EFFECTS OF MUSIC ON AEROBIC PERFORMANCE IN MALES WITH DOWN SYNDROME

EFEITOS DA MÚSICA NO DESEMPENHO AERÓBICO EM HOMENS COM SÍNDROME DE DOWN

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Abstract: Music is a powerful stimulus that can influence psychological and emotional states, potentially affecting motor performance. This study investigated the effects of fast tempo music (FTM) versus slow tempo music (STM) on aerobic capacity during the 1-mile test in individuals with Down syndrome (DS). **Methods:** Twenty-seven men with DS (mean age: 26.2 years) were recruited from Special Education Schools. Participants completed three 1-mile tests: the first without music (WM), the second with FTM, and the third with STM. The main variables analyzed were completion time and heart rate at progressive distances (400, 800, 1200, and 1609 m). Performance differences between tests were analyzed using an independent t-test ($p < 0.05$). **Results:** Compared to WM, FTM significantly reduced completion time between 1200 m and 1609 m ($p < 0.05$), whereas STM significantly increased completion time across all distances ($p < 0.05$). **Conclusion:** FTM may be an accessible, low-cost, and practical tool to improve motivation and aerobic capacity in men with DS during endurance activities.

Keywords: intellectual disability; endurance; cardiovascular fitness; motivation.

Introdução: A música é um estímulo poderoso que pode influenciar os estados psicológicos e emocionais, afetando potencialmente o desempenho motor. Este estudo investigou os efeitos da música de tempo rápido (Fast Tempo Music, FTM) em comparação com a música de tempo lento (Slow Tempo Music, STM) na capacidade aeróbica durante o teste de 1 milha em indivíduos com síndrome de Down (SD). **Métodos:** Vinte e sete homens com SD (idade média: 26,2 anos) foram recrutados em Escolas de Educação Especial. Os participantes realizaram três testes de 1 milha: o primeiro sem música (WM), o segundo com FTM e o terceiro com STM. As principais variáveis analisadas foram o tempo de conclusão e a frequência cardíaca em distâncias progressivas (400, 800, 1200 e 1609 m). As diferenças de desempenho entre os testes foram analisadas por meio de um teste t independente ($p < 0,05$). **Resultados:** Em comparação com WM, a FTM reduziu significativamente o tempo de conclusão entre 1200 m e 1609 m ($p < 0,05$), enquanto a STM aumentou significativamente o tempo de conclusão em todas as distâncias ($p < 0,05$). **Conclusão:** A FTM pode ser uma ferramenta acessível, de baixo custo e prática para melhorar a motivação e a capacidade aeróbica em homens com SD durante atividades de resistência.

Palavras-chave: deficiência intelectual; resistência; aptidão cardiovascular; motivação.

1. INTRODUCTION

Individuals with Down syndrome (IDS) are considered a high-risk population due to their predominantly sedentary lifestyles (Andriolo et al., 2010; Agiovlasitis et al., 2020; Lynch et al., 2025). The genetic disorder underlying this syndrome contributes to significant physical impairments, which may be linked to the general apathy towards structured physical activity observed in this population

(Silva et al., 2006; Barnhart & Connolly, 2007). Additionally, their characteristically low basal metabolic rate predisposes them to obesity and cardiovascular diseases in adulthood. Weight and health problems in individuals with DS usually begin in childhood (Hetman & Barg, 2022)

Supporting these findings, several studies have reported that individuals with Down syndrome (IDS) exhibit lower cardiovascular capacity compared to the general population and even to peers with other intellectual disabilities (Dyer, 1994; O'Brien, 1996; Eberhard et al., 1997; Stephens, 1998; Balic, 2000; Andriolo et al., 2010; Barnhart & Connolly, 2007; Melo et al., 2022). Multiple investigations have further confirmed this reduced cardiovascular capacity in individuals with Down syndrome (Fernhall et al., 1996; Fradoca, 1999; Balic, 2000; Maia, 2002; Fernhall, 2001; Costa, 2006; Roizen et al., 2014).

