



Effects of Music on Athletic Performance

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Abstract

Arousal or mental/physical stimulation can have a significant impact on sports performance. By achieving or maintaining an optimal arousal state, athletes can perform better, both mentally and physically. Listening to music during exercise may serve as a tool to achieve and maintain this optimal arousal. The purpose of this study is to explore the practicality of music's use in intense exercise/sport. This study utilized the Broad Jump (BJ) and Illinois Change of Direction Test (ICODT) to assess lower body power and agility. Participants completed three trials of each test to assess their performance. The first trial acclimated the participants to the movements. The second trial used no music, and the last trial used the participant's choice of music. The only song requirement was a tempo of at least ~100BPM (fast tempo). A Paired Samples T-Test showed a mean increase of 0.099m and a standard deviation of 0.0599m from non-music to music trial for the BJ and a t-value of -5.88. The ICODT had a mean decrease of 0.634s from the non-music to music trials, a standard deviation of 0.455sec, and a t-value of 4.402. Both tests produced statistically significant results (p -value <0.05). The results indicate music can facilitate high-level performance.

Introduction

Listening to music has a profound effect on the brain. It can elicit emotions, help recall memories, improve focus, reduce stress, and improve exercise performance (Atan, 2013; Jarraya et al., 2012). An in-depth understanding of how the brain functions when listening to music, is necessary to comprehend its effects on physiology and cognitive functioning.

Music can alter the neurochemistry of the body, and consequentially, its physiological state. Neurochemistry refers to various neurotransmitters that change the body's internal environment and impact the functioning of different systems (ex. cardiovascular, nervous, respiratory system, etc.). Physical and mental states can vary depending on the neurotransmitters produced, leaving the individual in either a controlled or uncontrolled

state (ex. fight or flight). Music is a positive stimulus that many people use because of its ability to balance these messengers and allows for better control of their arousal levels or levels of stimulation.

When participating in sports, having a clear mind and low stress levels is essential because excessive stimulation can increase perceived exertion, physically and mentally, leading to greater injury risks (Farris et al., 2017). Naturally, the brain wants to stray away from harmful stimuli as well. To do so, physical processes such as muscle firing rate and motor control are slowed down resulting in significant performance declines and increased injury risks.

Additionally, music can create synchronous movement because of tempo manipulating the pace of the body functions. A human's natural adaptation to music can increase an individual's motivation to perform specific tasks. Increased motivation can lead to greater work output and less effort put forth by the individual. This occurs because of the brain seeking pleasure and it is focusing its attention on tasks that may result in a pleasure response. Pleasurable stimuli or anticipation of it creates a release of dopamine from the anterior aspect of the brain. Being motivated to complete a task while being in an ideal mental state is desired because this state of optimal arousal will create better performances (Jarraya et al., 2012).

Current Literature

In the current literature regarding this topic, the information provided by researchers is conflicting (Atan, 2013). Part of the disparity may involve the methodologies used. In particular, the lack of specificity in the testing methods potentially had minimal carryover to athlete's performance during practice, competition, etc. As a result, the use of music as a performance enhancer may have mixed results. More research regarding athletic performance and music should be conducted using more specific methods by mimicking the same or similar motions used in sports. By using more sport-specific testing procedures, the data gathered can provide a better outlook on music's performance-facilitating ability. Functional tests used in Sports Medicine and Strength & Conditioning have high specificity for athletes because they divide different components of athletic movements to test them. Data collected on the relationship between music and performance can be better represented if the testing methods used are more correlated to the activities regularly performed by the athletes.

In comparison to other testing methods, the functional tests for this study will be more specific to athletic skills (Atan, 2013; Pujol & Langenfeld, 1999). Specificity is crucial because the more specific the testing method is, the more carryover it can have for the athlete's ability to perform.

What is Arousal?

Arousal is described as an individual's state of being awake, alert, and attentive (Arousal in Psychology: Definition, 2016). Arousal can affect how motivated someone is to per-

form a single task (Shrestha, 2017; Wu et al., 2017). By achieving the optimal arousal level, the performance of a task can be done to the individual's best ability. However, any deviation from the optimal level might cause a significant decline in performance (Figure 1; Shrestha, 2017).

