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THE EFFECTS OF LISTENING TO MOTIVATIONAL MUSIC ON PERFORMANCE OF KNEE EXTENSION AND FLEXION IN HEALTHY ADULTS

Alexander Lesser
University of the Pacific, alesser1@bellsouth.net

THE EFFECTS OF LISTENING TO MOTIVATIONAL MUSIC ON PERFORMANCE OF KNEE EXTENSION AND FLEXION IN HEALTHY ADULTS

By

Alexander S. Lesser

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Alexander S. Lesser

APPROVED BY:

Thesis Advisor: Eric G. Waldon, Ph.D.

Committee Member: Feilin Hsiao, Ph.D.

Committee Member: Courtney Jensen, Ph.D.

Department Chair: Feilin Hsiao, Ph.D.

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DEDICATION

This thesis is dedicated to all who at one point in time thought they couldn't, but found a way to. To those who are still searching, you only fail by giving up. Don't!!

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I would like to acknowledge my thesis advisors for their time, assistance, and patience with me throughout this process. Without your guidance and support the completion of this project would not be possible.

I would also like to acknowledge my wife. My true best friend for longer than most people know. You know the best of me, and the worst of me, yet still you accept, love, and support me throughout all life has to throw at us. You are without doubt, the best part of my life. I am truly the luckiest person on earth because you continue to choose me. #'s

THE EFFECTS OF LISTENING TO MOTIVATIONAL MUSIC ON PERFORMANCE OF KNEE EXTENSION AND FLEXION IN HEALTHY ADULTS

Abstract

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The purpose of this study was to determine whether listening to motivational music prior to performing leg extensions and flexions effected peak torque performance. Participants included 23 adults between the ages 18 and 48 years. Participants engaged in three sets of leg extensions and flexions utilizing a Cybex Humac NORM system following a warm-up period consisting of listening to either researcher-selected music, self-selected music, and in silence. Two one-way ANOVAs comparing participants' data showed significant results in leg flexions performed following warm-up while listening to self-selected music. Significant results were not achieved for leg extensions yet a similar trend was seen providing evidence that listening to self-selected music before performing activities increased level of performance.

TABLE OF CONTENTS

LIST OF TABLES

Table

LIST OF FIGURES

Figure

CHAPTER 1: INTRODUCTION

A common topic in media, social events, athletics, the medical field, and even in the military, focuses on peoples' struggle with staying healthy and with managing weight. A national study collected data from over three thousand people medically classified as overweight/obese (De Heer, Kinslow, Lane, Tuckman, and Warren, 2019). Out of the roughly two thousand participants who were informed they should seek assistance to lose weight, 68% reported making an effort, yet only 10% actively sought professional help.

Globally, obesity and being overweight, considered a major concern (Fildes et al., 2015). People frequently set and fail to meet goals to get in shape. Many are willing to try anything to accomplish this goal. Yet "anything" often fails to work, or comes with adverse side effects. Linked to the development of cardiovascular diseases and type 2 diabetes, obesity is a common cause of rising medical costs and prescription drug usage (Mancini & Edna de Melo, 2017).

According to the Centers for Disease Control (Hales et al., 2016) more than a third of the population is classified as obese and a large-scale epidemiological analysis demonstrates a relationship between obesity and increased risk of cardiovascular disease, diabetes, hypertension, stroke, osteoarthritis, and all-cause mortality Most people, including people with neurodegenerative diseases such as Alzheimer's and Dementia, can associate music to particular times in their lives (Singh and Ratnawat, 2018). It gives people a way to share emotions, stories, and fulfilling life events with others to help improve their mood and overall health.

In the military, motivation to exercise is usually driven by the desire to avoid consequences such as receiving disciplinary actions resulting in loss of rank or the withholding of promotion, fitting into a uniform to avoid being mocked and singled out, or being forced to adhere to a limited diet (Shank et. al., 2019). Motivation to manage weight often does not

continue after a month or even a couple weeks. The act of working out, once begun, for most is bearable and as noted by Chizewski (2016), listening to self-selected music while exercising makes working out enjoyable. However, the difficult part for most people is not performing the work; instead, it is becoming motivated to begin the work.

Elite athletes gain motivation by targeting goals to either perform better, or to not fail (Šmela, Pačesová, Kraček, & Hájovský, 2017). Thus, studying methods to improve motivation can produce strategies for enhancing performance.

Bowles, Curtis, Davies, Lengerich, and Bugajski (2019) noted that over 80% of participants within a cardiac recovery program reported that music assisted with reducing stress while engaging in physical exercise. Participants experienced a more intense workout while listening to music, and planned to continue using music in future workouts. Schutz and Rotters (2019) found increased intrinsic motivation and better performance of horse riders engaged in equestrian sport who listened to music while riding. This suggests that music may increase motivation and result in enhanced physical performance.

As early as in high school (Berkowitz, Cockrell Skinner, and Lohr, 2019), athletes are facing similar problems with obesity. Berkowitz et al. noted that although the highest rate of athletic obesity was found in football players, developing and maintaining motivation to stay fit are essential for all athletes to avoid losing play time, maintain team social status, perform at a high level, and limit injury. Athletes will attempt anything including altering diets, fasting, taking supplements and vitamins, or using anabolic steroids to improve performance even though most methods of enhancement are unproven, and those that do work, can come with a host of adverse side effects. The Mayo Clinic (2019) lists possible risks for some performance enhancing stimulants as: irritability, insomnia, dehydration, heatstroke, addiction, and increased

tolerance which can lead to higher dosages and more serious side effects. Efforts to obtain a stronger body, faster time, or more intense workout can be detrimental to the long-term health of an athlete. Especially when athletes put extreme stress on the mind and body which may result in symptoms including tremors, hypertension, stroke, heart attack, and other respiratory and circulatory diagnoses. Anabolic steroids most commonly affect muscle growth by binding testosterone with androgen receptors (Anstey et al., 2018). Much like natural hypertrophy, and as one's tolerance begins to grow, improvement in performance will taper off, leading to the use of more stimulants to sustain continuous growth. For steroid users, the bigger the stack (the more steroids used at once) the bigger the gain. Thus, the average athlete taking one or two testosterone enhancers will potentially see very little significant gains in size and performance.

