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Impact of Classical Music Listening on Cognitive and Functional Performances in Middle-Aged Women

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Abstract: The purpose of this study was to examine the impact of listening to classical music on functional (upper and lower body strength, functional mobility and aerobic endurance) and cognitive (attentional capacities and working memory (WM)) performances in women aged between 50 and 60 years old. A total of 24 middle-aged women were enrolled to participate in this study. Their functional and cognitive performances were assessed under two-auditory conditions (no-music vs. with music conditions) using the Timed Up and Go (TUG) test for functional mobility, the Arm Curl test and 30 s Chair Stand Tests for the upper and lower body strength, respectively, and the 2 min Step test for aerobic endurance. To assess the attentional capacities and the WM, a simple reaction time (SRT) test and Corsi Block-Tapping Task were used, respectively. As a result, we found that listening to music significantly decreased the scores of the TUG test ($p < 0.001$) and capacities ($p < 0.05$), and increased the 2 min Step test values ($p < 0.001$) compared to the no-music condition. However, no significant changes were found for the upper and lower body strength and WM. We conclude that listening to classical music, i.e., Mozart's Symphony, is effective in improving functional mobility, aerobic endurance and attentional capacities in middle-aged women. However, these gains were absent for muscle strength and WM, suggesting that the positive effects of music on functional and cognitive performances were dependent on a specific task.

Keywords: health promotion; cognitive performance; functional performance; music; midlife; women

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1. Introduction

With age, both women and men exhibit various manifestations of the aging process. These manifestations encompass self-reported visual impairment [1], a decline in postural balance and muscle strength [2,3], an elevated prevalence of chronic diseases and morbidity [4,5], and a decreased level of physical activity [6], which consequently lead to difficulties in performing daily life activities. In particular, these alterations may already start at middle age for women as a result of menopause. Menopause transition induces a significant drop in estrogen levels, linking to significant changes in cognitive [7] and physical functions for middle-aged women [8]. A decline in functional performance and cognitive function can predispose one to a significant risk of falls, fractures and functional dependence, leading to poor health-related quality of life [9]. To evaluate physical fitness, multiple test batteries, such as the Groningen Fitness Test [10], Senior Fitness Test [11], and Alpha Fit Test Battery [12] have been used. However, the Senior Fitness Test battery is the most frequently used testing battery to assess the functional abilities of an aging population, mainly women over 50 [8,13].

Interestingly, music is considered one of the most enjoyable and satisfying human activities [13]. A significant portion of people perform most of their daily tasks like cooking, driving, working or studying, in the presence of background music [14]. It has been well documented that listening to music positively influences mood, excitatory control and physical performance. Music appears to exert significant effects on psychological responses within the central nervous system [15]. A suggested mechanism of music's influence during exercise involves the increased release of excitatory neurotransmitters (e.g., serotonin and endorphin), potentially mitigating feelings of pain and exertion resulting in enhanced physical performance [16,17].

Listening to music was found to improve performance while performing different exercises such as running, cycling and treadmill tasks in athletes [15]. Additionally, previous studies revealed that music influences task performance, ratings of perceived exertion, muscular endurance and grip strength performance [18,19], suggesting that exercisers who listen to music during physical activity report less associative attention and more dissociative attention, leading to more positive affective responses, especially at submaximal exercise intensities [16,17]. Likewise, listening to classical music, i.e., Mozart's Symphony No. 41 in C major, KV 551 (Jupiter), was found to be effective in boosting postural balance performance [20,21], with a tempo of 132 (bpm) [22], leading to optimal cognitive and emotional arousal [23].

Furthermore, previous studies highlighted that music exposure can influence the brain by promoting neurogenesis, synaptic plasticity and the levels of the neurotransmitter (e.g., dopamine) [24,25]. In particular, it has been suggested that classical and familiar music is linked to increased grey and white matter volume in brain areas implicated in cognitive processing, increased functional connectivity and modulated activity in structures related to emotional regulation, reward, behavior, attention and working memory (WM) [26–28]. Similarly, classical music significantly enhanced cognitive functions including WM [29], processing speed [30], executive function and attention in the elderly [31].

