The effect of music on isokinetic peak torque during performance in female collegiate athletes

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Abstract.

BACKGROUND: Studies—focused mainly on cycle ergometry, treadmill exercise and psychological impacts, while largely ignoring isokinetic exercise, have found that music can significantly improve exercise performance.

OBJECTIVE: This study proposed to investigate the effect of up-tempo music on isokinetic peak torque as measured by the knee extensors.

METHODS: Researchers recruited 25 female collegiate varsity athletes, who performed concentric knee extensions on the Cybex NORM for 4 sessions separated by at least 24 hours. Each session, with randomized up-tempo music and no-music conditions, subjects performed submaximal and maximal concentric knee extensions at five velocities (60, 120, 180, 240, and 300 deg/sec) to achieve peak torque with a one-minute rest between sets. A paired t-test (\(\alpha < 0.05\)) was performed between music and no-music conditions for the five velocities.

RESULTS: Researchers marked no significant difference in performance between musical conditions at any velocity.

CONCLUSION: The results of this study agree with previous isokinetic research: Music did not significantly affect isokinetic performance. Results could be attributed to music’s reduced effect on trained athletes or music’s inability to affect exercise fueled mainly by the ATP-PC system. Future isokinetic research should consider testing untrained subjects and isokinetic endurance.

Keywords: music, trained subjects, motivation
1. Introduction

In the past 15 years, research has increased dramatically regarding the effect of music on various types of exercise. Most of this research has focused on cycle ergometry [1-7], treadmill running/walking [8-12], and specific sport application [13-16]. This research began with Karageorghis, Terry, and Lane [17] when they found that the rhythm, musicality, cultural impact, and associations of a particular song determined its motivational qualities. Songs with faster tempos that were familiar and had positive associations to a particular population were considered the most motivational. By carefully selecting songs fitting the aforementioned characteristics, the music was found to influence work, enhancing physiological effects such as higher endurance, power, productivity, or strength.

Many aspects of exercise have been found to be influenced by music. Bartolomei, Michele, and Mern [10] showed that self-selected music (at least 120 bpm) improved each subject’s bench press endurance by 5.8% compared to 1.2% improvement for non-listeners over the course of 2 weeks. Other studies have also noted improvements in endurance, including improved time to exhaustion and a greater distance traveled [2]. Further studies have shown that music reduces a subject’s rating of perceived exertion (RPE) at lower intensities during aerobic exercise [3,6]. For example, Nethery [3] found that college-aged males had a significantly lower RPE while listening to music on a cycle ergometer at 50% VO₂ max for 15 minutes. However, there was no significant difference when exercising at 80% VO₂ max. Also, other studies have found that music provided a distracting effect while exercising at lower intensities [2,4,8]. Though RPE did not decrease in their study, Waterhouse, Hudson, and Edwards [4] found that music kept the subject’s mood positive in the music condition, allowing them to tolerate faster cycling speed.
and higher thermal discomfort. Additionally, music has been shown to improve power output in common anaerobic power assessments, including the Wingate test [7, 18].

Though multiple studies have found many positive benefits of exercising with music, other studies have shown no such associations [8, 12]. In past studies, methodologies regarding music selection, subjects, and type of exercise studied have varied dramatically. As a result, it is unclear whether the lack of improvement in exercise capabilities in certain studies relates to methodological failings or music’s inability to improve exercise performance fueled primarily by immediate sources (ATP-phosphocreatine system), nonoxidative (glycolytic system), or oxidative (O2 system) pathways of energy metabolism. According to Boulay et al. [19], the ATP-PC system is responsible for providing energy when the exercise is less than 10 seconds long. The glycolytic system is the main fuel source for exercise lasting up to 2 minutes. Finally, the oxidative source of energy is associated with prolonged exercise. Immediate and glycolytic energy sources are both considered anaerobic exercise, while oxidative is considered aerobic exercise.