Arousal can be affected by several factors, such as our senses (sight, smell, hearing, touch, taste), emotional state, and what we consume (food, drugs, etc.) (Arousal in Psychology: Definition, 2016). The effects of different stimuli can vary. The strength and duration of a stimulus are two factors that can influence arousal levels. The neurological responses to stimuli may lead to hormonal changes in the body as well.

Neurotransmitters play a significant role in the level of arousal. They can improve focus on the stimuli present in both the internal and external environment (Arousal in Psychology: Definition, 2016). Neurotransmitters such as dopamine, norepinephrine, epinephrine, and serotonin are the primary messengers that play a role in arousal because of their significance in physiological function.

Dopamine is responsible for producing a pleasure response. It can affect how motivated someone might be due to the pleasure caused by certain stimuli. For example, drugs, sugary foods sugary, and music increase dopamine levels, therefore they create stimuli that can be highly motivating (Haynes, 2018). The pleasure response caused by dopamine also has an inhibitory effect on stress hormones such as cortisol and norepinephrine. As a result, a decrease in perceived exertion is felt by those with exposure to a pleasurable stimulus.

Norepinephrine is responsible for cardiorespiratory changes when stressful stimuli are present (Goldstein, 2010). In high-stress situations, norepinephrine causes vasodilation and increases heart rate (Goldstein, 2010). Epinephrine, also known as adrenaline, can also increase heart rate and blood pressure and cause vasoconstriction of blood vessels. Epinephrine also affects a greater variety of tissues (Goldstein, 2010). In addition to cardiovascular changes, respiratory and skeletal muscle stimulation occurs from modulating epinephrine production. Vasoconstriction makes it easier for blood to flow between tissues and allows muscles to function optimally during exercise.

Serotonin plays a critical role in regulating emotions. It regulates mood, memory, and an individual's ability to learn (McIntosh, 2018). It also sets the tone for the central nervous system and cognitive functioning (McIntosh, 2018). An inadequate level of serotonin is associated with mood-related disorders such as anxiety and depression, both of which affect the ability to think effectively and reduce motivation (McIntosh, 2018). While serotonin is associated with positive stimuli, stressful stimuli do not have a direct correlation with its production. Being in higher stress situations have little effect on the serotonin levels, but increased anxiety can block the neurological response from serotonin when anxiety becomes uncontrolled (Lv & Liu, 2017). Anxiety may be decreased by increasing the pleasure response, thus, improving serotonin level.

These neurotransmitters play a huge role in physical and mental function. While these components of arousal are crucial for positive performances, inappropriate levels can cause a neurological cascade that leads to detrimental changes in skill. For some, it may be difficult to regulate factors that influence the previously mentioned neurotransmitters. Physically active individuals, especially athletes, often seek out tools that ease their ability to achieve optimal arousal levels. These tools may be supplementation, drugs, or music.

Music's Effects on Arousal Response

Current literature supports that music can be used to modulate arousal levels (Pujol & Langenfeld, 1999; Thakare et al., 2017). Pleasure responses created by music can reduce stress and anxiety for individuals because it [music] can modulate dopamine output. In addition to dopamine regulation, norepinephrine, epinephrine, and serotonin can also be controlled by listening to music (Salimpoor et al., 2011; Wu et al., 2017).

Anxiety creates mental fog, which inhibits an athlete's ability to think and focus during activities. While competing in their sport, athletes can also experience high levels of stress, however, it can become uncontrolled and inhibit their performance. Music eliciting pleasurable responses reduces stress and anxiety to manageable levels. By controlling their stress and anxiety levels, athletes can achieve can become optimally aroused or stimulated without the negative effects of too much or too little stimulation (Atan, 2013; Wu et al., 2017). Music also increases motivation to perform, which can potentially boost focus and willingness to push past mental and even physical barriers. Music's use before competitions and during training sessions can likely be attributed to these benefits.

Synchronous Movement with Music

Current literature states there is a correlation between the beat of music and movement (Jarraya et al., 2012; Large, 2000). Changes involuntary movement patterns naturally change while listening to music. The tempo or beat of a song changes the psychological pace, and the body adjusts the rhythm of its internal systems to match it (Jarraya et al., 2012; Large, 2000). An example of a physiological change that occurs as a result of listening to music is heart rate. The external environment plays a role in physiological rates, and if adjusted, the internal environment will follow suit. This phenomenon also occurs within the respiratory and muscular systems (Atan, 2013; Wu et al., 2017).

