |
| Mohammadzadeh, Tartibiyan, & Ahmadi (2008) | The effects of music on the perceived exertion rate and performance of trained and untrained individuals during progressive exercise | Series Physical Education & Sport | To determine the effects of listening to music during progressive exercises on perceived exertion rate and performance | 24 healthy students, 18 males and 6 females voluntary participated while during one session listening to music and the next session not listening to music | Perceived Exertion Scale | Improved performance, lower exertion level | The results suggest that using music in progressive exercise would have a positive effect in terms of performance |
| Razon, Basevitch, Land, Thompson, & Tenenbaum (2009) | Perception of exertion and attention allocation as a function of visual and auditory conditions | Psychology of Sport & Exercise | To study the role of auditory (music) and visual sensory on perceived levels of exertion and attention | 6o young adults, 33 males and 27 females were recruited to perform a hand grip squeezing task 4 groups<br>1. Full vision and preferred music<br>2. full vision no music<br>3. blindfolded and preferred music<br>4. | Perceived Exertion Scale | Improved performance | Participants who had both forms of sensory held for a longer duration than participants in other conditions. External stimuli may serve as mediating agents in diverting attention away from internal and painful stimuli |

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| | | | | blindfolded and no music | | | |
| Schwartz, Fernhall, & Plowman (1990) | Effects of music on exercise performance | Journal of Cardiopulmonary rehabilitation | To determine the influence of music on sub maximal exercise performance | 10 untrained males and 10 untrained females performed a maximal bicycle ergometer test 2 trails one with fast tempo music and one without music | Cycle ergometer | No change in performance | This data shows that music does not alter the sub maximal exercise performance or physiological response for either men or women |