CHEST

The Impact of Listening to Music During a High-Intensity Exercise Endurance Test in People With COPD

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BACKGROUND: In people with COPD, dyspnea is the primary symptom limiting exercise tolerance. One approach to reducing dyspnea during exercise is through music listening. A constant speed endurance test reflects a high-intensity aerobic exercise training session, but whether listening to music affects endurance time is unknown. This study aimed to determine the effects of listening to music during a constant speed endurance test in COPD.

METHODS: Participants with COPD completed two endurance walk tests, one with and one without listening to self-selected music throughout the test. The primary outcome was the difference in endurance time between the two conditions. Heart rate, percutaneous oxygen saturation, dyspnea, and rate of perceived exertion were measured before and after each test.

RESULTS: Nineteen participants (mean [SD]: age, 71 [8] years; FEV_1, 47 [19] % predicted) completed the study. Endurance time was greater (1.10 [95% CI, 0.41-1.78] min) while listening to music (7.0 [3.1] min) than without (5.9 [2.6] min), and reduced end-test dyspnea (1.0 [95% CI, –2.80 to –1.80] units) (with music, 4.6 [1.7] units; vs without music, 5.6 [1.4] units, respectively). There was not a significant difference in heart rate, percutaneous oxygen saturation, or leg fatigue. There were no adverse events under either condition.

CONCLUSIONS: In COPD, dyspnea was less while listening to music and was accompanied by an increased tolerance of high-intensity exercise demonstrated by greater endurance time. Practically, the effect was modest but may represent an aid for exercise training of these patients.

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ABBREVIATIONS: 6MWT = 6-min walk test; HR = heart rate; MDP = Multidimensional Dyspnea Profile; PR = pulmonary rehabilitation; Spo_2 = percutaneous oxygen saturation

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Pulmonary rehabilitation (PR) reduces symptoms and improves physical capabilities as well as quality of life in people with COPD.[1,2] However, the primary deterrent to effective aerobic training is dyspnea.[3,4] These limitations can be partially overcome by desensitization approaches achieved through repeated supervised exercise sessions[5,6] or through listening to music.[7-11] In healthy individuals, listening to music during exercise reduces the ability to attend to fatigue[12]; a reduction in the conscious perception of this sensation enables an increase in exercise tolerance.[8,11] The music needs to be sufficiently arousing to compete with the mental processing of the fatigue or dyspnea stimulus to alter symptom perception.[8] Self-selection of the music tempo and genre will maximize its beneficial effects.[13]

A systematic review found that listening to music during a 6-min walk test (6MWT) increased treadmill but not ground-based walking distance.[14] During an externally paced incremental exercise test, dyspnea at comparable power levels was reduced and overall exercise time increased.[15] Endurance-based walking tests measure the duration of tolerance during high-intensity, constant power walking[16,17] and are more responsive to the effects of interventions.[18] These tests are reflective of an aerobic exercise training session prescribed as part of PR.[2,19] Information on the impact of music on exercise tolerance may inform a possible role for music listening to enhance the benefit of exercise training, but its impact on a constant speed endurance walk has not been examined. This study aimed to determine whether listening to music increased endurance time during a constant speed endurance walk in people with COPD.

Methodology

Study Design

A prospective, randomized, cross-over study design was used. The primary outcome was the time to symptom limitation (t_{limit}) determined when walking with and without music. Participants were randomly allocated to condition order, which was determined by a computer-generated randomized schedule, kept in sealed, opaque envelopes, and administered by an individual unrelated to the study.

Participants

Potential participants were recruited from the PR programs at West Park Healthcare Centre (Toronto, ON, Canada). Individuals were eligible if they met the following criteria: diagnosis of COPD with spirometric confirmation (FEV_1/FVC $<$ 70),[20] and clinical stability (no exacerbation of COPD within the previous 4 weeks). Individuals were excluded if they had a primary diagnosis other than COPD or a hearing impairment requiring hearing aids. The institution's research ethics board approved the study with written informed consent from all participants.

To "blind" participants and minimize potential expectation bias, participants were not informed as to the study purpose and the difference in testing conditions. Deception was used during the procedure. They were told that music was usually provided during the test. However, for the no-music condition they were advised that the portable device had a dead battery, was being charged and, for convenience, the test would be completed without the device.