The beat of the music modulates the pace that the body moves by serving as a "psychological pulse" (Large, 2000). Even when the music producing a pulse change, is no longer present, this byproduct of the auditory stimulus continues temporarily (Large, 2000). Additionally, music establishing the pace of movement can also allow individuals to focus better on the tasks that they perform (Atan, 2013; Large, 2000).

Table 1: Paired-Samples T-Test Results

		Paired Differences 95% Confidence Interval of the Difference Upper	t	df	Sig. (2-tailed)
Pair 1	BJ w/o music (meters) - BJ w/ music (meters)	- .056536648300 000	-5.246	9	.001
Pair 2	ICODT w/o music - ICODT w/ music(seconds)	.959802992000 000	4.402	9	.002

Methods

Participants Emails were sent to the coaching staff and team captains of both club and varsity athletics at the University of Wisconsin-Eau Claire to obtain player interest and contact information. Then, athletes from both university-sponsored sports and club sports were contacted directly and asked if they would like to participate in the study. Afterward, the researcher email those interested in the study, a schedule for data collection availability.

Those who have experience participating in sports are more coordinated than the average individual. Since the study is looking at using functional methods to assess athletic performance, using athletes was the best option. They would be able to not only perform the tests well but also have a much less chance of becoming injured.

Sports that change in direction often and require a powerful lower body were the source of the participant pool for this study. 10 participants from sports such as Soccer, basketball, rugby and football, and softball were involved in the study.

Functional Testing Methods

In the strength & conditioning and sports medicine fields, coaches and clinicians use several functional tests to assess an athlete's ability to perform sport-specific movements. These tests are used to measure baseline performance, post-training cycle abilities, and measure post-rehabilitation progress. Most sports require an athlete to move fast and be agile. Change-of-direction drills also referred to as agility drills, were used to measure this skill (Figure 2).

For this experiment, the Illinois Change of Direction Test (ICODT) was utilized to measure participant's ability to rapidly change the direction of their movements. The ICODT has

been shown to have high absolute reliability, which was assessed by Hachana et al., based on its intercorrelation coefficient (ICC= .94) and standard of error measurement (SEM= 1.24%) (Hachana et al., 2014). These scores indicate that the test can produce consistent results throughout multiple testing samples. In addition to agility, lower body power output is a vital component in most sports. Using a broad jump has been seen in literature as a valid test to assess lower extremity power output (Krishnan et al., 2017).

When individuals exercise, they often listen to fast pace music. In this study, 96-130 BPM was the range of song tempos used by the participants. The smallest BPM used would classify as allegretto meaning moderately fast-paced while the upper range falls more under allegro referring to a fast-paced or quick tempo (Masterclass, 2019). This study required participants to perform to the best of their ability, and listening to faster-paced music, hypothetically, allowed them to achieve optimal arousal.

Procedure

Completion of the warmup was done before doing any exercise. A proper warmup can reduce the chance of injury by increasing the body's core and tissue temperature and increasing the joint's range of motion (ROM), allowing them to move through the appropriate ranges during the session (Shellock & Prentice, 1985). Priming the body for the desired movements can also allow for the best performance possible (Shellock & Prentice, 1985). This is typically done by breaking down and completing portions of the primary motion during the warmup.

Warmup before completing the performance drills

1. *2-minute jog around the track or long length of the gym*
2. *High knees 10yds*
3. *Butt kickers 10yds*
4. *High skips 20yds*
5. *Karaoke 10yds switch sides and repeat*
6. *Lunge with twist*
7. *Over-under the line step 10 yds switch sides and repeat*
8. *Sweep the floor (hamstring stretch)*
9. *Gradual sprints 50-75-100% down and back, short side*

The functional tests were implemented once the warmup was completed. Participants were allowed a total of three trials with each test and an average of 90sec-2minutes rest in between attempts. Participants should've be fully recovered for each attempt, so fatigue from the previous run wouldn't affect their results.

The initial trial was for the participants to gain familiarity with the test. The second trial was the baseline test to see how well they could perform without music. Participants played their music of choice, if it met the minimum tempo requirement, during the last trial attempt.