Several factors may contribute to the reduced cardiorespiratory capacity observed in IDS (Dyer, 1994; Owlia et al., 1995; Kunde & Rimmer, 2000; Barnhart & Connolly, 2007; Mendonca et al., 2010; Clina et al., 2025):

i) limited opportunities to engage in high-energy physical activities
ii) insufficient support from caregivers or facilitators to promote and encourage such activities,
iii) the unique challenges associated with this population, including motor clumsiness and coordination difficulties, and most importantly,
iv) low motivation for activities requiring high energy expenditure.

Kunde & Rimmer (2000) further suggest that the cognitive limitations commonly present in IDS contribute to a lack of motivation for completing prolonged tasks. Some individuals struggle with fatigue due to poor endurance, while others have difficulty understanding concepts such as self-pacing and maintaining a steady rhythm.

Research indicates that music can serve as an effective stimulus and positive reinforcement for individuals with intellectual disabilities, enhancing both motivation and enjoyment in physical activity. Music has been shown to improve adherence to recreational exercise, particularly in activities requiring submaximal aerobic effort for health benefits (Wijnalda et al., 2005; Moreno-Garcia et al., 2020, Rodrigues dos Santos et al., 2025). Szabo & Hoban (2004) highlight that while music can have a positive psychological effect, its influence depends on exercise type, music genre, and, crucially, musical tempo, which must be synchronized with the activity to maximize benefits. O'Brien (1996) further suggests that musical tempo affects behavioral responses in both individuals with and without intellectual disabilities.

Music has been found to enhance motivation for physical activity by reducing perceived exertion, increasing arousal levels, improving coordination and movement synchronization, and promoting relaxation (Karageorghis & Terry, 1997; Szabo et al., 1999; Szabo & Hoban, 2004; Weng, 2006; Harmon & Kravitz, 2007; Radomsky & Chan, 2007). Additionally, music can enhance physical performance when integrated with exercise (Bean, 1998; Long, 1999; Weng, 2006). However, the effects of music on performance appear to differ between males and females (Long, 1999). Priest et al. (2004) reported that males tend to prefer music with strong bass components and respond more strongly to its stimulating qualities compared to females.

Given these findings, we question whether fast-tempo music can facilitate improved physical performance in individuals with Down syndrome. Although existing literature on this topic is inconclusive and primarily focused on neurotypical individuals, multiple studies support the notion that music can positively influence exercise performance when paired with physical activity (Copeland & Franks, 1991; Szmedra & Bacharach, 1998; Szabo et al., 1999; Crust, 2004; Yamamoto et al., 2003; Atkinson et al., 2004; Yamashita et al., 2006; Jing & Xudong, 2008). Therefore, the primary objective of this study was to examine the effects of fast-tempo music (FTM) versus slow-tempo music (STM) on endurance performance during a walk/run test in males with Down syndrome.

2. METHODS

Twenty-seven male adolescents and adults with DS, were recruited from Special Schools (SSPI), to participate in this study. The participants' characteristics were as follows (mean ± SD): age 26.1 ± 6.2 years, body mass 71.6 ± 13.3 kg, height 150.0 ± 7.5 cm, BMI 32.1 ± 6.1 kg/cm2, and HRmax 194 ± 6.2 bpm.

2.1. Inclusion criteria

Participants were required to meet the following criteria:

- No medical contraindications for exercising testing.
- Confirmed diagnosis of Down Syndrome.
- Engagement in regular physical activity (at least 2-3 times per week).
- Sufficient cognitive ability to comprehend test instructions (IQ ≥ 35, as per the American Association on Mental Retardation [AAMR] classification for moderate intellectual disability).
- No severe hearing impairments (hearing loss ≤ 25 decibels in the better ear, per WHO guidelines).
- Ability to perform the test independently, without assistance.

Written informed consent was obtained from all participants or their legal guardians before study participation. Participants were instructed to avoid strenuous physical activity on the day preceding testing. The experimental procedures adhered to the ethical principles outlined in the Declaration of Helsinki and the guidelines for medical research involving human subjects (Harriss et al., 2015).

2.2.Instrumentation

The following instruments were used in the study:

- Fitnessgram 1.0 Mile (1.609 km) Walk/Run Test
- Fitnessgram 1.0 Mile Walk/Run Test Data Recording File
- MixMeister BPM Analyzer 1.0
- Adapted "Three-Choice Pictograph Response Test" Data Recording File
- HRM Triax 100 - Nike (Heart Rate Sensor with Chest Strap)
- Technostar RCD 6900R Portable CD-Radio

2.3.Determination of Musical Preferences

A survey of participants' musical preferences was conducted in collaboration with institutional technicians and monitors. Based on existing literature (Glenn et al., 1981; Patton, 1991; Glush, 1992; O'Brien, 1996; Stephens, 1998; Karageorghis & Terry, 1997; Karageorghis et al., 1999; Priest et al., 2004; Karageorghis et al., 2006), a selection of 20 musical tracks was curated.

Musical selection was based on both objective and subjective criteria. Tempo was determined using BPM analysis, with fast-tempo music defined as >120 bpm and slow-tempo music as 60–80 bpm.

To ensure ecological validity and participant engagement, fast-tempo tracks were selected based on familiarity with participants' sociocultural background. In contrast, slow-tempo tracks were intentionally unfamiliar and presented in a foreign language to minimize emotional stimulation.

A preliminary assessment was conducted with a subgroup of four participants, under the supervision of a psychologist, using an adapted pictographic response test to identify tracks eliciting the most positive behavioral responses. Although the subgroup size was limited, this procedure aimed to enhance the appropriateness of musical stimuli for the target population. This limitation is acknowledged in the Discussion.

2.4.Adaptation to Testing

The feasibility of the Fitnessgram 1.0 Mile Walk/Run Test for the participants was evaluated using the same subgroup involved in the musical selection process. During this familiarization session, participants were introduced to the HRM Triax 100 - Nike (Heart Rate Sensor with Chest Strap) to ensure comfort and compliance with the equipment.f

Testing Procedure

Each participant performed the Fitnessgram 1.0 Mile Walk/Run Test under three conditions, with a minimum interval of two weeks between trials:

1. WM (Baseline): Test performed without music.
2. FTM: Test performed with Fast Tempo Music.
3. STM: Test performed with Slow Tempo Music.

No verbal reinforcement was provided during the attempts.

Data Collection

For each attempt, the following variables were recorded:

- Resting heart rate
- Time taken at key distances (400 m, 800 m, 1200 m, and 1609 m)
- Heart rate at each recorded distance

Statistical Analysis

Descriptive statistics are presented as means and standard deviations (SD). Data normality was assessed using the Shapiro-Wilk test. Since the assumption of normality was met, differences between conditions (WM, FTM, and STM) and distances were analyzed using a repeated-measures analysis of variance (ANOVA).

When significant main effects were found, post hoc comparisons were performed using the Bonferroni correction. Effect sizes were reported as partial eta squared (η^2p). The significance level was set at $\alpha = 0.05$.

All analyses were performed using R (version 4.1.2; R Foundation for Statistical Computing, Vienna, Austria).

3. RESULTS

Table 1 presents the overall time expenditure across the three trials at four distances (400 m, 800 m, 1200 m, and 1609 m).

Table 1: Global scores for time expenditure (s)

Distance	Trial	Time (n = 27)
400 m	WM	210 ± 34
	FTM	208 ± 38
	STM	229 ± 48
800 m	WM	476 ± 76
	FTM	468 ± 87*,**
	STM	508 ± 107
1200 m	WM	764 ± 122***
	FTM	741 ± 130**
	STM	799 ± 154

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	WM	**1054 ± 189***
1609 m	**FTM**	**1017 ± 178*,****
	STM	**1091 ± 208***

Note: Data are presented as mean $\bar{X}$ and standard deviation (SD).
Abbreviations: Meters (m), seconds (s), without music (WM), fast tempo music (FTM), and slow tempo music (STM)
Significance: *sig**;** **FMT vs WM; ***WM vs STM; = $p < 0.05$
Source: Authors (2026)

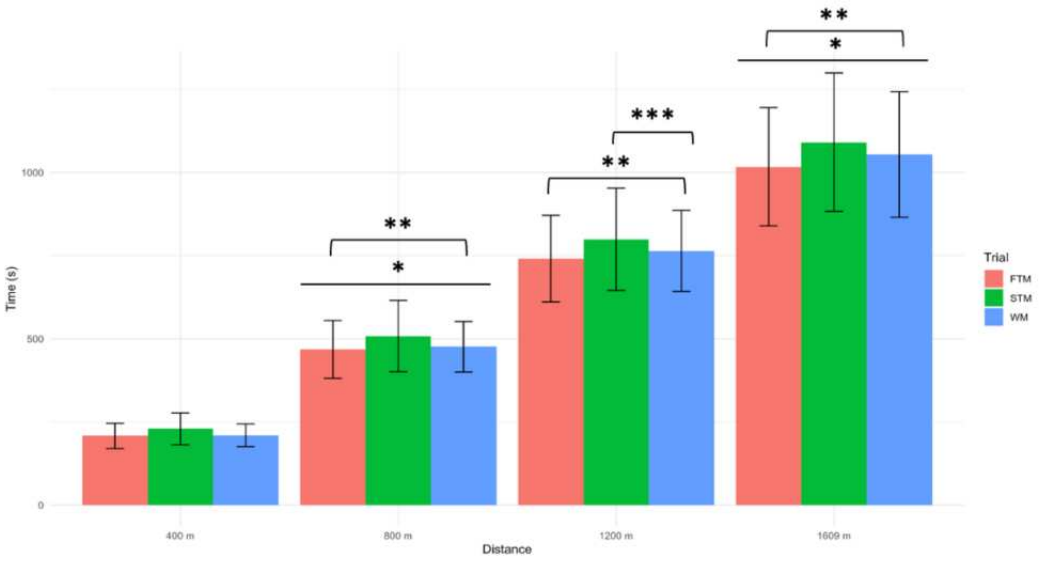

Figure 1: Global scores for time expenditure
Source: Authors (2026)

Abbreviations: Meters (m), seconds (s), without music (WM), fast tempo music (FTM), and slow tempo music (STM)
Significance: *sig for all conditions**;** **FMT vs WM; ***WM vs STM; $p < 0.05$

Time performance across conditions is presented in Table 1. A repeated-measures ANOVA revealed a significant effect of condition on time to completion across distances ($p < 0.05$).

Post hoc analyses indicated that the FTM condition resulted in significantly faster completion times compared to both WM and STM conditions at 800 m, 1200 m, and 1609 m ($p < 0.05$). In contrast, the STM condition was associated with significantly slower performance compared to WM ($p < 0.05$).

No significant differences were observed at 400 m between conditions. However, from 800 m onwards, a clear divergence emerged, with FTM demonstrating the best performance, followed by WM and STM.

Heart rate responses are presented in Table 2. A significant effect of condition was observed across all distances ($p < 0.05$). The FTM condition consistently elicited higher heart rate values compared to STM, particularly at 800 m, 1200 m, and peak exercise (1609 m).

Regarding heart rate recovery (HR1), significant differences were observed between conditions ($p < 0.05$), with STM showing a greater reduction in heart rate compared to FTM, suggesting enhanced recovery.

Table 2: Global scores for Heart rate (bpm)

Distance	Trial	Heart rate
400 m	WM	157 ± 19
	FTM	159 ± 16**,***
	STM	151 ± 17
800 m	WM	152 ± 17
	FTM	159 ± 20***
	STM	147 ± 20
1200 m	WM	149 ± 20
	FTM	157 ± 22**,***
	STM	144 ± 20
1609 m (HRpeak)	**WM**	162 ± 22
	FTM	166 ± 20*, ***
	STM	152 ± 21
HR1	WM	33 ± 12
	FTM	35 ± 15***
	STM	27 ± 11

Note: Data are presented as mean $\bar{X}$ and standard deviation (SD).
Abbreviations: Meters (m), seconds (s), without music (WM), fast tempo music (FTM), and slow tempo music (STM)
Significance: *sig**;** **FMT vs WM; ***FMT vs STM; = $p < 0.05$

Source: Authors (2026)

Heart rate responses across different distances and trials (without music, fast tempo music, and slow tempo music) are presented in Table 2. At 400 m, heart rate was significantly higher in the FTM trial (159 ± 16 bpm) compared to STM (151 ± 17 bpm), with no significant difference between FTM and WM (157 ± 19 bpm). A similar pattern was observed at 800 m, 1200 m, and 1609 m, where FTM trials consistently resulted in higher heart rates compared to STM, with significance between FTM and STM at all distances ($p < 0.05$).

For P2 (hrP1), heart rate was significantly higher in the FTM trial (35 ± 15 bpm) compared to WM (33 ± 12 bpm), and significantly lower in STM (27 ± 11 bpm), with FTM differing from STM ($p < 0.05$). The rate of heart rate change (HR1) also showed a greater increase in FTM (35 ± 15 bpm) compared to both WM (33 ± 12 bpm) and STM (27 ± 11 bpm), with significant differences between FTM and STM ($p < 0.05$).

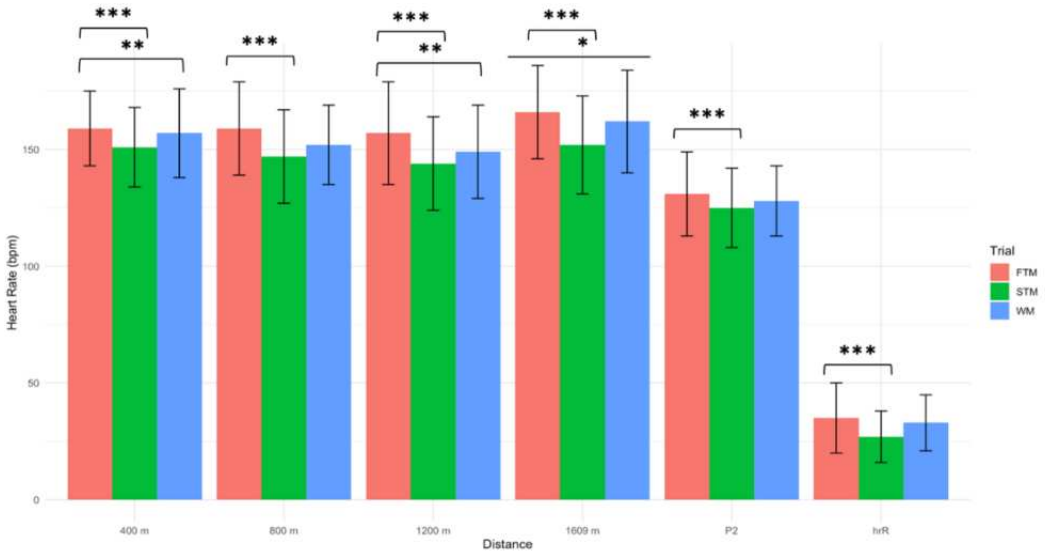

Figure 2: Global scores for heart rate
Source: Authors (2026)

Abbreviations: Meters (m), seconds (s), without music (WM), fast tempo music (FTM), and slow tempo music (STM)
Significance: *sig**;** **FMT vs WM; ***FMT vs STM; = $p < 0.05$

4. DISCUSSION

The primary objective of this study is to examine the impact of musical stimuli on physical exercise. Previous research on the psychophysiological effects of music during exercise in non-disabled individuals has produced inconsistent and, at times, contradictory findings (Brownley et al., 1995; Kotwal, 1995; Karageorghis et al., 1999; Long, 1999; Tenenbaum et al., 2004; Crust & Clough, 2006; Ifergan, 2006; Todd, 2006).

However, studies involving individuals with disabilities, including the present investigation on male individuals with intellectual disabilities (IDS), suggest a more consistent trend. In particular, research on aerobic exercise indicates that music reliably influences both performance and heart rate.

Our findings confirm that music—both fast-tempo (FTM) and slow-tempo (STM)—significantly impacts the physical performance of male IDS participants. This aligns with studies conducted on non-disabled individuals (Copeland & Francks, 1991; Atkinson et al., 2004; Elliot et al., 2004, 2005; Malik, 2005; Edworthy & Waring, 2006) as well as research involving individuals with intellectual disabilities (Owlia et al., 1995; O'Brien, 1996; Stephens, 1998; Kunde & Rimmer, 2000). Additionally, our findings are consistent with studies examining male-dominated samples, including those by Copeland & Franks (1991), Szmedra & Bacharach (1998), Crust (2004), Yamamoto et al. (2003), Atkinson et al. (2004), Yamashita et al. (2006), and Jing & Xudong (2008), all of which reported a positive influence of music on male performance.

Tenenbaum et al. (2004) proposed that music is most beneficial in the initial stages of exercise when exertion is more tolerable, rather than during later stages when fatigue intensifies. However, our

study did not support this claim, as FTM did not significantly reduce time expenditure in the early phase.

Moreover, our findings align with the hypothesis (Karageorghis & Terry, 1997), which suggests that during low-intensity exercise, external stimuli such as music exert a stronger influence on physiological responses than internal cues like fatigue, discomfort, or boredom.

Regarding heart rate, FTM significantly increased heart rate, particularly toward the end of the trial. This result is consistent with findings from studies on non-disabled individuals (Brownley et al., 1995; Atkinson et al., 2004; Edworthy & Waring, 2006) as well as research on individuals with intellectual disabilities (Ellis et al., 1993). Conversely, STM significantly reduced heart rate, corroborating previous studies on non-disabled participants (Copeland & Francks, 1991; Szmedra & Bacharach, 1998; Jing & Xudong, 2008).

In terms of heart rate recovery (HR1), both music genres had a significant impact, with STM demonstrating a particularly pronounced effect. This supports the notion proposed by Wethered (1973), O'Brien (1996), and Stanley & Ramsey (2000), who suggested that lower music volume or tempo, the absence of pronounced beats, and calm, structured compositions promote relaxation.

Furthermore, our study reinforces the findings of Priest et al. (2004), who observed that male individuals are particularly responsive to the stimulating effects of music.

Visual analysis of the different trials revealed distinct behavioral patterns among the male IDS participants. During the WM trial, participants showed low engagement, displaying signs of boredom and occasional discomfort. In contrast, the FTM trial—identified as the preferred condition—elicited greater enthusiasm, increased energy, and a heightened sense of fulfillment. Meanwhile, in the STM trial, participants appeared more indifferent and lethargic.

The present results consistently prove that in relation to baseline values, trial without music, FTM improves performance while STM worsens it.

The rate of heart rate recovery is influenced by the level of effort exerted in each trial. Despite variations in peak heart rates, the recovery values for both the Without Music (WM) and Fast-Tempo Music (FTM) trials were similar. In contrast, the Slow-Tempo Music (STM) trial facilitated a more substantial decrease in heart rate during recovery, suggesting a more relaxing effect of STM. This observation aligns with previous research indicating that slow-tempo music can enhance post-exercise recovery by promoting relaxation and reducing heart rate more effectively than fast-tempo or no music conditions

5. CONCLUSION

In conclusion, our study demonstrates that musical tempo significantly influences the physical performance and heart rate responses of male individuals with intellectual disabilities (IDS). Fast-tempo music (FTM) enhances performance and elevates heart rate, while slow-tempo music (STM) diminishes performance and facilitates greater heart rate recovery, indicating a more relaxing effect.

These findings align with existing literature on non-disabled individuals and underscore the potential of tailored musical interventions to optimize exercise outcomes in the IDS population. Future research should explore the underlying mechanisms of these effects and assess the applicability of various musical genres across diverse populations.

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