Procedures

To determine previous use or exposure to distracting activities, participants were asked if they typically engaged in conversation; listened to the radio, podcasts, or music; or watched television. If they listened to music when exercising, they were asked what type of music was listened to. All participants attended for testing on three occasions, 1 week apart.

First Visit

Usual and Fast Walking Speeds: The initial measurements for all participants were to establish their usual and fast walking speeds (s_{usual} and s_{fast}) from a rolling start.[16,17] For this test each participant walked, unaccompanied, following the instruction to "walk at your usual pace until you reach the far marker (18 m from the start) and return at a speed you consider to be fast." Usual and fast walk speeds were measured over the middle 10 m of each 18-m walk. This procedure was repeated after a 5-min rest; the average s_{usual} and average s_{fast} were calculated. These speeds were used to set the speed for the constant speed endurance walk test,[17] designed to result in a t_{limit} between 3 and 15 min.[21]

Preliminary Constant Speed Endurance Walking Test: At the same session as above, a preliminary conditioning test, under control conditions, was completed by all participants. If the t_{limit} was not within the target of 3 to 15 min, the speed of the endurance test was adjusted by $\pm$ 10 m/min. For this test, the investigator walked at a set speed and the participant followed behind, walking for as long as he or she was able, maintaining the distance behind the investigator. The participant was given no instructions on cadence. A standardized script was used to encourage the patients to keep walking until they were no longer able to maintain the speed. The test was conducted along a 30-m, indoor, straight hallway with markers at every 5 m. The investigator maintained the target speed, guided by a beeping audio signal that occurred as each marker was passed. When the participant stopped, the endurance time was recorded.

Second and Third Visits

Participants completed two endurance walk tests, using the same procedure as the preliminary constant speed endurance walking test, one with and one without listening to music (intervention and control), in random order. The tests were undertaken on separate days within a 1-week period. Oxygen saturation and heart rate were monitored throughout the test by a forehead probe connected to a Nellcor OxiMax N-500 pulse oximeter.

Music Self-Selection: A database of various musical genres including pop, classical, country and western, and big band, with details of artists and titles, was created by a research assistant. The musical tempo of each song was determined with commercially available cadence desktop software, with the optimal tempo of 90 to 120 beats/min[14] confirmed by two investigators. Tunes, songs, and instrumental pieces meeting tempo requirements were uploaded to a portable music playlist device (iPod Nano player; Apple).

Test Protocol: The testing protocol applied the speed identified during the conditioning test as the targeted walking speed. The investigator walking ahead of the participant during the test was blinded to the condition of each test (music or no music). During the control condition, no music was provided. During the intervention condition, participants self-selected their musical preference, which was applied via the portable device for the duration of the endurance walk test. At the conclusion of each participant's study, the investigator debriefed the participant as to the study's purpose and related hypotheses. Each participant was asked the following: "Did you guess what we anticipated the effects of listening to music might have on how long you walked for or your symptoms?" Their response was recorded to indicate the success of the masking procedure.

Primary Outcome

The endurance time (t_{limit}) for each condition was determined as the time at which the participant was unable to maintain the speed despite encouragement. This was determined by a research assistant observing the test, using a stopwatch.

Secondary Outcomes

Dyspnea and degree of leg fatigue were measured using the modified Borg scale[22] before, each minute during, and immediately after the test. The participants rated their response by selecting the number that most appropriately described the symptom intensity, based on two questions. For dyspnea, participants were asked "how much difficulty is your breathing causing you right now?" with scoring on a scale of 0 (nothing at all) to 10 (maximal). For leg fatigue, participants were asked "how tired do your legs feel right now?" with scoring on a scale of 0 (nothing) to 10 (maximal). Oxygen saturation and heart rate were recorded continuously during each walking test and extracted at 1-min intervals.