Results

A Paired-Samples T-Test was ran using the results from the participant's trials. The purpose of this test was to gather quantitative data. The mean values produced compare attempts in the non-music trial to attempts in the music trial. With a value of -0.0994 meters, non-music attempts were on average 0.0994 meters (about 4 inches) less than attempts in the music trial. (Table 1). The test used an alpha value of $.05$ while using the 95% confidence interval. Data with p-values less than the alpha of $.05$ would be yield a significant results. The tails of the distribution are cut at 2.5% meaning surpassing this threshold strengthens the significance of the data. The Paired-Samples T-Test also produced a 0.001 p-value for the broad jump and a 0.002 p-value for the ICODT (Table 2). Production of a p-value less than 0.05 means that the null hypothesis is rejected, and the smaller the value the stronger the evidence for rejection (Beers, 2021). The null hypothesis is that 'music does not have any effect on the performance of the ICODT and broad jump'. Therefore, evidence for rejecting the null hypothesis is strong with p-values of 0.001 and 0.002 .

Limitations

Conducting this study during a pandemic created several limitations. Many of which made the data collection process more difficult. Due to government-mandated shut-downs, data collection was moved to the fall 2020 semester due to lack of facility access. Additionally, due to prior commitments, scheduling was an issue as well. The fall semester is typically the busiest for athletics and as a result, the Athletic Training staff and students had their hands full.

Injuries within sports are difficult for athletes when participating in their sport. As part of the athletic training team, we take many measures to get them back to practice as soon as we deem reasonable. This might mean providing taping to restrict movement or hold them from participation to complete rehab for injuries. The only disqualification of this study was those dealing with injuries at the time of the study. There were many injuries this past year that occurred for a variety of reasons. These injuries didn't restrict participation completely, however, as an uncertified Athletic training student, the lead researcher was unable to implement the preventative taping techniques that kept many in their sport, during data collection. Additionally, most participants were recruited from athletics resulting in a drastic loss in potential participation. Lack of participation limited the potential power of the study as well, making the results less reliable.

Discussion

Functional tests, like the ones used in this study, are more specific to athletic skills than other tests used in previously conducted studies (Atan, 2013; Pujol & Langenfeld, 1999). The data becomes more accurate as the testing methods mimic the motions used in a sport more.

The mind-body connection is powerful. Even in research regarding pharmaceutical drugs, this connection has been shown to have a significant effect on participant outcomes (Miller & Rosenstein, 2006). Some people have experienced and believe that music facilitates performance. Participants potentially performed worse due to anticipating this change.

The mind-body connection is powerful and can be utilized by anyone to improve their performance. This can be seen within the biopsychosocial model. This model explains the connection between an individual's psychology, physiology or biology, and social life (Alonso, 2004). Each piece of this model plays a role and can affect the others. During athletic performance becoming nervous and increasing anxiety based on this model can thus impact performance. Again, under this model, believing a tool could impact performance will ultimately alter the biology, regardless of it having direct changes on the psychology or social wellness.

The application of this research in a more specific setting could be a good next step. Setting such as with athletes before an athletic event. Competition is ultimately what athletes train for and is typically when the greatest injuries occur. Implementing music with preferred songs before athletic events might allow for greater optimization of arousal compared to listening to music via speaker as some teams do doing their pre-game ritual. For some, the social aspect, in addition to the music altering the psychological state, might provide even greater benefit than just listening alone. Implementing these ideas and testing outcomes such as injury rates, or taking a mental wellness questionnaire, are just a few directions that this research project could turn.

Conclusion

To achieve optimal arousal, athletes need to have as much control over their emotions as possible. Many different neurotransmitters affect arousal and finding an appropriate balance can create a better internal environment for performance. Music can influence these variables, and as this study shows, allows for closer to optimal arousal levels. Music can also regulate how some of our body systems function. The tempo of music can set the tone for the body and increase the metabolic rates of several internal systems. Music has a positive effect on arousal when used appropriately for emotional control and autonomic nervous system efficiency. However, if the body becomes overwhelmed or underwhelmed, music may not positively affect performance.

Perception is critical to exercise performance due to the various physiological changes that can occur. By altering the brain's perception of high-intensity exercise, one can impact performance, whether its movement quality, less time taken to finish an exercise, or even more power output. How the brain perceives a stimulus will determine the changes in bodily function that occur. Listening to music can decrease the rate at which negative stimuli, created by strenuous exercise, are interpreted by applying a positive or pleasurable one, like music.

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