In order to understand which people (if any) benefit from music during exercise, it is important to explain the mechanisms behind these benefits. One such mechanism is known as attentional processing. The nervous system has a limited ability to remain focused on a specific task such as exercise. Adding music, especially at low and moderate intensities of exercise, distracts the person and appears to ease the rigors of the exercise [20,21]. Though not suited for all types of exercise, synchronous music may have the ability to reduce RPE due to the innate predisposition to synchronize movement with music [20]. Finally, music often triggers an emotional response for people while thinking about or performing exercise [14].
Certain types of music have been found to alter an athlete’s mental state and lead to improved performance [12,22]. Karageorghis et al. [11] studied the music-listening habits of 14 elite junior tennis players to determine how music was used to manipulate emotional states. It was found that, although the music selection between the individuals varied tremendously, all used music to attain a positive emotional state in order to enhance mood before performance. Later, Bishop [14] concluded that faster and louder music was more pleasant and arousing to the subjects and led to quickened reaction times. Though changed emotional status does not always directly correlate to an improved performance, if music can instigate a more positive mood while exercising, this may improve adherence to a particular program, and improve overall health.

While music’s effect on cycling, running, strength training, and other sports has been examined somewhat extensively, isokinetic exercise has been largely ignored, with only one article found on the subject [23]. Isokinetic machines move at preset velocities, no matter how much force is applied, allowing an individual to exercise at a specific speed. Isokinetic testing is a reliable and valid way to measure both torque and work in healthy and injured populations, Because isokinetic exercise controls for speed it is incredibly useful in rehabilitation settings for individuals recovering from injury or surgery [24-27]. Godwin and associates [23] found no indication that music improved peak torque in knee flexion at 60 deg/sec for average college students. Though no difference was found, a major weakness of this study was only examining one velocity. There was also only one song played during this test, and the study mentioned minimal familiarization to the isokinetic machine which may have affected the results.

The purpose of this study was to investigate the effects of music on isokinetic peak torque as measured by the knee extensors of collegiate female athletes on a Cybex NORM isokinetic dynamometer.
2. Methods

2.1 Subjects

Twenty-five female varsity athletes from the University of Puget Sound were recruited for this study. Descriptive statistics for the subjects’ age, height, and body mass can be found in Table 1. In order to participate in this study, subjects had to meet the following criteria: NCAA Division III athletes, college aged, apparently healthy, and no previous history of knee injury that could be aggravated by isokinetic exercise. Subjects were asked to come to the lab on 4 separate occasions: 2 familiarizations, and 2 experimental sessions. Subjects were asked to avoid any strenuous or maximal physical activity within 24 hours of any scheduled testing session. Finally, all subjects were asked to read and sign an informed consent form that had been approved by the University Institutional Review Board.

2.2 Equipment

Peak torque was measured and recorded using a CYBEX NORM Testing and Rehabilitation System (CSMi Medical Solutions, city, state) with HUMAC/NORM software (version 12.1.28). Gravity correction was included in each trial in order to correct torque generated at the knee joint when the lower leg was extending against gravity.
2.3 Protocols

Familiarization Protocol

The first 2 sessions familiarized the subject with the Cybex NORM isokinetic dynamometer (Cybex NORM) in order to minimize learning effects and equalize experience in regards to isokinetic exercise. In the first session, subjects began by reading and signing the informed consent form. Then, height, weight, and age were recorded. Before the test began, subjects were asked to warm up on a cycle ergometer for 5 minutes at a self-selected pace and resistance. The Cybex NORM was then adjusted to fit each subject’s specific body measurements. These adjustments were then recorded and saved in the HUMAC software in order to achieve measurement reliability. Before beginning each session on the Cybex NORM, the subject’s right leg was weighed to determine gravity correction. Supplementary warm-up also took place on the Cybex NORM. Subjects performed 4 concentric submaximal knee extensions at ascending velocities of 60, 120, 180, 240, and 300 deg/sec with flexion held constant at 300 deg/sec. There was a 1 min rest between each velocity set. After the warm-up was completed, subjects were asked to perform 4 concentric maximal knee extensions at the previously specified velocities. Again, flexion was held constant at 300 deg/sec with 1 min rest between each set. During the maximal knee-extensions, verbal encouragement was provided by the test administrator and subjects were shown visual feedback on the Cybex NORM monitor so they see how much torque was being produced. There was a minimum of 24 hours between testing sessions. High-tempo music was played during one familiarization session for the warm-up and performance tests. The
alternate familiarization and testing session had no music. The order of the music or no-music condition was randomized.