The Multidimensional Dyspnea Profile (MDP) assesses dyspnea during a specific time or a particular activity (focus period),[23] and has been used in patients with COPD.[24,25] The tool provides a measure of the sensory and affective dimensions of dyspnea, by rating the intensity of various sensory and emotional responses provoked by breathlessness according to a 10-point numerical rating scale immediately on completion of each walking test.[23,24] Its psychometric properties (validity, discriminative ability, responsiveness, and reliability) have been reported.[24,25]

The Global Vigor and Affect (GVA) scale is composed of eight visual analog scales, four related to global affect (how happy do you feel?, how calm do you feel?, how sad do you feel?, and how tense do you feel?) and four related to global vigor (how alert do you feel?, how sleepy do you feel?, how much of an effort is it to do anything?, and how weary do you feel?). Each visual analog scale is a 100-mm line separating opposite extremes of the mood or state of arousal.[26] Participants reported their overall state of calm and state of alertness immediately following each walking test. It has been previously applied in patients with COPD to assess acute response to exercise.[27] Each score was summed to provide a measure of global affect and global vigor score, ranging from 0 to 100.

Data Analysis

A moderate effect size (0.6) between the music and control conditions was considered to be clinically relevant in this population in the context of endurance walking.[28] With an effect size of 0.60, a one-tailed test, with an α of 0.05 and power of 0.8, required 19 participants for this study. Differences between testing occasions were analyzed by Student *t*-test or Wilcoxon signed rank sum test, depending on data distribution. To determine the effect of music condition and time on physiologic and symptom markers, a two-way repeated measures analysis of variance was done to examine the effect of the condition and time and the interaction between the two on the dependent variables of Spo_2, HR, Borg dyspnea, and leg fatigue. α was set at 0.05.

An average response throughout exercise of the secondary parameters (Spo_2, HR, symptoms) was created using a running median smoothing algorithm (SigmaPlot version 13.0; Systat Software Inc.). Each dependent variable was resampled at five uniform intervals over the independent variable, exercise time, for each individual test. In this way, the mean time at each interval and the corresponding mean of the dependent variable could be calculated, in absolute terms, and the mean group response and variability presented.

Results

A total of 19 participants (seven men) completed the study, with all participants undertaking all walking tests (Fig 1). Their characteristics are outlined in Table 1. Five participants typically used supplemental oxygen for walking and 10 used a rollator during the walk tests. Prior to undertaking this study, 12 participants regularly engaged in a distractive activity during exercise by listening to the radio, with 11 listening to music, and one listening to music and talkback radio. Of the 11 listening to music, six participants enjoyed pop music, three listened to classical, and one each listened to country and easy listening. Successful masking of participants to the objective of the study was achieved in 55% of cases. Successful blinding of investigators during the test was achieved in 40% of cases.

There was a significant increase (1.10 [95% CI, 0.41-1.78] min) in endurance time when listening to music (7.0 [3.1] min compared to without: 5.9 [2.6] min); an effect size of 0.39. There was also a significant difference in dyspnea between conditions (1.0 [95% CI, −2.80 to −1.80] units) at the end of exercise, an effect size of 0.40. There was no difference in rating of leg fatigue (−0.2 [−0.9 to 0.3] units). Dyspnea was reduced throughout the test, with the slope of the dyspnea-by-time relationship demonstrating a significant difference between conditions (−0.2 [95% CI, −0.4 to −0.1] Borg units/min). Heart rate, Spo_2, and leg fatigue, recorded every minute, did not differ between conditions (Figs 2A-2D). According to the MDP, the overall sensory perception of breathlessness was reduced when listening to music (median, 3.2 [IQR, 2.2-5.2] with music vs 4.6 [IQR, 3.0-6.5] without music; $P = .01$). However, there was no difference in the affective domain of dyspnea with the use of music (0.4 [0.0-1.4] with music vs 0.4 [0.0-2.8] without music; $P = .28$).