Brooks and Brooks (2010) tested differences in athletic and physical performance. Utilizing the Wingate stationary bicycle test while listening to music during physical activity, they identified a significant difference in peak power, average power, anaerobic power, and power-drop when participants listened to motivational music. However, little is known about the effects of music on performance when used as a pre-workout technique or as an additive to a warm-up routine. Identifying whether warm-up music can prepare a person for physical exertion may lead to further studies comparing music to less healthy practices of pre-workout preparation. Further, identifying whether self-selected music, music randomly played at gyms or sporting events, or silence has an impact on overall performance can lead to building personalized playlists or music selections to help alter one's training.

There are known relationships between music and emotional states within healthy adults, and listening to different types of music can result in the development of positive or negative emotions which can in turn affect performance (Geethanjali, Adalarasu, & Jagannath, 2018).

While studying music processing in the brain, the research of Geethanjali et al. identified significant changes in the autonomic nervous system, and concluded that music activity affects the anterior cingulate cortex and insular cortex (influential to changes in autonomic activity). When participants were exposed to music, their heart rate and blood pressure increased as a result of stimulating the sympathetic system.

Thus, research has shown that listening to music while performing strenuous activities such as riding a bike, running, or even swimming, can reduce the amount of perceived exertion by entraining breath and cadence, which can result in improved performance. Stork, Karageorghis, and Martin Ginis (2019) found that people who are typically less active can improve pleasure while engaged in sprint interval training by listening to music, which in turn may increase overall physical activity. Jarraya et al. (2012) studied the effects of listening to music as warm-up on performance of the Wingate cycle ergometer. They found that during a thirty-second testing duration, participants who listened to music during warm-up had an increase in peak power performance. These findings, along with those of Chtourou, Chaouachi, Hammouda, Chamari, and Souissi (2012), who similarly studied listening to music during warm-up for the Wingate test, were done using participants who qualified as physically active. What is less researched, however, is whether music can affect performance in force output when used as a pre-workout/warm-up assistant in a general population.

Based on the findings of Brooks and Brooks (2010) and Greethanjali et al. (2018) it appears that a relationship does exist between listening to music and enhanced execution of physical activity, which may assist the general public, people engaged in rehabilitation, as well as athletes to effectively utilize music to meet personal and professional goals. Therefore, the aim of this study is to answer the questions:

1) Does peak torque as measured by leg extension differ by warm-up music listening condition?

2) Does peak torque as measured by leg flexion differ by warm-up music listening condition?

Participants' peak torque was measured during the designated exercise after they performed a warmup routine consisting of three different music listening conditions selected at random. Listening conditions consisted of self-selected motivational music, researcher-selected music, and silence.

CHAPTER 2: REVIEW OF THE LITERATURE

Music and Physical Performance

Research in music therapy suggests that utilizing music in tandem with physical therapy can successfully assist with meeting goals focused on rehabilitation concerning gait as well as gross motor and fine motor functionality (Weller & Baker, 2011).

Physiologically, when people listen to music while engaged in activity, tempo and accidentals in selected music elicits a predominant response in breathing and gate speed due to a natural relationship and entrainment the brain has to these elements. This interaction results in reduced perceived exertion (Karageorghis & Terry, 1997). Music functions as a distraction, a guide for breathing rate, and a cue for foot placement. Koç and Curtseıt (2009) suggest that listening to music elicits a heightened sense of happiness and vigor, or increased motivation, which lends to a prolonged duration of moderate exercise before development of fatigue. Similarly, Ghaderi, Chtourou, Nikbakht, Jafari, and Chamari (2015) identified that participants engaged in circuit resistance exercise while listening to music, had reduced production of lactate, which is linked to an increase in fatigue. Fukui (2001), when testing testosterone levels while listening to music, found that levels of testosterone decreased in all music conditions when compared to the silence group. However, three of the five music conditions for this study included jazz, Mozart, and Gregorian chant which all provide musical elements typically used for relaxation.

Karageorghis et al. (1999) found that listening to stimulating music based on the BMRI promoted an increase in static strength when performing a handgrip strength test. In contrast, Bray, Oliver, Graham, and Martin Ginis (2013) found participants who listened to music while engaged in activity reported improved positive emotions and increased motivation, but displayed

no significant difference in the amount of time one could maintain a handgrip of 50% of their maximum voluntary contraction. These results may suggest strength depletion occurs when repetition of tasks requiring self-control and regulation takes place. However, Godwin, Hopson, Newman, and Leszczak (2014) noted that behavioral strategies, such as listening to music during activity, can improve sustainment of motivation, and in turn improve continued self-control and self-regulation through continued physical exertion. Lopes-Silva, Lima-Silva, Bertuzzi, and Silva-Cavalcante (2015) examined the effects music had on exercise between fatigued and non-fatigued moderate level exercise and found that music did have an effect on attention, yet did not result in enhanced performance regardless of fatigue level. Therefore, research has identified that increased motivation impacts performance in athletic activity, making it important to identify how music can affect mood and improve initial motivation.