Experimental Protocol

Participants were asked to refrain from any type of maximal physical activity prior to the experimental sessions. There was a minimum of 24 hours between experimental sessions. Each experimental session consisted of the previously stated warm-up on the cycle ergometer and both the submaximal warmup on the Cybex NORM, followed by the maximal performance on the Cybex NORM either with high-tempo music or without music from the start of warmup until the final set of isokinetic exercise was completed. On the first testing session, a coin was flipped to determine the testing condition: no-music or music.

2.4 Musical Conditions

In one random familiarization and one experimental session, subjects were required to listen to high-tempo music for the entire warm-up and testing protocol. The test administrator was responsible for selecting appropriate songs for the high-tempo playlist. This music was between 120 and 150 beats per minute. The playlist was comprised of popular songs published on Spotify© motivational work-out playlists. The music was listened to through a speaker system that was connected to a music player provided by the researcher.
2.5 Statistical Analysis

IBM SPSS Statistics 23.0 was used to perform a paired samples t-test with a significance level of (α < 0.05). Peak torque (dependent variable) was compared between the two experimental conditions (music and no music) at each velocity (60 deg/sec, 120 deg/sec, 180 deg/sec, 240 deg/sec, and 300, deg/sec).

3. Results

There was no significant difference between the music conditions at any of the velocities (α > 0.05) (Fig. 1). Average peak torque (Nm) in the music condition was 128.84 ± 31.49, 100.00 ± 29.27, 88.40, 73.36 ± 22.956, and 62.00 ± 20.36 at 60, 120, 180, 240, and 300 deg/sec, respectively. Average peak torque (Nm) in the non-music condition was 127.32 ± 31.49, 103.32 ± 28.86, 88.60 ± 34.72 69.36 ± 22.82, and 58.84 ± 20.36 at 60, 120, 180, 240, and 300 deg/sec, respectively.

4. Discussion

Previous research has suggested that music can help improve athletic performance in anaerobic and aerobic exercise [7,8,11,12,18,28] when the primary fuel source is either glycolytic or oxidative. Music can also provide psychological well-being surrounding performance [11,14,22]. There has been little research on music’s effect on anaerobic exercise primarily fueled by the ATP-PC pathway which includes both short sprints and isokinetic
exercise. The results of this study suggest that high-tempo music has no significant effect on isokinetic peak-torque for a variety of velocities in female collegiate athletes.

It was hypothesized that when college female athletes listened to high-tempo music during maximal effort isokinetic exercise, their peak torque would be significantly higher than in a non-music condition. No such significance was found. Currently, Godwin et al. [23] is the only other study that examines music’s effect on isokinetic exercise. While it is important to compare Godwin et al.’s [23] research to the current study, there were many methodological differences between the two. Godwin et al. [23] only examined music’s effect on isokinetic exercise at only one velocity: 60 deg/sec. Additionally, the subjects used in the study were PE students, not athletes, and only one song was played during the experimental testing session. Though Godwin et al. [23] similarly found that music had no significant impact on isokinetic exercise performance, the lack of research and methodological consensus makes it impossible to draw a definitive conclusion on music’s effect on isokinetic exercise, despite the similar findings.

Subjects in this study had varying levels of isokinetic experience. Though each subject was required to attend 2 familiarization sessions in order to minimize learning effects, subjects may have needed more practice in order to achieve a true maximal effort on the Cybex NORM. In addition, while subjects were required to have at least 24 hours between testing sessions, no maximal time was established. Some subjects completed all 4 sessions in less than a week, while others took more than 2 weeks. Finally, the music chosen for the study might have played a role in subject performance. While only well-known exercise music was chosen, some subjects might have been more motivated if had they chosen the music themselves because not all people have the same taste in exercise music.
Similar to previous studies that examined music’s effect on anaerobic [1,5] and isokinetic exercise [23], the present study found that music had no significant difference on exercise performance. This finding counters most previous research investigating music’s effect during anaerobic and aerobic bouts of exercise. In terms of aerobic exercise (oxidative fuel source), Elliott, Carr, and Ormn [2] found that when subjects were listening to high-tempo music while cycling at a self-selected pace (between 60-80% VO$_2$ max), they increased their distance traveled and their energy expenditure from 108 to 122 Watts. Edworthy and Waring [12] found that subjects were able to run faster at a reduced heart rate (HR) during 10 minutes of running.