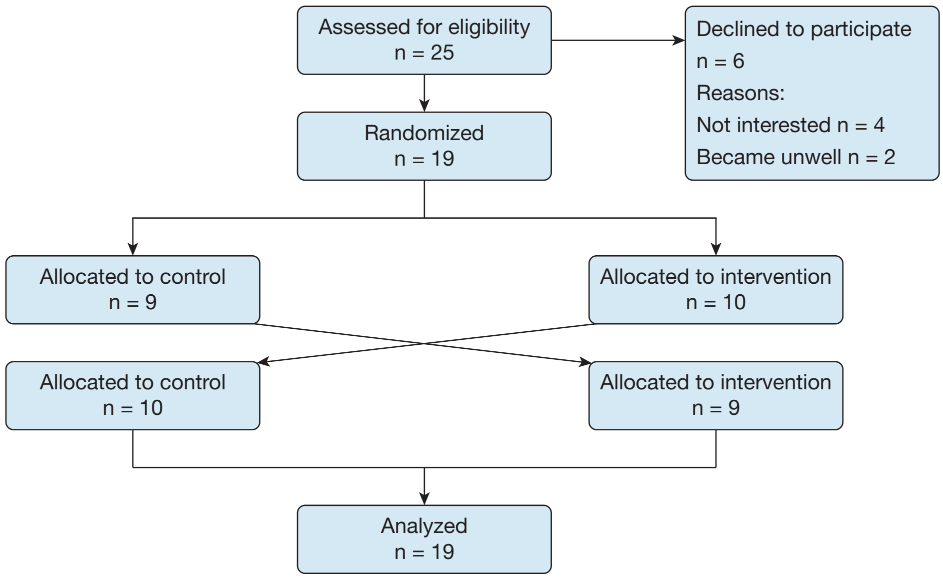

Figure 1 – *Flow of participants.*

In terms of overall affective state, participants reported feeling more calm (median, 78.7 [IQR, 52.4-54.8] vs 74.3 [IQR, 73.1-75.5]) points; $P < .001$) when using music during the walking test. However, there were no differences in level of alertness (median, 54.4 [53.4-54.8] vs 54.0 [53.1-54.4] points).

Discussion

In people with COPD, listening to self-selected music at a set cadence during a constant speed, endurance walk test increased endurance time and reduced their dyspnea during and at the end of exercise. Music did not reduce perceived exertion and had no effect on HR and oxygen saturation. There was an overall reduction in the sensory component of dyspnea. An increase in the degree of patient calmness was evident with music listening.

TABLE 1] Participant Characteristics

Demographic	Mean (SD)
Age, y	71 (8)
BMI, kg/m^2	31.9 (7.6)
Smoking, pack-years	49.3 (23.12)
FEV_1 % predicted	47.1 (19.2)
FVC % predicted	75.1 (20.2)
FEV_1/FVC	44.7 (13.1)
6MWD, m	324 (133)
Gait speed (usual), m/min	58.8 (13.9)
Gait speed (fast), m/min	73.4 (22.9)
Target speed, m/min	64.1 (19.4)

Data represent means and SD. 6MWD = 6-min walk distance.

The modest positive influence of music during constant speed (ie, power) walking was consistent with the reported 22% increase in walking during an incremental treadmill exercise test.[29] In contrast, music did not influence the distance walked in a ground-based 6MWT.[15,30,31] This may be related to the differing protocols used between tests. Thornby et al[29] increased the treadmill speed by 0.3 mi/h and elevation (0.5%) every 3 min, which would have provided an alinear increase in power throughout. For a ground-based 6MWT, instructions allow for self-pacing and symptom-based rest periods, which may encourage symptom perception and reduce the impact of the distractive effect of music[18] as well as changes in speed (power); this differs from the endurance walk test applied in the current study.

Dyspnea was reduced throughout exercise while listening to music in the current study, with a greater than 1-point, clinically significant change in the Borg dyspnea scale at the end of exercise.[32,33] Some studies report less dyspnea and lower perceived exertion with music,[15,29,34] whereas others found no difference.[30,31] Those studies reporting a reduction in dyspnea also noted an increase in walking distance.[15,29,34] Studies reporting a reduction in dyspnea also used individualized, self-selected music[15,29,34] rather than investigator-selected music, which does not cater to individual preferences[31,35]; this highlights the

