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Effect of Short-time Exercise with Music on Performance and Post-exercise Cardiac Recovery: A Comparison between Type 2 Diabetics and Young Adults

Maryam Bagheri [1], **Sajjad Salari** [1]✉

[1] Department of Physiology, Faculty of Medicine, Ilam University of Medical Sciences, Ilam, Iran

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✉ ***Correspondence to:***
Sajjad Salari
Department of Physiology, Faculty of Medicine, Ilam University of Medical Sciences, Ilam, Iran

Email:
sajjad.salari@medilam.ac.ir

ABSTRACT

Introduction: High-tempo music is commonly used during exercise to enhance physical activity. Post-exercise parasympathetic reactivation, responsible for cardiac recovery, is crucial for predicting cardiac arrhythmia and overall heart health. Previous studies have demonstrated positive effects of music on exercise performance in healthy individuals. However, little is known about its impact on diabetic (Type II) females and young adults. Therefore, we aimed to investigate the effect of listening to high-tempo music during exercise on workout performance and parasympathetic reactivation in these populations.

Material & Methods: We evaluated a total of 70 females, including healthy individuals (n=36) and diabetic (Type II) females (n=34). Prior to the experiment, lipid profile and cardiac risk ratio were measured in blood samples taken one week before the active sessions. Each participant underwent two separate active sessions: one session involved running without music, and the other involved running while listening to music for a duration of 6 minutes. Heart rate was measured before running and at zero, five, and ten minutes after exercise. Running distance was also recorded.

Results: In healthy adults, running distance significantly increased when listening to music during exercise compared to the non-music session ($P<0.0001$). Additionally, heart rate was significantly higher at time zero during running with music compared to the non-music session ($P<0.0001$). However, heart rate recovery was superior 10 minutes after exercise in the music group compared to the non-music group in diabetic females ($P<0.0001$).

Conclusion: Listening to high-tempo music during exercise may increase sympathetic activity and enhance exercise performance, particularly in healthy young adults. Interestingly, listening to music during exercise may accelerate parasympathetic reactivation to a greater extent in diabetic females, potentially reducing the risk of arrhythmias during the resting period without enhancing exercise performance.

Keywords: Music, Parasympathetic Nervous System, heart rate, diabetes mellitus, type 2

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Introduction

High-tempo music is commonly used during exercise to enhance physical performance and psychological effects. Additionally, it influences physiological parameters, including heart rate and blood pressure. Despite reported positive effects in some studies, the safety of this motivating factor on the cardiovascular system remains under discussion. Post-exercise parasympathetic reactivation is crucial for inducing cardiac recovery and predicting cardiac arrhythmia and health (1, 2). Heart rate increases during training due to sympathetic activation and vagal withdrawal and then rapidly declines after exercise to prevent excessive cardiac work. While evidence supports the role of vagal effect in cardiac recovery after exercise, heart rate recovery has been less studied, especially under pathological conditions (1). Evaluating cardiac recovery post-exercise is essential for assessing parasympathetic reactivation capacity and predicting cardiac arrhythmia using a valuable non-invasive tool (3-5). However, some researchers propose that this effect is autonomic nervous system-independent and related to the intrinsic capacity of intact circulation (2). Edworthy and Waring observed a significant increase in heart rate while listening to fast music during exercise (6). Conversely, Schwartz et al. found no significant change in heart rate (7). Birnbaum et al. reported a decrease in heart rate and blood pressure while listening to fast music during steady-state treadmill exercise (8).

Moreover, music has long been purported to enhance enjoyment and exercise performance during workouts (9, 10). It is believed that music can mitigate sensations of fatigue during exercise (6, 11). Additionally, both low and high-tempo music may alter arousal states, resulting in either increased hyperactivity or relaxation during exercise (12).

The effects of music on exercise and sport have been comprehensively reviewed by Terry et al., who discussed the potential benefits and underlying mechanisms associated with music listening during workouts (13). In a study conducted by Judy Edworthy and her colleagues, participants engaged in a 10-minute treadmill exercise while listening to fast/loud, fast/quiet, slow/loud, slow/quiet, or no music. The results indicated that fast/loud music can induce optimal exercise performance (6). Similarly, the effects of tempo music on performance and heart rate have been investigated in healthy young adults, revealing a significant increase in exercise endurance and heart rate (14).