While prior research indicated the positive effects of music, there is a significant gap in understanding its impact on both functional and cognitive abilities of middle-aged women. To the best of our knowledge, music's effects among these women were only investigated based on their postural performance. Indeed, Ben Waer et al. recommended listening to classical music as an effective way for middle-aged women to promote their postural performance while performing daily physical activities [20]. Given the essential role of functional and cognitive functions in maintaining independence and quality of life for middle-aged women, the current study aimed to investigate the effects of listening to classical music on both functional and cognitive performances, filling a crucial gap in our understanding. We hypothesized that listening to music would instantly promote functional and cognitive performances in these women.

2. Materials and Methods

2.1. Participants

The sample size was determined using the G*power software (version 3.1.9.2; Kiel University, Kiel, Germany) [32]. Values for α were set at 0.05 and power at 0.95. Based on the results of Waer et al. [20], a minimum of 10 participants was estimated in order to minimize the risk of Type II statistical error. Thirty-seven participants were voluntarily recruited from the general community in Romania to participate in the present study. The recruitment process involved direct advertisements and billboards placed in various public locations, such as community centers, and local markets, to ensure wide visibility. These advertisements provided information about the study's purpose, eligibility criteria, and contact details for those interested in participating. Once potential participants expressed interest, they were contacted by phone to confirm their participation and to provide further details about the study. During this phone call, all participants were checked for eligibility based on the study criteria.

The inclusion criteria were healthy women with no physical or mental illness (using a medical history questionnaire ref), physically independent, aged between 55 and 55 years and post-menopausal for at least 4 years (ensuring more stable hormone levels and less menopausal symptoms [33]), with a low physical activity level (using IPAQ [34]) and mild risk for falling (using the Self-Rated Fall Risk [35]).

Participants with grade III obesity, uncontrolled hypertension and a history of cardiovascular, neurological, metabolic disorders or ingestion of medication that can influence performance outcomes were excluded. Only eighteen participants [age: 57.4 ± 1.9 years; height: 1.58 ± 0.4 m; weight: 77.8 ± 5.2 kg] fulfilling the inclusion criteria were selected.

Participants were also thoroughly informed about both the risks and benefits associated with their voluntary participation. The communicated risks included the possibility of experiencing fatigue due to the prolonged use of headphones and engagement in study tasks, as well as the potential for the study to take more time than initially anticipated. Participants were also advised that they might experience mild discomfort from wearing headphones for extended periods. The benefits communicated included gaining insights into how music might affect their performance, contributing to scientific knowledge in this field and the potential for improved personal performance through the understanding of music's impact.

After being informed about the experimental procedures, their risks and benefits, all women agreed to participate voluntarily and signed an informed consent. This study was approved by the Ethics Committee of the Vasile Alecsandri University of Bacău (Nr. 224/2/16.01.2024) with respect to the ethical standards of the Declarations of Helsinki.

2.2. Exprimental Protocole

This study is a randomized, single-blinded, counterbalanced, crossover study design. It comprised three sessions spaced 2 days apart. These sessions were scheduled for Mondays, Wednesdays, and Fridays, respectively, from 9 a.m. to 12 a.m.

The first session was the familiarization one, during which participants took preliminary assessments to ensure eligibility for the study, and were familiarized with the tests with a short trial (about 10 s) for each task. The second two visits were the testing sessions (session 1: no-music; and session 2: with music), in which participants completed their cognitive and functional performances measurements, in two random auditory conditions: no-music (absence of auditory stimulus) and with music condition by wearing headphones. The randomness was implemented through the use of a computerized random number generator, which assigned participants to either the no-music or with-music condition in a random order for their second and third sessions, to eliminate potential order effects and biases.

Three trials were performed for each task condition with a one-minute rest in between. All trials were conducted in a random order and data were collected by the two experienced experimenters. The musical stimulus was Mozart's music, Symphony No. 41 in C major, KV 551 Jupiter with a tempo of approximately 132 beats bpm [22]. The same smartphone (Samsung Galaxy A30 (Suwon-si, Republic of Korea)) and its regular on-ear headphones, provided by the researcher, were used for all participants, with a music volume of 10/15 at an average 65 ± 5 decibel (dB)).

2.3. Functional Performance Assessment

The Rikli and Jones senior fitness testing battery [36,37] was used to evaluate the functional performance. This battery contained standard tests valid and reliable for aging populations, including women over 50 years old, such as the Arm Curl test [38], Timed Up and Go test [39], the 30 s Chair Stand Test [40,41] and the 2 min Step test [42].

2.3.1. Arm Curl Test

The Arm Curl test was used to assess the upper body muscle strength. In this test, participants were instructed to complete as many biceps curls as possible holding a hand weight of 2.27 kg during a 30 s period.

2.3.2. Timed Up and Go Test

Functional mobility was evaluated using the Timed Up and Go test. In this test, participants were required to stand from the chair, walk 3 m, and turn, and return to a seated position as quickly as possible. The time taken to complete the test is the final score.

2.3.3. Thirty-Second Chair Stand Test

This was selected to assess the lower body muscle strength. It consists of completing as many full sit-to-stand movements as possible from a seated position with arms across the chest for 30 s.

2.3.4. Two-Minute Step Test

Aerobic endurance was assessed using the 2 min Step test, in which participants need to complete as many full steps as possible in 2 min, fliting each knee halfway between the patella and the iliac crest.

2.4. Cognitive Performance Assessment

Cognitive performance was evaluated via attentional abilities and WM [43].

2.4.1. Corsi Block-Tapping Task Test

WM was measured with a computerized version of the Corsi Block-Tapping Task [44]. It is a reliable and valid test for aging populations [45]. The task featured a screen with nine 3 cm square cubes positioned at fixed, pseudorandom locations. Participants were required to scan the cubes, some of which briefly changed color and reverted to their original state, to recall their positions and to replicate at a sound signal the sequence by tapping the cubes in the correct sequential order. Initiating with the easiest level (i.e., a sequence of a single cube) and progressively the task becomes more difficult (up to a maximum of six cubes). Each level contained three trials. The reach level was recorded as the dependent variable for evaluating WM.

2.4.2. Simple Reaction Time Test

Attentional abilities were measured with a valid [46] and reliable [47] test, a simple reaction time test (SRT) using a "Superlab 4.5" program (Cerdus, San Pedro, CA, USA).

For this test, each subject was asked to sit on a comfortable chair in front of a micro-computer screen at a distance of 0.4–0.5 m. After 10 familiarization trials, each participant randomly performed 20 SRT measurements. As a starting signal, a white square appears on the screen. Each participant was then asked to press the space bar using their preferred hand as quickly as possible when a black square appeared at the center of the screen. The stimulus appeared on the screen for 50 ms. The interval between two consecutive stimuli varied randomly from 10 to 1500 ms. The score was determined by calculating the mean SRT for correct trials. SRTs of less than 150 ms and more than 800 ms were excluded from the analysis to avoid any effect of anticipation or temporary concentration.

2.5. Statistical Analysis

Statistical analyses were conducted with the STATISTICA Software (v.12.0, StatSoft, Maisons Alfort, France). The normality and the sphericity of data distribution were confirmed through the Shapiro–Wilk W and Mauchly's tests, respectively.

Functional (upper and lower body muscle strength, functional, mobility and aerobic endurance) and cognitive (SRT and WM) performances were analyzed using paired Student's *t*-test to examine the effects of music (no music condition vs. with music condition).

Additionally, effect sizes were indicated using Cohen's d ('conventional' values for small, medium and large effects, as d = 0.20, 0.50 and 0.80, respectively) [48]. Additionally, a 95% confidence interval (CI) was performed for each comparison.

Statistical significance was set at $p < 0.05$.

3. Results

3.1. Functional Performances

The paired *t*-test showed a significant main effect of music on functional mobility ($p < 0.001$, 95%CI [0.87; 1.55]) and aerobic endurance ($p < 0.001$, 95%CI [−40.36; −19.19]) with a large effect size (Tables 1 and 2). Indeed, the mean scores of the TUG and 2 min step tests were significantly improved while listening to music compared to the no-music condition (Tables 1 and 2). However, there was no significant difference in mean scores of upper and lower body muscle strengths between the with-music condition and no-music condition (Tables 1 and 2).

Table 1. Means ± SD of the mean scores of the functional [functional mobility (Timed Up and Go (TUG) test), upper (Arm Curl test) and lower (30 s Chair Stand Tests) body strength and aerobic endurance (2 min Step test)] and cognitive [attentional capacities (simple reaction time (SRT)) and working memory (WM) (Corsi Block-Tapping Task)] performances during the two auditory conditions (no-music vs. with music condition) in middle-aged women.

	No Music	With Music
Functional Performances		
TUG test (sec)	7.69 ± 0.72	6.47 ± 0.67 **
Arm Curl test (reps)	24.28 ± 5.12	24.94 ± 5.17
30 s Chair Stand test (reps)	21.28 ± 3.52	21.61 ± 3.52
2 min Step test (reps)	8.50 ±0.98	9.49 ± 1.21 **
Cognitive performances		
SRT (ms)	415.04 ± 64.98	382.39 ± 350.33 *
Corsi Block-Tapping Task (scores)	5.33 ± 0.84	5.78 ± 1.00

* Significant difference ($p < 0.01$) between no-music and Mozart's Jupiter at $p < 0.05$, ** ($p < 0.001$).

Table 2. Summary of paired *t*-test results of the functional and cognitive performances variables statistics values (F, p, η2p, 95% confidence interval (CI)) during two auditory conditions (no music vs. with music condition) in middle-aged women.

	t	*p*-Value	Cohen's d	95% CI	
				Lower Limit	Upper Limit
Functional performances					
TUG test (s)	7.58	<0.001	1.75	0.87	1.55
Arm Curl test (reps)	−1.04	0.31	0.13	−2.01	0.67
30 s Chair Stand test (reps)	−0.37	0.71	0.09	−2.22	1.55
2 min Step test (reps)	−5.93	<0.001	2.09	40.36	−19.19
Cognitive performances					
SRT (ms)	2.13	<0.05	0.57	0.42	64.86
Corsi Block-Tapping Task (scores)	−1.32	0.2	0.48	−1.15	0.26

3.2. Cognitive Performances

Our statistical results showed that music has a significant main effect on attentional capacities ($p < 0.05$, 95%CI [0.42; 64.86]) with a medium effect size (Tables 1 and 2). Indeed, in the music condition, the mean SRT scores were significantly lower compared to the no-music condition (Tables 1 and 2). However, no significant changes were found for the mean WM scores (Tables 1 and 2).

4. Discussion

Our main findings revealed that listening to classical music (Mozart's Symphony No. 41 "Jupiter" in C Major, K. 551) is effective in enhancing both functional and cognitive functions including functional mobility, aerobic endurance and attentional capacities. This is, to our knowledge, the first study investigating the impact of classical music on functional and cognitive functions among middle-aged women. One previous study examined the effect of such type of music on postural balance in this age group, concluding beneficial effects [20]. This effect is attributed to the connection between the auditory and balance systems in the peripheral receptors of the inner ear and the center nervous system [49,50]. Musical interventions have been employed in various contexts, such as before or during exercise, and have been shown to boost motivation and effort improving performance [51,52]. These improvements were explained by enhanced mood, higher exercise enjoyment and power feelings [53–55].