Additionally, two studies [8,11] observed a reduced RPE at lower exercise intensity. These same studies also observed that subjects improved their endurance while running to exhaustion at a predetermined speed. Wingate performance (glycolytic fuel source) was also improved while listening to music in 2 different studies resulting in improved fatigue index, peak power, and mean power output [7,18]. An important note is that no study that focused solely on music’s effect on exercise fueled primarily by the ATP-PC system, saw any significant results [15,23]. These studies focused on exercise at maximal effort that takes very little time to perform: maximal isokinetic concentric contractions and 20-meter sprints. Though subjects might have felt motivated by the music, the exercise period might have been simply too short to notice any effects. When the ATP-PC system fueled exercises were combined with endurance (making them primarily fueled by glycolytic and/or oxidative sources), listening to music did improve exercise performance as in both Bartolomei, Michele, and Merni [13] and Biagini et al.’s [22] studies regarding bench press and squat jump endurance. Neither of these two studies observed a significant improvement in the 1RM of the subjects’ bench press or squat jump capability.

Instead, Bartolomei, Michele, and Merni [13] found that the subjects were able to significantly
improve their bench press repetitions to failure by 5.8% over the course of 8-weeks of training with music compared to only 1.8% with no music. Similarly, Biagini et al. [22] saw a significant improvement in the rate of force and velocity production, and feelings of vigor in both squat jump and bench press exercises.

The results of this study could also be affected by the type of subject recruited. All subjects in this study were NCAA Division III female collegiate athletes. Previous research by Brownley, McMurray, and Hackney [] has suggested that music may have more effect on untrained versus trained individuals. Their study examined 8 trained and 8 untrained runners at low, moderate, and high exercise intensities in high-tempo and sedative music conditions. While there were no significant differences in performance between untrained and trained subjects while listening to music, the untrained subjects reported feeling significantly more positive after exercising to exhaustion than their trained counterparts. Trained athletes, such as those in the current study, are taught how to focus on exercise no matter what is going on around them. While music might make untrained subjects feel more positive during exercise, trained athletes may need no such motivation during performance. Though the current study agrees with Brownley, McMurray, and Hackney [], it is important to consider that other studies focused on trained athletes have found significant differences on music’s effect on exercise performance. For example, Bartolomei, Michele, Merni [13] found that resistance-trained men improved their bench press endurance more when listening to music during training. In addition Bood et al. [8] found that while listening to music, trained runners were able to improve their time to exhaustion, and reported lower RPE values and a distractive effect due to music. While it may be true that untrained individuals are more affected by music while exercising, highly trained athletes can be affected, as well, at least in certain exercise conditions.
Though high-tempo music may not significantly improve isokinetic peak force of the knee joint, it could still be beneficial psychologically. In a study that examined the ability to optimize exercise with music, Bishop [] stated that music has the ability to regulate an athlete’s emotional state. By listening to self-selected emotional music with a faster tempo at a louder volume, athletes were able to think more positive thoughts, feel energized, and practice visualization techniques. While these listening patterns may not actually improve performance, athletes used their music to channel their anxious feelings surrounding competition to feel motivated and calm before performance [14]. While it might not improve peak torque, the aforementioned emotional responses might achieve higher adherence to exercise programs because individuals find the exercise to be more enjoyable and feel less anxious. This higher adherence to exercise is especially important for untrained individuals who are trying to become fit, or those in the process of rehabilitation because these individuals are notorious for high drop out rates [21].

5. Conclusion

Previous research has demonstrated that music can affect exercise performance in both anaerobic and aerobic conditions. This difference is especially pronounced at lower intensities. This study investigated the effect of high-tempo music on maximal effort isokinetic peak torque during performance. Results indicated that the isokinetic peak torque of female athletes was not significantly affected by high-tempo music. Future research should investigate whether isokinetic endurance is improved with music. In addition, research should focus on untrained subjects.
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Table 1. Subject Demographics (mean ± SD)

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<tr>
<td>Age (years)</td>
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<td>Height (cm)</td>
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<tr>
<td>Body Mass (kg)</td>
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Figure 1. Mean peak torque values (and standard deviations) of concentric knee extensions at five different velocities in either music or non-music conditions.
References:


