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Exploring the impact of music on strength training performance in physically active women: a randomised crossover

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ABSTRACT

The influence of music on movement velocity and power during strength training has been poorly investigated in female athletes. A total of 14 physically active female participants completed two random visits with different conditions: 1) Music (MUS) and 2) No music (No-MUS). Jumping ability (countermovement jump), movement velocity and power in the back-squat at 50 and 75% of one-repetition maximum (1RM), muscular endurance, rate of perceived exertion and motivation were analysed. The trial was registered at ClinicalTrials.gov (NCT06070064). No differences were found between MUS and No-MUS conditions in jump height, nor in movement velocity and power in the back-squat exercise. With the MUS condition, an increase was observed in the number of repetitions to failure at 75% of 1RM (p= .034), as well as greater motivation (p= .029) and reduced perceived effort (p= .021). Listening to music induced an increase in muscular endurance performance with no effect on movement velocity and power during back-squat in physically active women.

KEYWORDS: resistance training; strength performance; back-squat; active female.

INTRODUCTION

To optimise sports performance, strength training (ST) has been applied as a strategy to improve power, overall strength, neuromuscular capacity, and resistance (Folland & Williams, 2007), through training programs varying intensity, volume, and load in an individualised manner (Schoenfeld et al., 2017).

Velocity-based training is a contemporary method of physical training that enables a precise and objective evaluation of the intensities and volumes reached during training programs (Weakley, Mann et al., 2020). The movement velocity at which a movement is performed has been described as an optimum indicator of fatigue state in an athlete (Sánchez-Medina & González-Badillo, 2011). Thus, changes in mean velocity can indicate altered neuromuscular capacities, which could potentially act as a quality indicator of fatigue symptoms or even overtraining syndrome, or on the contrary, act as an indicator of an appropriate adequation of a neuromuscular capacity or acute potentiation (Cunanan et al., 2018; Weakley, Ramírez-López et al., 2020).

Ergogenic benefit mediators during physical training can be physiological, psychological and/or psychophysiological, probably acting simultaneously to achieve better performance. In velocity-based movement training specifically, previous investigators have tried to evaluate how different variables and conditions can influence movement velocity in determined physical exercises, from recovery techniques in between sets (García-Sillero et al., 2021), dietary supplements (Ranchal-Sánchez et al., 2020), to the possible influence of varying the technique applied for certain exercises (Pérez-Castilla et al., 2020). However, aspects such as music influence over movement velocity and power during ST have been underinvestigated. To date, there is only one existing

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study on the influence of music on previous bench press performance (Ballmann, Favre et al., 2021). Collective evidence suggests there are different types of physiologic changes or alterations due to music while training neurologic (possible increases in cognitive processing velocity, movement organization) or metabolic changes (increased VO2 max enhancement, decreased lactate in blood) (Ballmann, 2021).

Numerous studies have investigated the effect of listening to music during resistance training in various weightlifting exercises, yielding contradictory results. There is evidence that listening to self-selected music improved peak grip strength and muscular endurance during lateral pull exercise. Furthermore, these improvements were accompanied by a decrease in the rate of perceived exertion (Silva et al., 2021). Other authors reported an increase in a number of repetitions to failure on the bench press while self-selected music was played during ST (Bartolomei et al., 2015); these findings were reinforced by another study that proved improvements in velocity and volume of repetitions while performing the bench press (Ballmann, McCullum et al., 2021). Associated benefits on motivation and exercise performance suggest that psychological subjacent alterations might have contributed to performance improvements. However, some other studies have shown little or no benefit from listening to music during a squat routine (Owens, 2018). Additionally, no differences were found in bench press movement velocity, although participants reported improved rates of strength and velocity development during explosive jumps (Biagini et al., 2012). Thus, the impact of adding music to strength training (ST) performance in specific exercises, such as the bench press (Ballmann, Favre et al., 2021; Biagini et al., 2012) or back squat (Biagini et al., 2012; Moss et al., 2018), is not entirely clear, as research has shown mixed results. Additionally, several factors may explain these discrepancies, including sample size, variations in music genre and tempo, exercise protocols, and the training experience of participants. Methodological differences in previous studies may contribute to conflicting results.