Similarly, it has been revealed that listening to music has positive effects on several physical performances including aerobic exercise (e.g., running, cycling), isometric exercise [56], functional strength [18,54], muscular endurance and strength performance [9,19]. Music gains were explained by the reduced perception of fatigue [57,58] and increased arousal level and neural activity while listening to music, which promotes exercise performance [59]. One potential mechanism of action of music during exercise is linked to the increased release of excitatory neurotransmitters (e.g., serotonin and endorphin), which can alleviate sensations of pain and exertion during exercise, leading to optimized physical performance [15,60].

Overall, music has been considered a motivational factor that increases exercise adherence. Indeed, listening to music can stimulate pleasant memories, resulting in an increased motivation and sensation of pleasure during exercise [61]. However, following our results, music gains were absent for the strength performance in middle-aged women. Maybe considering another type of music or selecting a better evaluative test may have different results.

Importantly, based on our statistical results, Mozart's symphony was effective in enhancing cognitive function in terms of attention capacities. Similarly, Innes et al. (2018) revealed that musical intervention (based on listening to classical ones) for 12 weeks, at a rate of 20 min/day, was beneficial for cognitive performance including (promoting executive function, attention, memory and psychomotor speed) in older adults [31]. The gains in cognitive functions thanks to music could be explained by stimulating the brain areas that are primarily associated with emotional processing and higher cognitive processes (like the limbic system and frontal lobes, respectively) [62,63]. Similarly, it has been demonstrated that exposure to music has positive effects on the brain, particularly in terms of improved neurogenesis, synaptic plasticity and the levels of neurotropes and neurotransmitters (e.g., dopamine) levels [24,25]. Previous studies suggested that listening to classical and/or familiar music can also regulate activity in brain structures involved in reward and emotional regulation, attention, behavioral responses and WM [26–28].

In contrast, our findings showed that listening to Mozart's Symphony failed to improve WM. WM tasks are often more sensitive to specific cognitive loads and may not benefit equally from classical music as tasks involving simpler or more reactive cognitive processes [64]. It has been suggested that the complexity of WM tasks required a higher degree of focus and less external stimulation [65], which could explain why no significant differences were observed in our WM test (Corsi Block-Tapping Task).

This study has some limits that need to be addressed in future research. One is that, as we hypothesized that arousal levels and mood may explain the observed performance improvements when listening to music, it would be interesting to investigate the effects of music on such parameters to confirm this hypothesis. Additionally, our sample was limited to healthy middle-aged women, making it difficult to generalize these findings to other populations, especially those with specific needs. Further investigations are needed for these groups. Given that we used only classical music as the musical stimulus, considering different types of music, such as self-selected music, rock, rap and pop would be of interest. Finally, future research should incorporate other cognitive parameters (e.g., alertness level, vigilance) and psychological parameters (e.g., mood, anxiety, depression) to obtain more comprehensive outcomes among these women.

This study has several interesting practical implications. It suggests that listening to classical music is a promising strategy for enhancing attentional abilities, functional mobility and aerobic endurance in healthy middle-aged women. Consequently, healthy middle-aged women are encouraged to listen to this type of music, particularly Mozart 's symphony, to immediately improve these performances, offering a better quality of life. However, listening to classical music failed to improve participants' muscle strength or WM. It seems that the beneficial effects of classical music on both functional and cognitive functions depend on specific performed tasks. To achieve more generalizable results, further research is needed that involves more sessions, tests that are more applicable to real-world contexts, and a longer follow-up period.

5. Conclusions

The present study revealed that listening to classical music, i.e., Mozart 's symphony, improved attentional abilities, functional mobility and aerobic endurance, in middle-aged women. Yet, these gains were absent in participants' muscle strength or WM, suggesting that the positive effects of music on functional and cognitive performances were task-specific.

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Data Availability Statement: The original contributions presented in this study are included in the article, and further inquiries can be directed to the corresponding author.

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