Music and Mood

Elements of music elicit different emotions. Wellman and Pinkerton (2015) categorize music into three prime emotions: unsettled, soothed, and energized. Listing one's preferred music into these categories and actively listening to a playlist of music in that order repeatedly over a span of a couple months, has been shown to improve overall mood. By listening purposefully to music and engaging in verbal processing, people can improve symptoms of depression, anger, and improve reality orientation and motivation (Pitts & Silverman, 2015). Kuan, Morris, and Terry (2017) noted that mood and state of mind, referring to the emotional stability of athletes prior to engaging in activity, is a well-established link to quality of performance. Demonstrating the importance of research which identifies warmup routine methods to improve motivation and performance.

The BMRI (Karageorghis et al., 1997) categorizes motivational music which meet a criterion of musical elements such as tempo, melody, harmony, and lyrics. To be classified as motivational, selected music consists of a tempo greater than 120 beats per minute, include a dominant rhythm, and have components which induce physical reaction. It suggests that combined with personal associations to the music, sociocultural backgrounds, and specific musical preferences, these elements determine the motivational strength of a piece of music. Karageorghis et al. (1999) discussed the concepts of Gfeller (1988) who theorized that abstract associations such as running like the wind or being strong as a monster, are developed by elements of music, lead to improved motivation, and provoke engagement in physical activity. The BMRI was developed to identify musical elements which possess motivational qualities in order to assist in programing effective music both before and after physical activity. It has been utilized for multiple athletic research studies to select motivational music.

Consideration was taken for both music factors and personal factors (i.e. familiarization or emotional connection) as people relate differently to music (Budd, 1989) and can interpret emotional qualities of a single piece of music as either pleasant or unpleasant. Fukui (2001) suggested that emotions developed while listening to music are more intense than a typical mood. Therefore, a listener's self-selected music for motivation may in turn prove to be more useful despite not fitting into the BMRI as the mental association to the song could provide a stronger effect.

Music and Motivation

Previous research concludes that self-selected music has a stronger impact on a person engaging in activity. Brandt, Razon, Blom, and Bolin (2019) found that while running a mile, participants displayed greater motivation while listening to self-selected music, and in turn

performed at a higher level than participants who ran while listening to either researcher-selected music or in silence. Similarly, Belkhir, Rekik Chtourou, and Souissi (2019) identified that following a ten-minute warm-up which included self-selected motivational music, soccer players had improved high distance and total distance in a five-minute shuttle run test than those who engaged in warm-up with either neutral music or without music.

Music listening has been linked with reduction of stress hormones, anxiety, the perception of pain, heart rate, blood pressure, and diminished need for anesthesia (Batt-Rawden, 2010; Good, Anderson, Stanton-Hicks, Grass, & Makii, 2002). Batt-Rawden noted how people independently use music as a self-prescribed remedy for both medical and emotional situations causing stress and pain. Musical elements such as melody and harmony can influence and change a person's emotional state, or mood, and therefore shape a specific response both emotionally and physiologically (Karageorghis, Terry, & Lane, 1999). It is thought that music utilizing a slower tempo with a somber tone may evoke emotions of depression, and thus cause a person to feel sluggish or unwilling to perform. Where music of a higher tempo with a brighter tone or melody may invoke feelings of satisfaction and elicit pleasing feelings and relaxation. However, research is lacking in the area of identifying the effects of music through psychometric analyses, and physiological and emotional responses to music qualities can differ between individuals.

Among Finnish adolescents, elevation in physical fitness corresponding to increased perceived physical competence was strongly related to performance; in turn, perceived competence improved a situational positive predictor of intrinsic motivation (Jaakkola et al., 2013). Awruk and Janowski (2016) discuss types of motivating factors leading to regular training as being pleasure derived from physical activity, improvement of physical performance,

improvement of one's appearance, and obtainment of motivation dependent on social approval. Moreno, González-Cutre, Martín-Albo, and Cervelló (2010) measured the effects of motivation on physical performance. They discovered that motivation at the onset of activity, consisting of lifting a board laterally as many times as possible for a duration of twenty seconds, resulted in better performance for the first trial. Groups who scored lower for the first trial improved performance during the remaining trials, suggesting an increase in motivation to improve their previous score.

Globally, music has been identified as one of few culturally and universally recognized practices which evoke a range of emotions from exciting to relaxing, pleased to sadness, distress to comfort, or any other combination (Chanda & Levitin, 2013; Nilsson, 2008). Colegrove, Havighurst, and Kehoe (2019) identified that engaging in non-verbal music communication interventions improved emotional regulation in parent-adolescent dyads, and evoked a response which results in less conflict. Guillén, and Ruiz-Alfonso (2015) studied the effects of music as listening conditions during a twenty-minute static bicycle exercise and noted significant increased motivation in the groups who listened to techno music. However, they suggested the type of music was not significant, but rather the association of music to films. Considering their results, film scores such as *Eye of the Tiger* (Sullivan & Pererik 1982) from the movie "*Rocky,"* do fall under the motivational category outlined in the BMRI and could be a positive way to induce motivation prior to performing physical activities.

Knowing how people connect mood and motivation, it can be assumed one is going to develop a greater motivation to be physically active if they are motivated not only to lose weight, obtain pleasure, improve performance, or obtain a feeling of approval within a social aspect, but if they are initially in a positive state of mind and a good mood. Research has displayed that

listening to music does affect mood, elicits feelings of motivation, and has shown to have an effect on athletic performance. The effects of listening to music while exercising continues to be studied to identify ways to provide distractions and improve performance while decreasing perceived levels of exertion, pain, and anxiety. More research is needed to identify the effects of listening to music prior to performance, and how music therapists can effectively provide music interventions to people aiming to improve their physical and athletic performance.

CHAPTER 3: METHODOLOGY

Design

The study employed a randomized control trial to limit reoccurrence of the treatment order. The order of treatment was randomized using the Latin-square design to minimize error. Richardson (2018) emphasizes that the Latin-square design is useful in selecting orders at random and ensures no replicating pattern occurs. Each participant acted as their own control by completing each level of treatment prior to performance of the exercise. Data collected using the Cybex system included peak torque to answer the questions:

1) Does peak torque as measured by leg extension differ by warm-up listening condition?

2) Does peak torque as measured by leg flexion differ by warm-up listening condition?

Participants

Inclusion criteria included consenting adults between age 18 and 50 years who were able to perform leg extensions and leg flexions utilizing their dominant leg and who were willing to complete all sections of the testing in one sitting. Participants were recruited through in-person presentations and verbal communication. Figure 1 outlines the order in which participants were recruited and engaged in the experiment. Random assignment of condition was achieved through each participant rolling a single six-sided die. Exclusion criteria consisted of current, or history of injury to the dominant lower extremity which may prohibit muscle testing, and extreme hearing loss or use of hearing aid which distorts perception of sound. Ethical concerns were addressed by de-identifying all participants in the database.

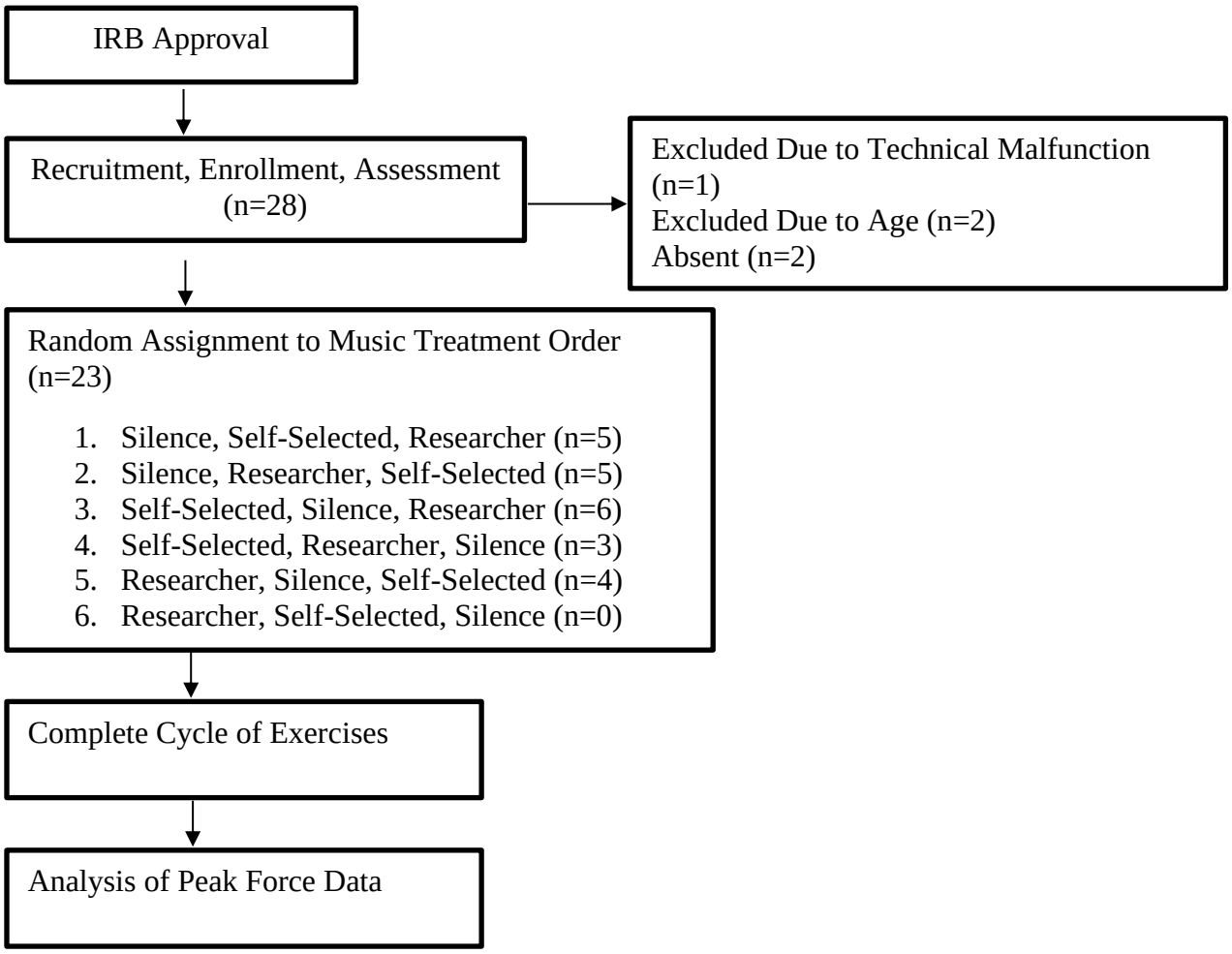

Figure 1. Flow of participants through each stage of the experiment. Submission and approval of experiment with live subjects from Institutional Review Board (IRB), recruitment, enrollment, and, assessment for eligibility (contacting researcher via email, text, or phone call), random assignment to treatment group (roll of a six-sided die), complete exercises on Cybex Humac NORM, and data analysis of peak force.