The increased motivation and ergogenic potential of music during exercise have been previously mentioned in studies cited by Ballmann, McCullum et al. (2021), which found that participants reported significantly higher motivation when listening to their preferred music compared to non-preferred music. There is also evidence that music with a tempo of ≥ 120 beats per minute can increase the number of repetitions in the bench press to muscle failure (Cutrufello et al., 2020). Self-selected music is associated with higher rating on the scale of perceived effort perception (RPE) than other types of music, such as metal or electronic dance music, and RPE was similar between self-selected, metal, and no music conditions, while electronic dance music revealed higher responses. Thus, the musical style used may influence training performance (Moss et al., 2018). This suggests that the selection of music could be a determining factor in optimizing performance outcomes.

While the aforementioned studies provide valuable insights, it is important to note the lack of research specifically targeting female populations. Studies that focus on mixed-gender groups or male participants often fail to account for the distinct physiological and psychological responses exhibited by women during ST (Roth et al., 2021; Szabo et al., 2020). The differences in neuromuscular responses and hormonal fluctuations across the menstrual cycle may influence how music impacts performance, a factor that has been rarely addressed in existing studies. Therefore, the current research aims to bridge this gap by investigating the influence of music on strength performance, specifically in women.

Altogether, evidence suggests that listening to music during ST might help improve explosive movements; however, the potential benefits on movement velocity, power, and muscular endurance in the back-squat are still unknown. In this way, the objective of this study was to evaluate the effect of music on movement velocity, power, and muscle endurance of the lower body in physically active women. The hypothesis of this study is that listening to music during the back-squat exercise may enhance strength endurance performance and motivation in physically active women.

METHODS

Study design

The study involved an experimental double-blind crossover randomised trial. The study was designed following the CONSORT statement (Suppl. Mat. – Checklist CONSORT). The study took place in the Sports and Physical Activity laboratory at the University School Osuna. The trial was registered at ClinicalTrials.gov (NCT06070064).

Participants

A total of 14 physically active women were recruited through advertisements in local gyms, social media, and information posters on university premises. To assess the eligibility of physically active women with experience of ST programs, the following inclusion/exclusion criteria were considered: 1) age between 18 and 30 years; 2) more than 6 months doing ST programs; 3) familiarity with back-squat and countermovement jump (CMJ); 4) no consumption of any type of nutritional supplement or anabolic substances in the preceding 3 months or during the study period itself; 5) no musculoskeletal injuries that could interfere with the exercise protocol during the research; 6) normal hearing ability. These criteria were verified through personal interviews, which were conducted both in person and virtually, depending on the availability of the interested parties. The researchers, at each of the visits, asked the participants about their menstrual periods and the consumption of birth control pills, to keep track of changes during the study. The women were cited when they were in the follicular phase.

The participants recruited were briefed on the protocol and purpose of the study, and all signed a written consent prior to the start of the research. The study was conducted in accordance with the Declaration of Helsinki, and the project protocol was approved by the Ethics Committee of the University of Seville (reference 0553-N-22).

Study interventions

Anthropometry and corporal composition

Anthropometric measures and corporal composition of each participant were registered during their first visit. Height was measured using a portable stadiometer (Seca 214; Hamburg, Germany), and bioelectrical impedance (InBody 770, Biospace Co., Ltd., Seoul, South Korea) was assessed to report corporal composition, with an emphasis on body fat percentage. Measurements were done according to the International Society for Advancement of Kinanthropometry (ISAK) (Marfell-Jones et al., 2006). All the anthropometric measurement data were collected by an ISAK-certified technician (J.M.J-C.) with a technical measurement error of 0.57%.

Protocol familiarisation and One Repetition Maximum test

At an initial session, participants got familiar with the protocol test proposed for this study. First, they performed 5 CMJ of increasing intensity; afterwards, they performed a back-squat in a Smith machine (Salter M-1033, Barcelona, Spain) with 20 kg at maximum movement velocity, with a total of 3 repetitions. The technique was evaluated and corrected if necessary.

Before starting the protocol to determine the back-squat one repetition-maximum (1RM), participants performed a specific warm-up. Based on previous research, the warm-up started with 10 minutes pedalling on a cycle ergometer (first 4 minutes at free intensity and next 6 minutes at 75% of maximum heart rate (Polar H10, Kempele, Finland). Subsequently, they performed 1 warm-up series of back-squat with light intensity (30-40% of estimated 1RM).

The initial load to calculate 1RM in the back-squat was set at 20 kg and gradually increased by 10 kg until the mean velocity was less than 0.5 $m{\cdot}s^{-1}$. Later, the load was adjusted with smaller increases (5-10 kg) for each participant, so that the 1RM was determined with precision. The heavier load each participant was able to carry with full knee extension was considered their 1RM. For lighter loads (mean velocity > 1 $m{\cdot}s^{-1}$), 3 attempts were performed for each weight. For medium loads (mean velocity > 0,50 $m{\cdot}s^{-1}$ ≥ mean velocity ≤ 1,0 $m{\cdot}s^{-1}$), two attempts were given to each participant, and only one attempt for maximal load (mean velocity < 0,50 $m{\cdot}s^{-1}$).

Resting time between each series of repetitions was adjusted according to load intensity: 2-3 minutes for light and medium weights, and 5-6 minutes for heavier loads, as recommended by Moran-Navarro et al. (2017). In accordance with the fastest mean velocity method (González-Badillo & Sánchez-Medina, 2010), only the best repetition for each load was considered for analysis.

Protocol for obtaining results and blinding of participants

After the previously described 1RM first visit, each participant completed 2 aleatory and counterbalanced additional visits, each with one condition: Music (MUS) and No Music (No-MUS). The participants were informed that they would attend the laboratory to perform evaluation tests under different environmental conditions. However, they were not informed that the specific change between conditions was the presence or absence of music. The researchers responsible for data collection were blinded to the experimental conditions. The investigator managing participant assignments and music exposure was different from the data collectors, ensuring objectivity in the assessments.

Experimental measurements were taken in the morning, at the same hour of the day (± 0,5 h) for each individual, to standardise the influence of circadian rhythm, with an environmental temperature of 23°C (± 1°C).

Music selection

During the session, MUS participants performed a back-squat test and CJM test while listening to music. The chosen songs had at least 120 beats per minute (BPM), a tempo selection supported by prior research that associates rhythms of ≥ 120 BPM with improvements in motor synchronisation and physical performance (Cutrufello et al., 2020). The tempo of each track was calculated using BPM software (Tangerine! v.1.4). Participants were not allowed to select their own music; instead, a standardised playlist with the aforementioned characteristics was used to control for variations in music preferences. Music was reproduced using an iPhone X (Apple Inc., Cupertino, CA, USA) connected to a portable speaker (Sony MHC-V02, Sony Co., Tokyo, Japan). Sound intensity was adjusted and standardised for all participants at 75 dB (at the level of the ear) using a Decibel X-dBA Sound Level Meter (Decibel X, SkyPaw Co., Ltd., Vietnam). Contemporary music from the trap and reggaeton genres was selected based on their popularity among younger populations, which could enhance familiarity and enjoyment of the music, factors shown to positively influence motivation during exercise (Moss et al., 2018). Music was played before, during, and after the test to provide a consistent auditory environment. At the end of the test, they were asked how satisfied they were with the music they listened to.

Study variables

Jumping Ability (CMJ Test)

Before evaluating participants, a warm-up with CMJ familiarisation was performed. After that, a brief, specific 5-jump warm-up was completed. The warm-up was designed to prepare the muscles and nervous system for the maximal effort required during the test (Bobbert & Van Soest, 1994).

After a couple of minutes of rest, the participants performed the test, which consisted of 3 CMJs. The jump technique involved a flexion-extension of the hips and knees at the fastest velocity possible to achieve maximal jump height. At maximal flexion, the knee angle should be approximately 90° before returning to its initial position. Participants were encouraged to perform maximal jump height during the concentric phase of each repetition, ensuring maximal muscular effort (Markovic, 2007). The CMJ was measured using a validated optical measurement system (Optojump, Microgate S.R.L., Bonzano, Italy) (Cormie et al., 2011).

Movement velocity and power in back-squat at 50% and 75% 1RM (mean and peak measurements)

As previously described, the same warm-up protocol as when evaluating 1RM was indicated for each participant, followed by 5 repetitions at 40% of 1RM and 3 repetitions at 60% of 1RM (González-Badillo & Sánchez-Medina, 2010).