Moreover, the effects of music have been studied in various health conditions, including diabetes mellitus, beyond just healthy individuals. A study by Eseadi et al. in 2023 examined the potential impact of music interventions on controlling diabetic patients, demonstrating that listening to music while exercising could improve certain health parameters and reduce blood sugar and heart rate (15, 16). Additionally, positive psychophysiological effects of music during exercise have been observed in diabetic patients (15). Similarly, music intervention has been found to promote activity in diabetic females aged 50-59 (17).

Importantly, these studies highlight gaps in the literature regarding the physiological outcomes and parasympathetic reactivation after exercising while listening to music in diabetic females. Given the importance of physical activity in diabetes management, our study aims to investigate the effect of high-tempo music during running on exercise performance and subsequent parasympathetic reactivation in diabetic (type II) females, comparing the findings with those of healthy young adults.

Materials and methods

Healthy young females (n=34, aged 18-26) and diabetic females (n=36, aged 41-52) were recruited for the current study. All participants had no cardiovascular health issues. Those in the diabetic group had been on medication for approximately two years prior to the experiment and none were using insulin.

The study followed the ethical guidelines approved by the Ethics Committee at Ilam University of Medical Sciences (IR.MEDILAM.REC.1397.100). Participants were provided with a detailed explanation of the research process before the project commenced, and written consent was obtained from each individual. A schematic timeline of the project is illustrated in Figure 1.

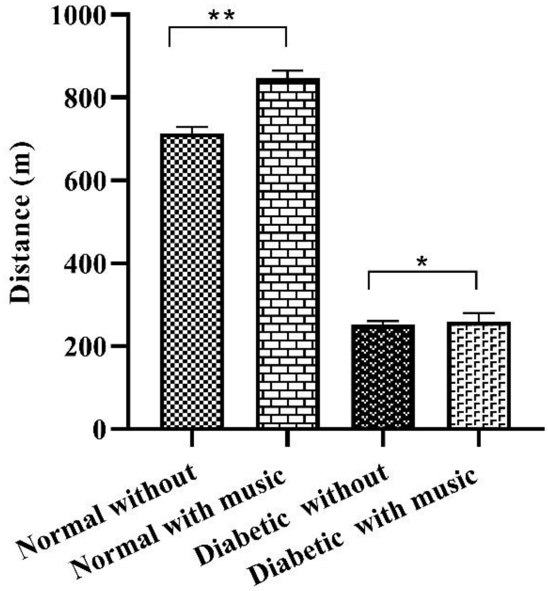

Figure 1. **Running Distance during 6-Minute Sessions in Healthy Adult Females and Diabetic (II) Females**. Exercise performance, indicated by increased running distance, was significantly higher in sessions with music compared to sessions without music in healthy adult females ($p < 0.0001$). However, the performance enhancement was not significant in diabetic females ($p < 0.49$).

Venous blood samples were collected from participants in both the diabetic and healthy groups approximately one week before the running sessions. Lipid profile and cardiac risk ratio were assessed for all participants. Individuals with abnormal laboratory results were excluded from the study, resulting in a final selection of 36 subjects out of 43.

Participants underwent two running sessions: (1) a six-minute run without listening to music, and (2) a six-minute run while listening to high-tempo music. There was a 72-hour resting period between the two running sessions. Prior to each running session, all subjects had a 20-minute rest period. Heart rate (HR) was measured before running as a baseline, and at 0, 1, 5, and 10 minutes after exercise. Running distance was also recorded.

The protocol remained consistent in the second session, with the only difference being the inclusion of high-tempo music during running. All measurements were repeated for all participants. Exercise performance and heart rate recovery were then analyzed in both groups. Heart rate (HR) was measured using the Omron M6 comfort digital apparatus, with each subject evaluated separately.

It's worth noting that systolic blood pressure (SBP) and diastolic blood pressure (DBP) were also measured at baseline, and at 0, 5, and 10 minutes after running, although the data for these measurements is not presented here.