Facilities

Research activities were conducted at a private university using the Cybex Humac NORM system located in a health science lab. Time of testing was selected by the participant. Testing occurred while no classes were in session. Once scheduled, participants met with the researcher individually outside of scheduled class time to allow for limited distractions of classmates. A window beside the entry door was viewable peripherally while seated in the Cybex machine. However, participants were positioned facing the wall of the room to limit

visual distractions. To limit participants' performance anxiety, individual data was only shared after completion of the experiment. Music listening condition was delivered through over the ear headphones to eliminate any potential effects of room acoustics.

Procedure

Prior to testing, the researcher recorded demographic, behavioral, and anthropometric data: height, weight, age, sex, musical experience, average duration of exercise per week, average amount of sleep per night, and history of lower extremity injury. Each participant was seated in the Cybex Humac NORM dynamometer. Direction and placement of the machine was adjusted based on the dominant side reported by the participant and comfort of the participant to allow for the optimal performance of the leg extensions and flexions. Following adjustment, participants were provided headphones with sanitation covers and listened to a short excerpt of music, not qualified as motivating under the standards of the BMRI, to obtain a comfortable volume level. Treatment order was randomized as each participant rolled a single die to determine which of the six variant delivery orders would be used. Independent variable conditions consisted of: warm up period of four repetitions of leg extensions and flexions while listening to either self-selected motivational music, researcher selected motivational music (*Sandstorm* by Darude, 1999), and in silence. Self-selected motivational music was chosen in the moment by the participants after receiving a verbal prompt to choose a piece of music they felt would motivate them. Each level of the music treatment was delivered via an iPad and over the ear headphones during warm-up of four repetitions. Warmup condition including silence was performed wearing headphones with no music or sound being provided to maintain consistency. Each level of treatment consisted of listening to roughly 30-60 seconds of music to fill the duration of warmup. Peak torque was then recorded during five repetitions of leg extension and

flexions. Each participant performed this protocol in one sitting and received a two-minute break between each level of treatment.

Measures

Peak torque measures the maximum amount of force applied to an object on its axis. For this experiment, the torque measured was the maximum amount of force being applied to the knee axis of the participants while extending and flexing the leg. Of the five repetitions performed during each listening condition, the best repetition provided the peak torque data for comparison. Physiologically, muscles surrounding the axis, or joint, provide the force to control movement at the axis. Torque is then calculated based on the leverage produced by the muscles surrounding the joint during the movement. Figure 2 displays the Cybex Humac NORM Isokinetic Extremity System (Computer Sports Medicine, Stoughton, MA, 2019) utilized for this study.

Figure 2. Cybex Humac NORM Isokinetic Extremity System

Using the algorithms programed in the Cybex Humac NORM software (Computer sports medicine, 2019), the researcher was able to record the maximum amount of torque in foot-pounds produced by these muscles while the participants are engaging movement at the knee axis.

Analysis

Statistical tests were performed using SPSS version 25 (IBM SPSS Statistics, IBM Corporation, Chicago, IL, USA). Differences in baseline data between men and women were detected using chi-squared tests for categorical data and independent-samples t-tests for continuous data. One-way repeated measures analysis of variance (ANOVA) tested differences between the three listening conditions; all subjects performed all conditions.

CHAPTER 4: RESULTS

Participant Characteristics

The research sample consisted of male (n = 7) and female (n = 16) healthy adults with varied musical experience (Y = 22, N = 1) and exercise engagement per week (3.0 ± 2.4 hours). Participants' mean ages were 25 years (for men) and 27 years (for women). All male participants reported prior musical experience, average weekly exercise as 3.8 hours, and receiving an average of 6.7 hours of sleep per night. Of the female participants, 15 reported prior musical experience, average exercise per week as 2.6 hours, and receiving an average of 6.6 hours of sleep per night.

Table 1
Participant Demographics

Demographics	Total Sample	Male (n = 7)	Female (n = 16)	Homogeneity of variance	Sig.
Mean age	26.7 ± 8.4	25.3 ± 10.3	27.4 ± 7.6	Yes (p=0.993)	0.593
Music Experience	Y=22, N=1	Y=7, N=0	Y=15, N=1	N/A	0.499
Exercise/week (hrs)	3.0 ± 2.4	3.8 ± 3.6	2.6 ± 1.7	No (p=0.005)	0.431
Sleep/night (hrs)	6.6 ± 1.2	6.7 ± 1.3	6.6 ± 1.1	Yes (p=0.857)	0.828

Research Question Analyses

Research Question 1

As a preliminary step in carrying out the one-way repeated measures ANOVA, Mauchly's test of sphericity was used to examine the equality of variances between all pairs of within subject conditions. The first research question addressed was whether listening condition impacted peak force during leg extensions. Because Mauchly's test was significant (p = .02),

sphericity was not assumed. Using Greenhouse-Geisser, the ANOVA was significant, $F(2, 44) = 4.02$, $p = .036$, partial $\eta^2 = .154$.

Post hoc analysis using Bonferroni correction for multiple comparisons as shown in Figure 3, found no significant differences in mean peak force between listening conditions: Silence, $M = 80.35$; Participant-selected, $M = 92.00$; Researcher-selected, $M = 85.78$.

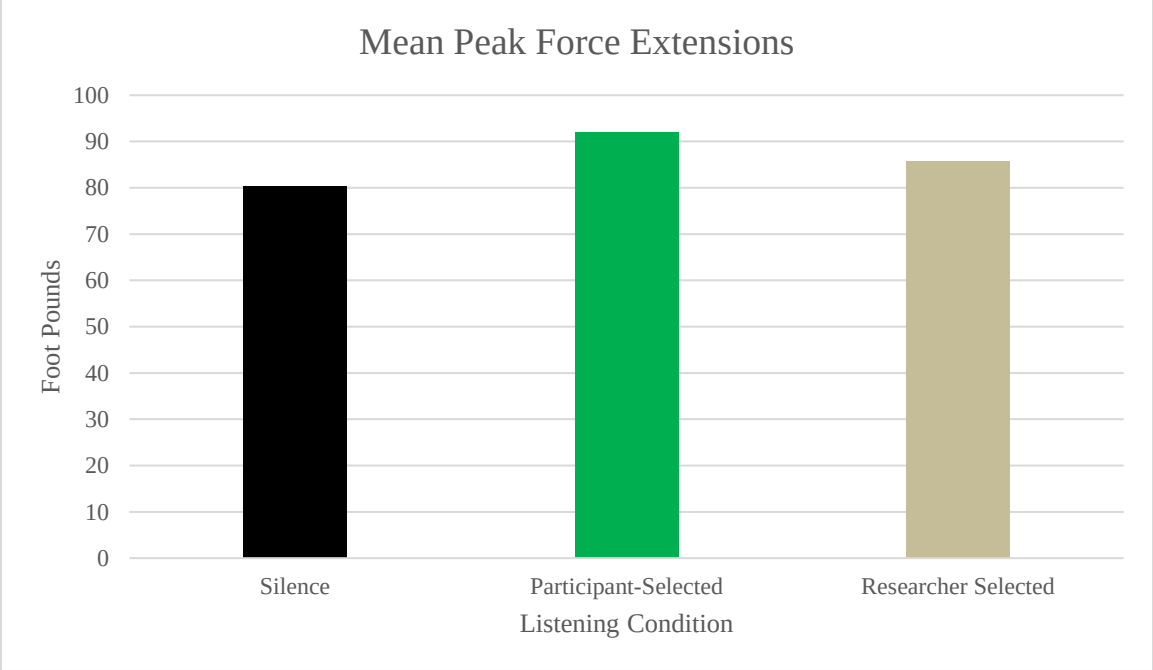

Figure 3. Mean peak force measured in foot pounds during leg extension.

Research Question 2

For the second research question, whether peak force during leg flexions varied by listening condition, Mauchly's test was not significant: sphericity was assumed, ($p = .06$). The ANOVA was significant, $F(2, 44) = 5.077$, $p = .01$, partial $\eta^2 = .19$. Post hoc analysis using Bonferroni for multiple comparisons yielded one significant finding: the mean difference in peak force during flexion as shown in Figure 4 was significantly different between the silence ($M = 47.89$) and participant-selected ($M = 54.13$) conditions. There were no such differences between researcher-selected music ($M = 50.26$) and the other conditions.

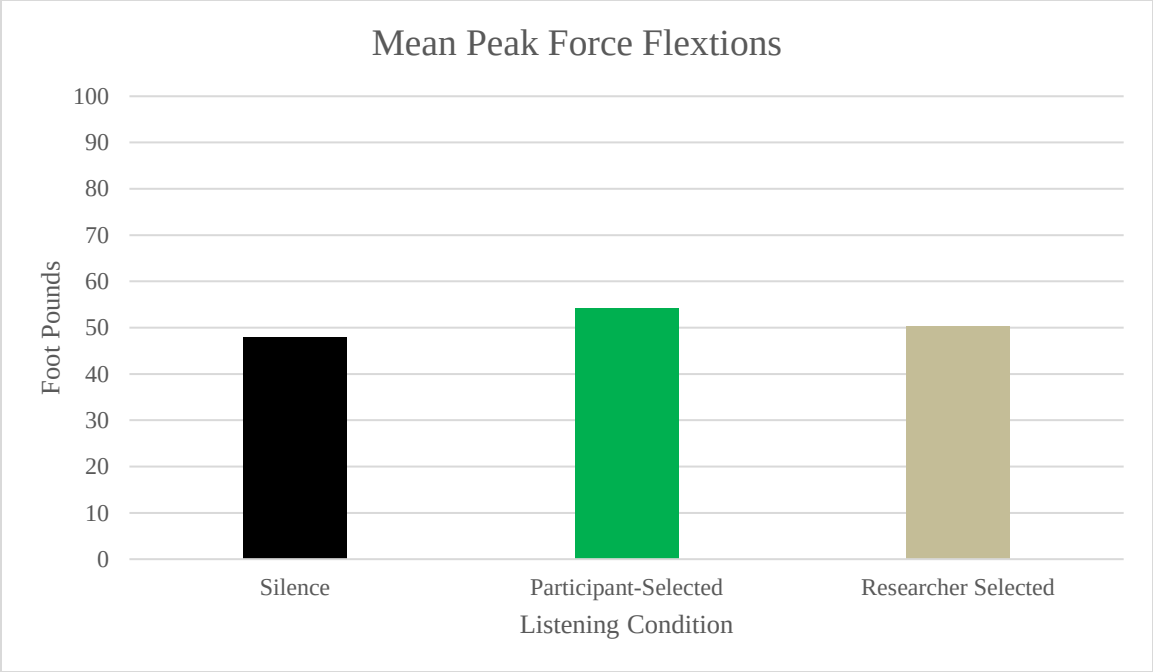

Figure 4. Mean peak force measured in foot pounds during leg flexions.