After 3 minutes of rest, two back-squat using a Smith machine (Technogym, Barcelona, Spain) were performed while measuring movement velocity and power. The first test consisted of 2 repetitions at 50% of 1RM. After a 3-minute rest, the second test was performed. It consisted of 2 repetitions at 75% of 1RM. Both tests were performed at maximal velocity. Correct back-squat technique involves maintaining a straight back, feet aligned at shoulder-width distance, and hands holding the bar, sustained by the trapezius muscles. Participants then flexed their knees and hips at an angle greater than 90° and returned to the initial position. Participants were motivated to realize the best possible effort at the concentric phase of each repetition to ensure maximal muscle strength. Mean velocity was recorded in m/s in both repetitions, and the peak velocity of both squats (at 50 and 75% of 1RM) was recorded. Additionally, mean power (measured in Watts) and maximum power were recorded. Movement velocity was controlled by investigators using a validated lineal position transducer (T-Force, Ergotech, Murcia, Spain) (González-Badillo & Sánchez-Medina, 2010).

Muscular endurance

After a 3-minute rest, a test was performed to determine the maximal number of repetitions to concentric failure at 75% of 1RM. This test was designed to evaluate muscular endurance by measuring the maximum number of repetitions participants could perform at a given intensity (Sánchez-Medina et al., 2010).

Participants' motivation through an analogic visual scale

Analogic Visual Scale (AVS) consisted of a straight line of 100 mm in which 0 mm indicated "no motivation at all", while 100mm indicated "extremely motivated". Participants marked over the line how motivated they felt during exercise. Afterwards, investigators measured the distance between 0 mm and the mark that participants placed over the line (Maddox et al., 2014).

Participants perceived effort

As soon as participants completed the muscle endurance test, RPE was evaluated with a 0 to 10 scale. The answers provided by participants were recorded by the investigators (Borg, 1998).

Randomisation

To ensure double blinding, an external researcher randomly allocated participants to either the first or second session in a counterbalanced fashion. In each session, 50% of the participants listened to music during the first session, while the remaining participants did so during the second session. (https://www.randomlists.com/ team-generator; 2 February 2023).

Sample size calculation

The sample size was determined based on a similar study (Karow et al., 2020) to assess the impact of music during exercise in a comparable female population, with a power of 0.80 and a two-tailed α level set at 0.05. Statistical power analysis was conducted using GPower software (v.3.1.9.7, Faul et al., 2009). This analysis considered the observed effect size, sample size, and a significance level of $\alpha = 0.05$ for the main study variables (back-squat and CMJ test performance). The results of the statistical power analysis indicated that the study achieved a power greater than 80% ($\beta < .20$) to detect significant differences in the key variables, further supporting the statistical validity of the results. The minimum number of participants required to detect performance improvements was estimated to be 14.

Data analysis

The data are presented as mean± standard deviation (SD). To assess the normality of the variables, Shapiro-Wilk tests were performed, and the equality of variance was contrasted with the Levene test. To analyze the effect of No-MUS vs. MUS on the maximum value attained during the CMJ tests, the MV, PV, MP, and PP at 50 and 75% 1RM for the back-squat, and RPE of the session, a paired-samples t-test was employed (t). The mean difference (MD) ± SD between conditions was calculated to further interpret the results. Significance was set at $p < .05$. SPSS software (Version 22.0, IBM SPSS Statistics for Windows, 2013; IBM Corp) was used for the statistical analysis. For a practical significance of the results, the effect size (ES) was calculated using Hedges g. ES were considered to have large ($ES > .8$), moderate ($ES = .8\text{-}.5$), small ($ES = .5\text{-}.2$), or trivial ($ES < .2$) effects (Hedges, 1981).

RESULTS

All the participants completed the trial (Figure 1).

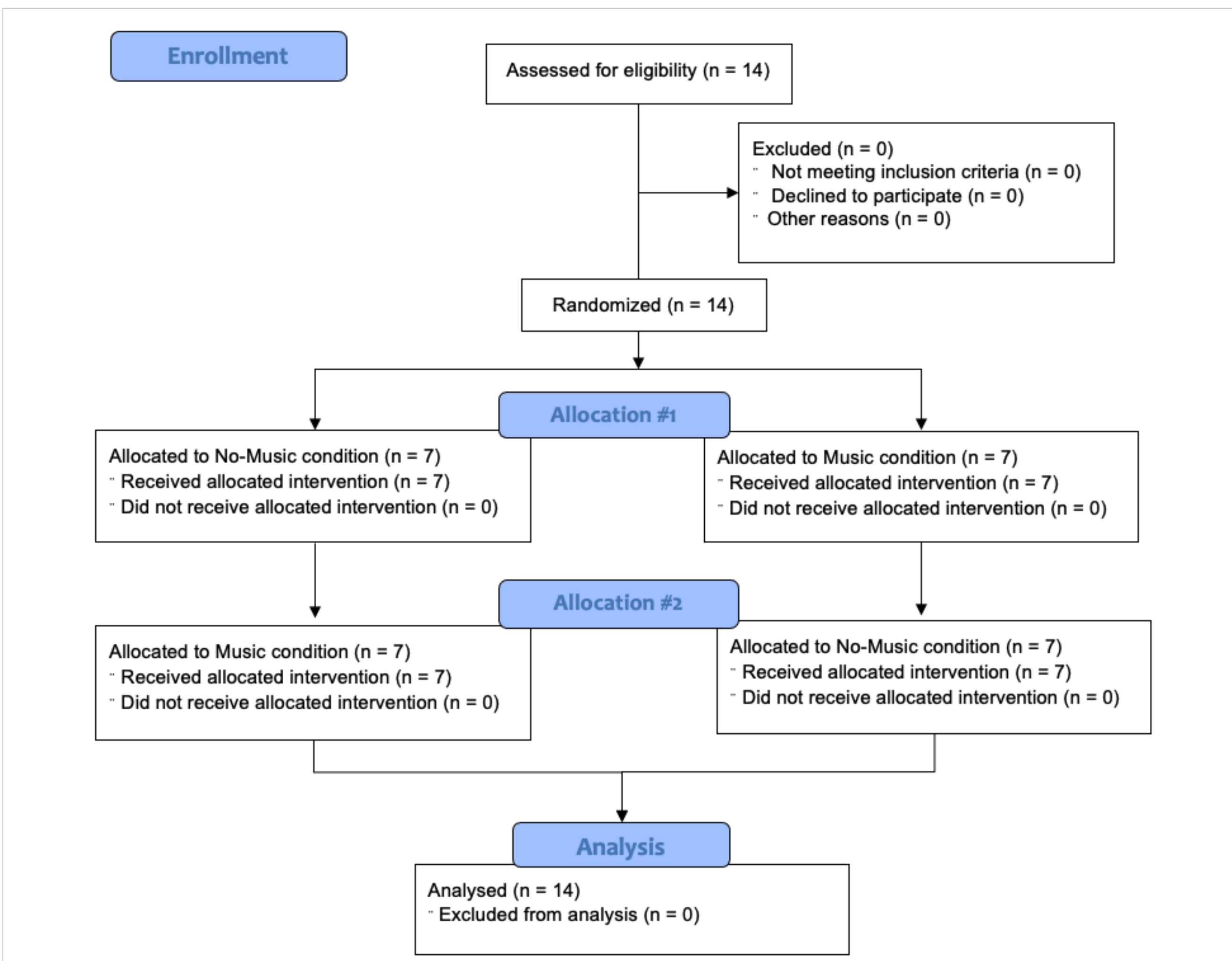


Figure 1. Flow diagram utilising Consolidated Standards of Reporting Trials (CONSORT) guidelines.

The characteristics of the participants are shown in Table 1. The participants had an ST experience of 10± 4 months.

No differences were observed in the height reached by the CMJ test (*No-MUS* = 22.5 ± 3.9 cm vs. *MUS* = 21.8 ± 3.7 cm; *MD* = .7± 2 cm; *p* = .178; *t* = 1.425; *ES* = .179) (Figure 2).

No differences were observed in movement velocity and power measurement in back-squat exercise (Table 2).

A difference was observed in the number of repetitions to failure at 75% 1RM in favor of the MUS condition (*No-MUS* = 18.9 ± 6.5 vs. *MUS* = 22.4 ± 6.9; *MD* = 3.5 ± 5.5; *p* = .034; *t* = 2.374; *ES* = .507; 18.5% of increase) (Figure 3).

The participants had 14.5% more motivation when subjected to the MUS condition (*No-MUS* = 73.6 ± 16 vs. *MUS* = 84.3 ± 13.4; *MD* = 10.7 ± 16.4; *p* = .029; *t* = 2.446; *ES* = 0.704). In addition, the participants had a lower RPE with the MUS condition (*No-MUS* = 9 ± .8 vs. *MUS* = 8.6 ± .9; *MD* = .4 ± .6; *t*= 2.621; *p* = .021; *ES* = .456).

Table 1. Descriptive characteristics and anthropometric data of the physically active women participants.

Variables	Mean± SD
Age (years)	23± 4
Weight (kg)	65.3± 11
Height (cm)	162.2± 7.1
Total lean body mass (kg)	25.2± 3.4
Total estimated body fat (kg)	19.5± 7
Total estimated body fat (%)	29.2± 6.4
Back squat 1RM (kg)	74.8± 14.1

Note: Data is shown as mean and standard deviation (SD). 1RM, one-repetition maximum.

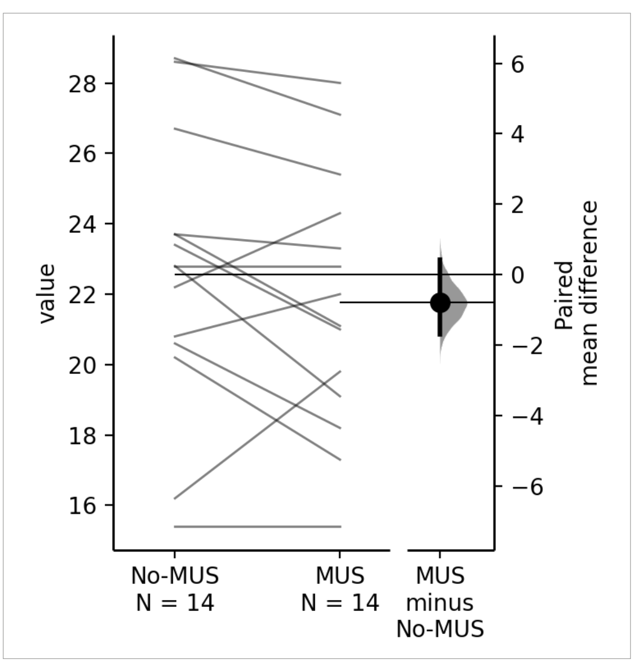


Figure 2. Difference in the height reached (cm) in the CMJ test between No-Music and Music conditions in physically active female participants. MUS, Music condition; No-MUS, No-Music condition.

DISCUSSION

This study reveals a notable increase in repetitions until failure, accompanied by significantly heightened motivation. Conversely, there were no observable alterations in jump height, velocity, or power. These results hold relevance for female physical performance, offering insights into potential gender-based differences among athletes.

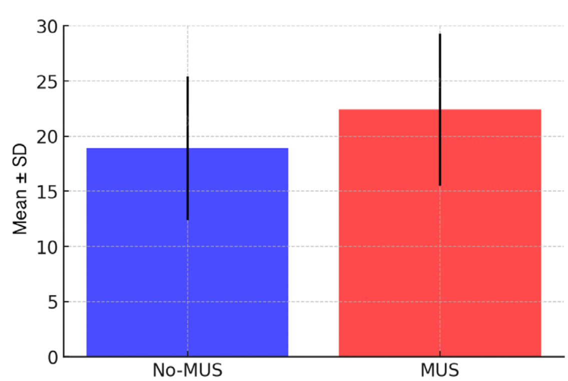
There is sufficient evidence to consider music as a strategy for improving physical performance, as demonstrated in a meta-analysis (Biagini et al., 2012). Despite these results, it is important to know the effect on strength actions, as it is one of the most demanded physical capacities in the practice of any sport. Previous studies have shown that listening to music during or prior to (Ballmann, McCullum et al., 2021) ST can generate improvements in strength variables. Thus, our results do not support those shown above, as is the case in the work of Moss et al. (2018). An attempt to explain this discrepancy is necessary. The reasons for this lack of change in measures of power and bar velocity are not yet clear, but according to selective attention loading theory, it could be attributed to some extent to the relative complexity of the task (Lavie et al., 2004). That is, when there is a challenge for the subject, the perceptual processing system utilises most of the available resources to identify the most relevant aspects of the task, thereby reducing the possibilities of processing external information, such as music (Elliot & Giesbrecht, 2010). This could explain why music influenced localised muscular endurance but did not affect movement velocity and power.

