

# The Effects of Music on Muscular Fatigue and Performance in Adults With Previous Knee Injuries

Bryan J. Pizarro, Amber M. Shipherd, CMPC, Robert J. Kowalsky  
Human Performance Laboratory, Department of Health & Kinesiology  
Texas A&M University–Kingsville, Kingsville, TX

## INTRODUCTION

- Music can provide ergogenic, psychological, and psychophysical benefits during sport participation and exercise (Ballmann, 2021).
- Music has shown to have an impact on strength training. For example, it has been shown to improve bench press endurance by 3.9% while listening to music compared to a no music control group. (Köse, 2018).
- Listening to one's preferred music has shown to optimize arousal and increase motivation during exercise which lead to performance improvements, such as increased repetitions, power, and velocity on strength tasks (Ballmann, 2021b).
- Music is thought to produce these benefits via psychological, physiological, and psychophysiological mechanisms, including reducing perceived exertion, increasing muscle activation, and increasing blood flow (Ballmann, 2021; Ballmann et al., 2021a; Waterhouse et al., 2010).
- Given rehabilitation patients often struggle with adherence rates due to lack of enjoyment, lack of progress, or increased pain and fatigue (Arvinen-Barrow & Walker, 2013), music may be an effective strategy in promoting rehabilitation adherence by reducing fatigue and improving strength performance.
- Thus, identifying how to more efficiently integrate music into the rehabilitation setting may improve rehabilitation effectiveness and adherence.

## PURPOSE

- The purpose of this study was to examine the effects of preferred music, non-preferred music, and no music on quadriceps fatigue and strength in individuals with a prior knee injury.

## METHODS

### Participants

- 12 participants (male = 9, female = 3) with the following knee injuries: ACL/meniscus ( $n = 2$ ), MCL ( $n = 4$ ), MCL/meniscus ( $n = 1$ ), meniscus ( $n = 4$ , and PCL ( $n = 1$ ).
- Participants were classified as physically active ( $n = 9$ ) and inactive ( $n = 3$ ). See Table 1 for additional participant characteristics.

### Study Design

- A randomized crossover design was used with each participant completing one control (no music; NM) and two experimental conditions (preferred music; PFM and non-preferred music; NON-PFM).
- These 3 visits were separated by a minimum of 48 hours to allow the body to recover and the physiological effects to washout.

### Procedures

- Following approval by the institutional review board, individuals between 18 and 55 years old with a previous knee injury and were able to participate in moderate-vigorous intensity exercise, as defined by the American College of Sports Medicine (ACSM, 2018), were recruited for this study.
- Individuals ranked six music genres from 1 (most preferred) to 6 (least preferred).
- Participants then participated in a 5 minute warm up on a cycle ergometer followed by a knee extension/flexion assessment (Thorstensson fatigue test) using the Biodex dynamometer (see Figure 1).
- Peak torque was recorded to assess quadriceps strength and a fatigue index was calculated to determine quadriceps fatigue.
- Music above 120 bpm was played via a speaker throughout the warm-up and Thorstensson test during both music conditions.
- Following the music conditions, participants then completed a manipulation check that assessed their degree of preference for the music played.

## METHODS, cont.

Table 1: Participant Characteristics

Variable	Mean $\pm$ SD	Range
Age (years)	24.83 $\pm$ 9.32	18 – 54
Height (in)	67.31 $\pm$ 4.18	61.5 – 72
Weight (lbs)	228.17 $\pm$ 70.58	127 – 370
Time passed since injury (years)	4.38 $\pm$ 2.06	1 – 8

### Statistical Analysis

- One-way ANOVAs were conducted to assess for differences in condition order on quadriceps fatigue and strength.
- One-way repeated measure ANOVAs were conducted to assess for differences in quadriceps fatigue and strength across all conditions (PM, NON-PM, or NM).
- An alpha level of .05 was used for indication of statistical significance.

## RESULTS

- The one-way ANOVAs revealed there were no order effects present.
- No significant differences were found across conditions in quadriceps fatigue ( $F(2,22) = 0.007, p = 0.993, \eta_p^2 = 0.001$ ) or quadriceps strength ( $F(2,22) = 0.269, p = 0.767, \eta_p^2 = 0.024$ ). See Table 2 for means and standard deviations.

Table 2: Quadriceps Fatigue and Strength Means and Standard Deviations

Condition	Quadriceps Fatigue		Quadriceps Strength	
	Mean	SD	Mean	SD
No music	56.96	10.78	139.24	37.31
Non-preferred Music	57.33	12.16	139.50	35.99
Preferred	57.08	9.66	142.97	37.31

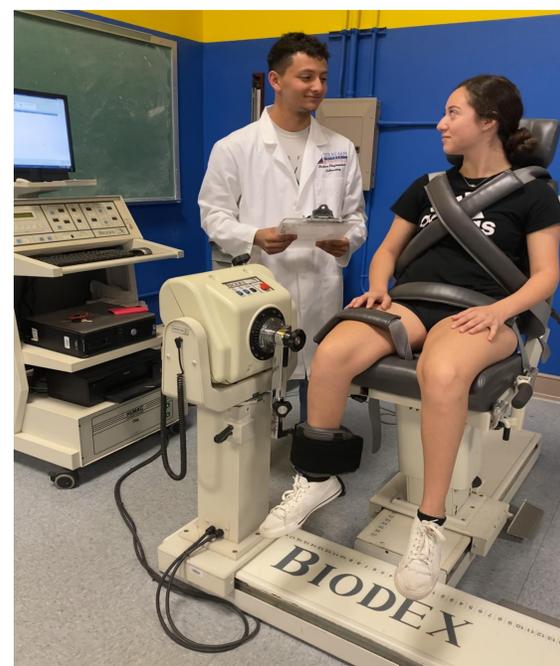


Figure 1: Biodex Dynamometer (not actual participant pictured)

## DISCUSSION

- No differences in quadriceps fatigue or strength were observed between the conditions. This finding supports some research that failed to demonstrate differences in physiological variables between preferred and non-preferred music genres (Ballmann et al., 2019). However, other studies have found preferred music increased repetitions to failure during a strength exercise (Ballmann et al., 2021b).
- The nonsignificant findings in the current study may be attributed to the small sample size, the large number of physically active individuals included in the study, or the high intensity of the Thorstensson test. Previous research demonstrated that music produces greater benefits in inactive individuals as compared to active individuals (Brownley et al., 1995). Research has also found that dissociative strategies, such as listening to music, are less effective at high levels of exercise intensity or when physical effort is high (Tenenbaum & Hutchinson, 2007).

### Limitations

- Small sample size, resulting in insufficient statistical power to detect differences.
- A manipulation check was included, but we did not assess whether participants' attended to the music specifically during the Thorstensson test.
- Larger individuals were excluded due to the fit and range of motion requirements of the Biodex.

### Conclusions

- Music did not impact quadriceps fatigue or strength in the present study.
- Rehabilitation practitioners should consider that that music may not be the most effective strategy to increase strength or reduce fatigue in a rehabilitation setting, and should explore other techniques to address these variables and improve rehabilitation adherence.

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