CHAPTER 5: DISCUSSION

Music and Physical Performance

The purpose of this study was to determine if listening to music during warmup had an effect on peak torque while performing leg extensions and flexions. The research questions addressed in the current study were:

1) Does peak torque as measured by leg extension differ by warmup music listening condition?

2) Does peak torque as measured by leg flexion differ by warmup music listening condition?

Data collected from 23 participants indicated a significant difference in peak torque in leg flexions following warmup while listening to self-selected music. Much like the findings of the Books and Brooks (2010) Wingate experiment, it is seen that motivational music did have a positive effect on participant performance. The added factor in the current study was the self-selected music treatment, which provides similar findings as studies where performance is improved while participants listened to their own preferred music. Results displayed a similar trend for leg extensions, yet did not display significant findings.

The experiment required participants to utilize both type 1 and type 2 muscles and to engage in activity which required short durations of maximum effort. For this reason, although exercise per week was not a predictor in the data collected, fatigue may have played a role on the outcome due to lack of training and experience. If replicating this study, it is recommended that each participant engage in multiple days of data collection to compare results from two to three sessions and allow for multiple tests of peak force in different situations. This would provide a more complete data profile of the individual's mean peak torque under multiple situations and levels of fatigue.

Further regression analysis could be done for identifying whether any conditions were a significant predictor in the maximum torque in either extensions or flexions. However, for this study, the number of participants may limit the findings. Therefore, if replicated with a higher number of participants, and greater number of trials, a regression analysis might be beneficial to gain a greater understanding of the correlations between the conditions and results. For this study, a trend was present between the data of flexions and extensions; thus, the results are consistent with the hypothesis that self-selected motivational music, when listened to as a warmup, does have a positive effect on performance.

An additional limitation of this study was the participants becoming familiar with the experiment and what is expected from them. It was observed by the researcher that on average, participants displayed more comfort with the exercises during the second level of treatment. Regardless of the condition level, the participants appeared familiar with the process following the first trial. By collecting data across multiple days in a replicated study, not only would there be more comparative data, but participants will have time to learn and become more familiar with the experiment and possibly provide more compelling results. Offering multiple collection opportunities will allow for extra time to recruit a larger sample size as well.

Listening to music while exercising has been noted to have positive effects on mood, which can enhance performance through diverting attention and decreasing levels of perceived exertion (Godwin et al., 2014). If replicating this study, it is recommended that a mood questionnaire be presented to the participants to identify their mood and state of mind prior to and after exercise. As a multi-level study, this questionnaire could be provided after each level of the condition to compare mood and state of mind after the different music treatments. As Terry et al. (2006) noted, mood and state of mind are well-established links to enhancing

performance. Identifying whether music during different conditions effects the participants' mood or state of mind in between trials can provide data for future studies to focus on trends or predictive factors of listening to playlists while exercising.

Music listening has been shown to reduce stress hormones, anxiety, the perception of pain, heart rate, and blood pressure (Batt-Rawden, 2010). Thus, it would be beneficial to include physiological measures (e.g., blood pressure, heart rate, respiration) and biological markers (e.g., levels of cortisol or testosterone) to obtain a clearer picture of the effects of warmup music. Similar findings from Yamasaki et al. (2012) suggest the use of music produces metabolic effects to assist the body in recovery, which assists in balancing energy levels for the duration of an activity.

For the current study, it was observed that the majority of participants began to experience fatigue within the second trial condition regardless of treatment level. Identifying whether or not music used as a warmup assists with stabilizing energy levels before exercise could provide useful data for athletes and trainers. Future studies should provide questionnaires to identify perceived energy levels of participants before and after warmup music to identify if participating in music listening or active music making interventions has an effect on energy levels prior to exercising. Results of this study were similar to those from Jarraya et al. (2012), where music as a warmup for the Wingate test identified that power output of participants was significantly higher in those who received music as a warmup. A similar trend in increased performance after listening to self-selected music was achieved in the current study. These results can assist athletes, trainers, and coaches in identifying a music-assisted regimen to use before engaging in training, sporting events, or competitions. More so, studies into the effects of music listening prior to performing exercise, and in between durations of activity, would benefit

athletic teams and individuals who may be reacting to random music played in arenas, stadiums, or gyms. Replicated studies can adjust delivery methods, activity recorded, and music selection to collect data from players or athletes during practices or training sessions to study the effects of music in between plays or during down-time. Similar to the findings of Karageorghis et al. (1996), listening to stimulating music based on the BMRI promoted an increase in static grip strength; results of this study show improved performance and enhances the general knowledge of the effects of music used during warmup periods.

Music Selection

Music therapists working in a clinical setting typically choose to use music that can improve symptoms of depression and anger, and assist with reality orientation (Cassity, 1976; Pitts & Silverman, 2015). For this study, participants were prompted to select a piece of music that they believed would motivate them to perform well. Silverman, Letwin, and Nuehring (2016) noted that utilizing patient preferred music was effective for music therapists to use for interventions focusing on reducing pain perception, nausea, and other physiological symptoms. In these cases, though, preferred music is decided upon by the therapist based on the current state of mind, and level of pain and anxiety of the patient. The current study did not consider the pain and anxiety level of the participant before participating, which could have influenced their self-selected music choice.