On the other hand, the gender of the study population and the physiological differences found between men and women must also be taken into account (Roberts et al., 2020), as the main studies that have observed improvements in velocity and power movements (Ballmann, Favre et al., 2021) have been developed with men, while our research was developed with women. This difference in the gender of the population studied should be considered, as it has been observed that women exhibit greater resistance to fatigue compared to men. Therefore, in ST based on movement velocity, it may be more effective for women to perform a higher volume (Rissanen et al., 2022). Therefore, when comparing the manifestation of strength by gender at the same training volume, women have shown lower levels of neuromuscular

Table 2. Measurement of movement velocity and power during the back-squat exercise (No-Music vs. Music conditions) in physically active female participants.

Variables	No-MUS	Back-squat			*t*	ES
		MUS	MD	p-value		
50% 1RM						
MV (m/s)	.73± .1	.73± .05	.00± .07	.900	.128	.001
PV (m/s)	1.35± .13	1.38± .1	.02± .1	.487	.715	.251
MP (w)	272.4± 52.4	268.5± 39	3.9± 30.5	.643	.475	.082
PP (w)	649.6± 145.2	652.9± 145.2	3.2± 87	.891	.140	.022
75% 1RM						
MV (m/s)	.60± .1	.58± .08	.02± .06	.173	1.442	.214
PV (m/s)	1.2± .13	1.18± .11	.02± .07	.325	1.023	.161
MP (w)	323.8± 59.8	317.2± 58.1	6.6± 26.1	.362	.944	.109
PP (w)	792± 182.9	796± 150	4± 81.3	.858	.183	.023

1RM: one-repetition maximum; ES: effect size; MD: mean difference; MUS: Music condition; MP: mean power; MV: mean velocity; No-MUS: No-Music condition; PP: peak power; PV: peak velocity; *t*: t-test; w: watts.



MUS: Music condition; No-MUS: No-Music condition.

Figure 3. Difference in the number of repetitions to failure at 75% 1RM between No-Music and Music conditions in physically active female participants.

fatigue compared to men (Linnamo et al., 1998). Although the exact mechanisms underlying these differences are not known, it is possible that women have a greater concentration of slower-contracting fibres (Staron et al., 2000), which may justify the lack of statistically significant differences in variables involving greater velocity and power. This physiological distinction may help clarify why the benefits of music were seen in endurance rather than power-related outcomes in our study.

A similar study (Ballmann, McCullum et al., 2021) that analyzed the effect of music on ST also obtained similar values to those shown in our results (increase in the total volume of repetitions of 15.4 vs 18.5% finding in our work). In another study, it was demonstrated that music at a high tempo increases the electromyographic fatigue threshold, resulting in enhanced exercise tolerance (Centala et al., 2020). This supports the notion that music may enhance endurance-related aspects of performance rather than maximal strength or power.

The effect of music on athlete performance may vary based on several factors, including the athlete's gender, personal circumstances, musical preferences, and the tempo of the song (measured in beats per minute, or BPM) (Terry et al., 2019). In terms of gender, there is evidence that in men the choice of music did not significantly change running performance, whereas in women an improvement was observed when they listened to their preferred music, so that listening to preferred music instead of non-preferred music had a greater effect on women's endurance running performance than men's (Cole & Maeda, 2015). Another study also observed gender differences in physiological responses to music during an incremental running test, showing that women tend to exhibit higher heart rate values at the individual anaerobic threshold compared to men under conditions without music. Similarly, after exceeding their individual anaerobic threshold, women also presented with elevated blood lactate concentrations, increased heart rate, and higher RPE levels when exposed to preferred music. Furthermore, music seems to have a greater influence on women's RPE and psychological state during exercise. These findings suggest that women may be more susceptible to the effects of music on both RPE and psychological responses during physical activity (Rasteiro et al., 2020). Previous evidence has also shown that women may exhibit greater emotional sensitivity to musical stimuli compared to men (Nater et al., 2006). Concerning tempo, songs with a slower pace (< 120 BPM) are commonly applied for relaxation purposes (Karageorghis et al., 2017). Nevertheless, studies observing the impact of music with a slower tempo during higher-intensity exercise have reported a calming effect (Karageorghis & Jones, 2014). Consequently, songs with tempos exceeding 120 BPM are associated with enhanced physical performance, as observed in our study. The chosen music genre of trap and reggaeton in our study had a tempo of > 120 BPM and has become a significant trend among the youth in recent years (in Spain, this music genre has experienced a 44% increase in recent years). Thus, intentionally utilizing this music genre can serve as a strategic approach to boost performance by fostering greater motivation during the execution of physical effort. This highlights the importance of cultural and personal relevance in selecting workout music.