Statistical analysis

One-way ANOVA with repeated measures and paired-sample t-tests were employed to compare the data. Data analysis was performed using GraphPad Prism VIII software. All data are presented as mean

± SEM, with significance set at $P < 0.05$. Heart rate and running distance parameters were compared within each group under two conditions: without music and while listening to music.

Results

Table 1 presents the mean values of age, BMI, total cholesterol, triglycerides, low-density lipoprotein cholesterol (LDL), high-density lipoprotein cholesterol (HDL), and cardiac risk ratio (total cholesterol/LDL). In the young adult group, the mean age was 22.5 ± 0.8 years, and in the diabetic group, it was 46.2 ± 2.8 years. The mean BMI was 24.4 ± 0.3 in young adults, within the normal range, and 27.4 ± 0.2 in diabetic females, indicating overweight status. Lipid profile parameters were within the normal range in young adults and approximately normal in diabetic females. These measurements were conducted to exclude high-risk participants from the study.

Table 1. General Characteristics of Participants in Healthy Adults and Diabetic Females.

Parameters (Mean ± SEM)	Young adults	Diabetic (II)	Healthy range
age	22.5 ± 0.8	46.2 ± 2.8	-
BMI	24.4 ± 0.3	27.4 ± 0.2 (over weight)	18.5-24.9
Total cholesterol	180± 11.8	197± 13	<200 mg/dl
Triglyceride	132±9.8	143± 9	<150 mg/dl
LDL	74 ±7.6	98±2.9	<100 mg/dl
HDL	58±4	31 ±3.7	50-59 mg/dl
Cardiac risk ratio*	3.09-3.11	6.34-6.50	4.5-7 (average risk)

General characteristics of all participant including age, BMI, lipid profile that expressed as (mean ± SEM) in all parameters. *Cardiac risk ratio calculated by total cholesterol divided by HDL

Exercise performance

Figure 1 illustrates the running distance in two sessions for healthy adults. In the session without listening to high-tempo music, the running distance was 714.8 ± 2.5 m, while it increased significantly to 846.6 ± 3.15 m when listening to high-tempo music ($P < 0.0001$). Conversely, in diabetic females, the running distance was 251.1 ± 1.58 m without music and 261.3 ± 3.9 m with music, showing no significant change.

Heart rate measurements in healthy adults

Heart rate was measured before starting the activity as a baseline, with a value of 84.15 ± 0.95 beats per minute (bpm) in session I. In this session, heart rate increased significantly to 167.6 ± 1.3 bpm at time 0, then declined to 113.4 ± 1.4 bpm at time 5 and to 111.6 ± 1.5 bpm at time 10 following exercise. Conversely, in running while listening to music, the maximum heart rate at time 0 was 175.3 ± 1.48 bpm, followed by a decrease to 106.2 ± 1.46 bpm five minutes after running and 104.5 ± 1.69 bpm ten minutes after running. The comparison of running with music showed a significant increase in heart rate value at time zero ($P < 0.0001$) and a significant decrease in heart rate at five and ten minutes after running ($P < 0.0001$) as illustrated in Figure 2.