Participants self-selected music choices (see Appendix A) in this study did and did not meet all of the categorical elements in the BMRI. The BMRI elements were not clarified before selection opportunity, and if replicated, future research should introduce the requirements for identifying motivational music to have consistency in each selection. As is discussed by Wellman and Pinkerton (2015), music is interpreted differently by each individual. Therefore,

specific elements or sections of a song, such as *Let it Go* from the Disney movie *Frozen* (Anderson-Lopez & Lopez, 2013), may be interpreted differently depending on the listener. Under the BMRI inventory, this song meets the qualifications for being labeled motivating. The tempo marking is a half note equals 69 beats per minute, which converts to 138 quarter note beats per minute. This is within the BMRI limitations of a motivating, moving tempo. However, each music selection in this study was played from the beginning. The rhythm at the beginning of *Let it Go* emphasizes the slower, half note tempo. Therefore, the self-selected song choice in this instance might have had a negative effect on the participants' peak performance. Under this condition, future studies would benefit by providing opportunities for participants to identify a particular verse, or section of a song which adheres to the BMRI motivation music identifiers.

Considering this, replicated studies should provide music which similarly consists of musical characteristics that qualify a song as motivational. This study followed the BMRI inventory for selecting the constant music condition (*Sandstorm* by Darude, 1999). However, the beginning of this song similarly has a less forward moving rhythmic feel, and may have influenced performance in a negative manner. Validity of performance outcomes based on music selection would be improved in future studies by ensuring all music in the study conforms to the same criteria.

Duration of music delivery during warmup period should remain consistent in future studies to identify if listening to motivational music for longer periods of time has an effect on performance. Providing multiple conditions where time is the independent variable may provide data on the immediate effects of listening to music. O'Konski et al. (2010) provided twenty-minute durations of music. Although the average duration of music provided in this study was thirty seconds to one-minute, results demonstrated a positive effect on performance following a

short exposure to self-selected music. This information can assist music therapists, coaches, and athletes identify music to use for short interval training and time-constricted warmup routines.

Practical Application in Music Therapy

Music therapists utilize music to assist patients improve mood, lower levels of anxiety, decrease perception of pain, and express emotions in ways that verbal conversation does not allow. This suggests that athletes experiencing similar symptoms, both before and during activity, may benefit from being engaged in a form of music therapy intervention. Having a positive mood and state of mind is a well-established method to enhance performance in athletes **(**Terry et al., 2006). Physical activity, be it athletic events or physical therapy, once begun, is not the most difficult aspect of engaging in exercise (Chizewski, 2016). The results of the current study provide evidence that listening to music prior to the performance of an activity might positively influence the desire to begin, and impact performance outcomes.

Therefore, as results show a positive effect on performance after listening to self-selected music, music therapists working with patients in rehabilitation or a physical therapy setting can utilize active music-making, music listening, and musical discussions regarding motivational elements of music for patients. With this knowledge, clients can develop self-prescribed music lists to use before activity. The music therapist can then program a motivational music warmup regimen for patients to utilize prior to performance.

Practical Application in Athletics

The findings of this study contribute to the research which suggests that athletic performance of healthy adults between the age of 18 and 50 is enhanced when listening to music. However, music was delivered prior to the performance of a short duration physical activity and more research is needed to identify the effect of music prior to athletic performance in a long

duration activity. Such research could provide data on the effects of music in-between sections of sporting events such as plays in football, quarters in basketball, or event heats in the Olympics. Music in these events is often selected based on fan preference, sponsor, or tradition. If replicated, studies should provide opportunities for coaches and athletes to provide feedback on music selections for downtime during events. As many coaches and athletes are actively engaged in verbal communication during this time, it would be interesting to add questionnaires to identify the amount in which both coaches and athletes are aware of the music playing before and after plays and other non-play time.

Results of this study support music being used as a training aid in athletics, and music therapists should use this knowledge to provide services for athletes and people working towards a goal of improving physical training. By combining music listening, music medicine, and music therapy, therapists might identify ways for their clients to regulate emotions during stressful physical activity. Introducing music therapy into the world of sports, which can be used in conjunction with sports psychology, individuals can learn to enhance their warmup regimen, regulate emotions, communicate more efficiently, and enhance overall performance. This may be beneficial to athletes prior to engaging in physical activity by not only decreasing anxiety but by improving overall mood and motivation. In team sports, actively engaging in music therapy may enhance group cohesion, and further research should be done to study the effects of group music interventions used as warmups on performance. As Batt-Rawden (2010) noted, people independently use music as a self-prescribed remedy for both medical and emotional situations causing stress and pain. It would be useful for music therapists to provide guidance for athletes to identify the motivational characteristic of music to assist in making educated music selections.

Continued research to identify how and why music effects physical performance can not only provide important knowledge to athletes and people engaging in physical activity, but provide ways for music therapists to engage in structuring music interventions to assist with more diverse populations. Linking music to motivation can assist people who are struggling to lose weight, recover from an injury, maintain physical strength, improve physical performance, and identify non-stressful heathy ways to begin and continue improving performance.

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APPENDIX A: PARTICIPANT-SELECTED MUSIC

Participant-selected songs

1. Let it go (Frozen)
2. Juice (Chromio)
3. Fed up on you (Morgan James)
4. Aint no mountain high enough (Marvin Gaye and Tammi Terell)
5. Wasted years (Iron Maiden)
6. Eye of the tiger (Survivor)
7. Wouldn't it be nice (Beach Boys)
8. Killing in the name (Rage against the Machine)
9. Sill D.R.E. (Dr. Dre)
10. Thriller (Michael Jackson)
11. The final countdown (Europe)
12. Uprising (Muze)
13. Abide (Jenny and Taylor)
14. Sorry (Justin Bieber)
15. Red Mercedes (Amine)
16. Enter Sandman (Metallica)