Previous studies have shown that listening to music prior to or during exercise can lead to greater motivation towards exercise (Ballmann, McCullum et al., 2021; Karow et al., 2020). Our results support these findings, as our research revealed a 14% increase in motivation compared to performance without music. This increase in motivation during exercise may also contribute to the improvement in the total number of repetitions achieved before muscle failure. Although we know that motivation is a multifactorial phenomenon and an underlying factor that maximises performance, it is necessary to delve deeper into this subject in order to understand and be able to generalise the results to athletes who have different degrees of internal motivation (Ballmann, Favre et al., 2021).

Listening to music during exercise not only enhances motivation but also has a significant impact on overall physical performance. Music serves as a motivational stimulus, positively influencing mood and reducing the subjective perception of effort, which can potentially result in improved performance and increased exercise tolerance (Karageorghis & Priest, 2012; Terry et al., 2019). Furthermore, music can synchronise movements, enhancing efficiency and coordination during physical activity (Bood et al., 2013). The synchronization effect may explain the endurance benefits observed in our study, as rhythmic cues could help maintain a consistent movement pattern during prolonged effort.

An important aspect of enhancing performance with music is personal choice. Many gyms, locker rooms, and competition environments play music through communal speakers, but if the music played is not preferred by the individual, performance may be affected. Therefore, athletes should consider using headphones with their preferred music to optimise performance and training (Ballmann, 2021). Coaches and athletes should consider individual musical preferences when designing training strategies. However, it is important to note that in our study, despite the music not being self-selected, all participants reported enjoying it. This suggests that individual preference was not a confounding factor in our results. Future studies could further investigate whether music preference plays a more substantial role when satisfaction levels vary among participants.

Furthermore, the evidence currently reviewed suggests that an important aspect of enhancing performance with music is personal choice. In many gyms, locker rooms, and competition environments, music is played through a communal loudspeaker system. The current available data suggest that if the music played through the loudspeakers is not preferred by the individual performing the effort, performance may be affected. Therefore, coaches and athletes should take into account individual musical preferences when attempting to optimise performance and training.

This benefit extends to specific training programmes or injury rehabilitation, where motivation and adherence to the exercise program are critical. Music not only makes sessions more enjoyable, thereby increasing adherence to the program (Paul & Ramsey, 2000), but also acts as a crucial motivational stimulus for those facing challenges during the process (Weller & Baker, 2011). Studies (Ferguson & Voll, 2004; Wood et al., 2021) have shown that music can help reduce stress and anxiety associated with rehabilitation, thereby creating a more conducive environment for effective recovery. Moreover, it would be interesting to understand whether these results are replicable across the entire age spectrum or whether phenomena such as menopause may influence these results (Monteiro et al., 2022).

Although the study reveals that this type of music has a positive impact on performance in women, it is essential to acknowledge certain limitations. The selection of participants was conducted through convenience sampling, which introduces an inherent bias into the study and limits the possibility of generalising the results to broader populations. Additionally, a completely random selection procedure was not employed, which is a significant methodological weakness. Finally, given that the participants were university students with previous ST experience, the results may not be representative of individuals with different levels of experience, physical activity or demographic characteristics. Moreover, the sample size may have limited the statistical power of the study, potentially reducing the ability to detect meaningful differences between conditions. Therefore, these findings should be interpreted with caution and not directly extrapolated to the general population.

CONCLUSIONS

No statistically significant differences were found in back-squat movement velocity or power between the MUS and No-MUS conditions. However, listening to music significantly improved strength endurance performance, enhanced motivation, and reduced RPE. These findings suggest that music may be an effective strategy for enhancing muscular endurance by increasing the number of repetitions to failure, boosting motivation, and reducing RPE during the back-squat exercise in physically active women.

These findings suggest promising practical applications for the strategic integration of music into exercise sessions. Music, by acting as a motivational stimulus, has the potential to maintain a positive attitude during challenging performance sessions. Moreover, the tempo of music appears to play a crucial role, with rhythms exceeding 120 BPM proving more effective in enhancing performance. Personal music selection is also essential, as listening to preferred songs can optimize performance, particularly in women, who appear to be more responsive to musical stimuli. These findings highlight the importance for coaches and health professionals to incorporate personalized music as a motivational tool and performance-enhancing strategy.

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