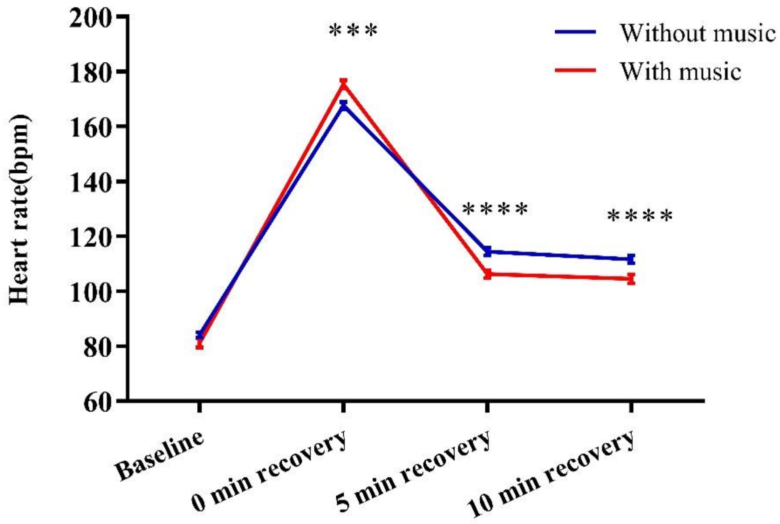

Figure 2. Heart rate values at baseline (pre-exercise) and at 0, 5, and 10 minutes post-running during a 6-minute exercise session without music (Session I) and with music (Session II) in healthy adult females. Significantly higher heart rates were observed at time 0 when running with listening to music compared to running without music ($P < 0.0001$). Moreover, heart rate recovery was notably enhanced following exercise while listening to high-tempo music ($P < 0.0001$).

Heart rate measurements in diabetic females

Baseline heart rate was 79.15 ± 0.95 before starting the exercise in diabetic females. In session I, which involved running without listening to music, the maximum heart rate value reached 120.6 ± 1.3 immediately after running (time 0), followed by a decrease to 82.4 ± 1.46 at five minutes and to 79.65 ± 1.4 at ten minutes after running. Interestingly, the maximum heart rate in the group listening to music was 135.3 ± 1.46 bpm, which was significantly increased compared to running without music ($P < 0.001$). Furthermore, in the recovery period, the heart rate declined to 80.21 ± 1.46 bpm five minutes after running with no significant difference compared to running without music. However, the heart rate value was 75.44 ± 1.31 bpm ten minutes after exercise, showing a significant decrease compared to running without music ($P = 0.03$, Figure 3).

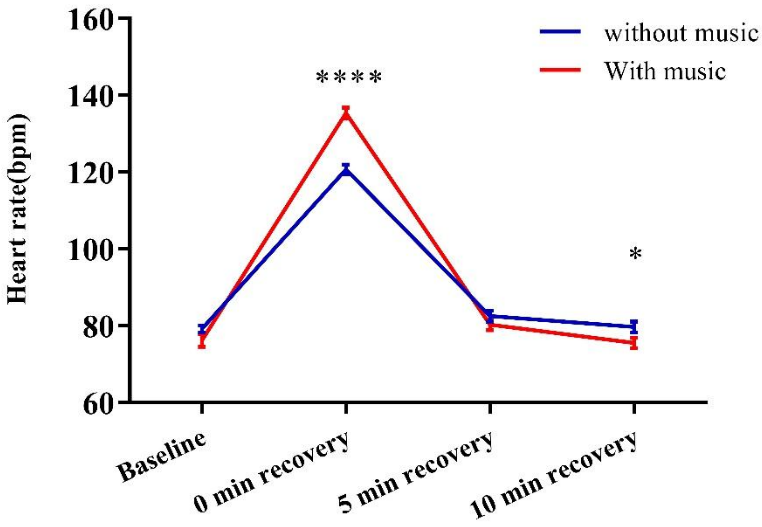

Figure 3. Heart rate values at baseline (pre-exercise) and at 0-, 5-, and 10-minutes post-exercise in diabetic females. A significant increase in heart rate after running with music, at time 0, was observed compared to running without music in diabetic females (P < 0.0001). There was no significant difference in heart rate recovery 5 minutes after exercise between running with or without music. However, 10 minutes after exercise, heart rate recovery was significantly superior in running with music compared to running without music in diabetic females (P < 0.0001).

It should be mentioned that systolic and diastolic blood pressure were measured before running and at time 0, 5, and 10 minutes after running to observe the condition of participants, which are not expressed here.

Discussion

Our findings indicate that listening to high-tempo music while exercising can increase heart rate in both healthy adults and diabetic participants. Additionally, exercise performance was notably increased with music intervention in healthy adults, while the effect was negligible in diabetic females. Moreover, heart rate recovery after running with music was enhanced in both healthy subjects and diabetic females, with a superior effect observed in the latter group.

This study sheds light on the differential effectiveness of short-term exercise accompanied by music intervention between diabetic patients and healthy individuals, providing valuable insights into personalized approaches for optimizing exercise outcomes in diverse populations.

Christopher Ballman (2021) conducted a review on the effects of music preferences during exercise in healthy subjects, revealing various impacts such as changes in oxygen uptake, cardiac output, blood flow, hormonal response, and lactate clearance (18). Notably, music listening has been shown to influence heart rate recovery after exercise, with differing results reported by researchers. Arazi et al. (2015) observed an increase in maximum heart rate during warm-up and resistance exercise without music (19). However, in line with our findings, R. Archana reported a significant decrease in sympathetic tone and heart rate after listening to high-tempo music in the resting state among medical students (20).

High-tempo music is commonly utilized during exercise to enhance physical endurance, as demonstrated in studies involving a 10-minute treadmill session for healthy subjects and during a walk test for individuals with COPD (6, 21). Additionally, research indicates that heart rate and blood pressure return to baseline values more rapidly after exercise while listening to low-tempo music compared to fast-tempo music. It is hypothesized that slow-tempo music may induce relaxation by reducing arousal levels (9, 22). Furthermore, findings from another study revealed a 10.7% increase in exercise duration and a 13% faster heart rate recovery post-exercise when accompanied by fast-tempo music, consistent with our results (12).

The effect of music on performance may vary across different exercise intensities, as demonstrated by studies examining high and low-intensity exercise with varying tempo music (23). For instance, heart rate increased by 69.56 beats per minute during high-intensity exercise accompanied by fast-tempo music, with a baseline heart rate of 78.97 ± 8.15 beats per minute (23). Additionally, some research has explored the impact of music intervention on physiological parameters such as blood glucose levels in individuals with diabetes mellitus (12). For instance, a study involving elderly diabetic patients found that listening to music during exercise for six months could improve blood circulation, reduce stress levels, and lower heart rate (24, 25).

Eseadi (2006) highlighted the positive impact of listening to music during exercise on heart rate in elderly diabetic patients (15). Similarly, in our study and in line with previous research, listening to high-tempo music during running significantly increased running distance. While the precise mechanism underlying this enhancing effect of music remains unclear, it has been suggested that high-tempo music can elevate neuroendocrine factors such as noradrenaline and beta-endorphins in plasma (26). Elevated plasma levels of noradrenaline and beta-endorphins may contribute to pain reduction and increased physical endurance (27, 28).

Rao et al. (2014) demonstrated that music intervention can have a positive effect on autonomic balance in diabetic patients (29). However, our findings indicated a higher activity of the parasympathetic nervous system in enhancing heart recovery in diabetic females. Interestingly, previous studies have highlighted the positive effects of music during exercise in various healthy and diabetic populations (29).

In a Cochrane review involving individuals with cancer, authors reported that music intervention could moderately reduce pain and slightly alleviate fatigue while improving physical activity (30). However, in contrast to these findings, our study showed that listening to music did not significantly enhance exercise performance in diabetic females, diverging from previous research.

Exercise can indeed increase sympathetic activity, circulation, heart rate, and blood pressure (15). However, its effectiveness may vary between short-term and long-term activity, as evidenced by our study's results.

Furthermore, previous research has demonstrated that the increment in heart rate and blood pressure during exercise correlates with the intensity of physical activity (31, 32). However, it's worth noting that our study did not include high-intensity exercise sessions.

During the initial minutes of rest after exercise, the parasympathetic system undergoes reactivation, leading to the fast phase of heart rate recovery along with sympathetic withdrawal. This process may subsequently induce the slow phase of heart rate recovery, aligning well with our findings (3).

Parasympathetic reactivation plays a crucial role in intensifying heart rate recovery immediately after exercise (4, 5). This compensatory mechanism is vital as it helps reduce the risk of arrhythmia during resting periods and serves as an indicator of cardiac health.

Conclusion

In summary, the findings suggest that engaging in physical activity accompanied by high-tempo music may enhance sympathetic activity and exercise performance more effectively in healthy adult females compared to those with diabetes. Conversely, for diabetic females, listening to music during exercise could promote quicker reactivation of the parasympathetic nervous system, potentially lowering the risk of cardiac arrhythmia during rest periods.

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Conflict of interest

The authors declare no competing interests.

Authors' contributions

SS contributed to the study conception and design. SS conducted the data collection, while SS and MB performed the analysis and interpretation of results. MB prepared the manuscript.

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