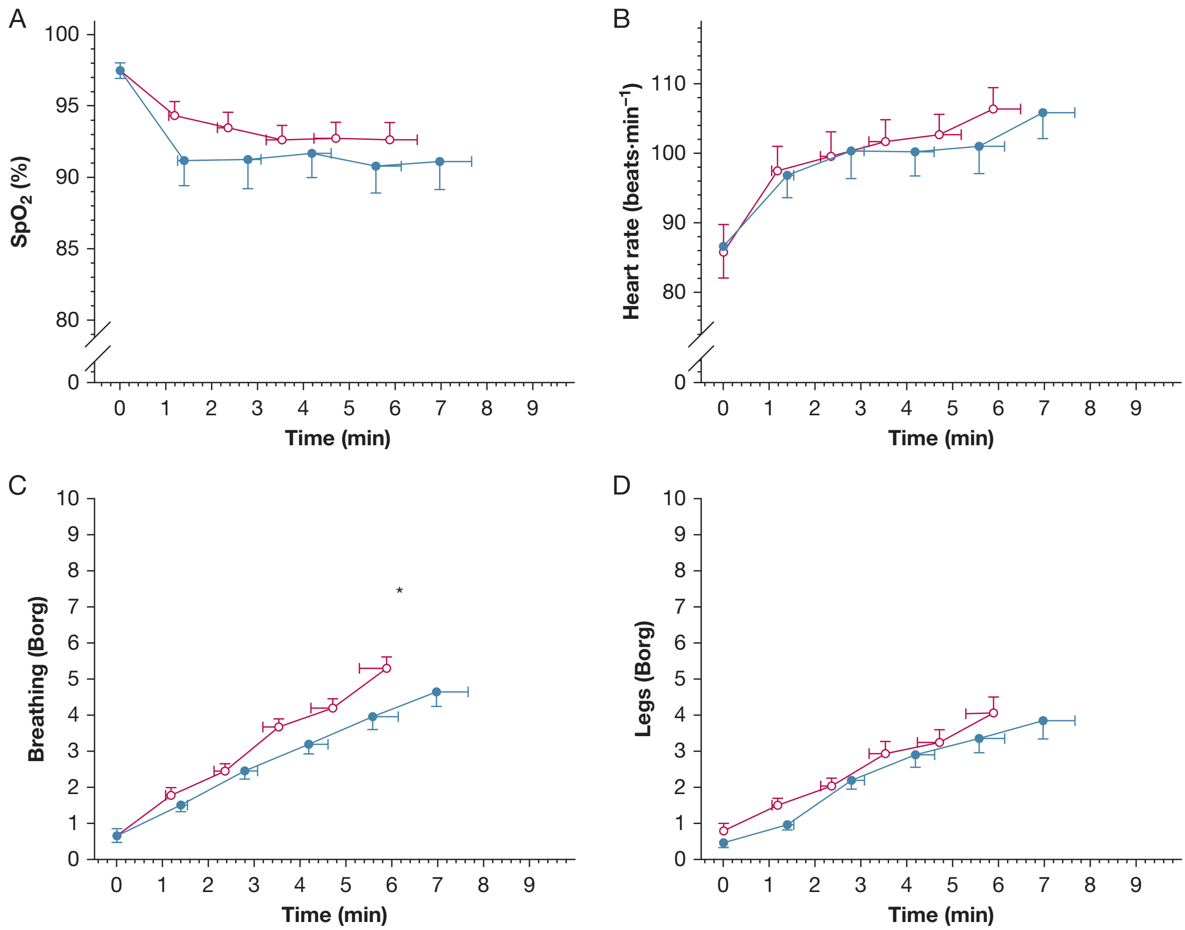

Figure 2 – *(A) Difference in* Sp_{O_2}*, (B) HR, and symptoms of (C) dyspnea and (D) leg fatigue with music (closed circles), vs without music (open circles) (*P* $< .05$*). Means and standard errors, bidirectional error bars, at equal intervals (quintiles) are the product of a running median smoothing algorithm applied to time and the independent variable of each individual test. HR = heart rate;* Sp_{O_2} *= percutaneous oxygen saturation.*

importance of autonomy in music selection to maximize effect. While unexpected, the absence of changed rating of leg fatigue despite an increased exercise time might reflect a profound ventilatory contribution to the limitation to exercise relative to the peripheral muscle contribution, a common finding in moderate to severe COPD.[36] In addition, music listening may not have moderated the sensory domain of leg fatigue. Alternatively, it could influence the affective domain of this symptom,[37] but was not captured by the modified Borg scale.

The clinical significance of a modest 1-min improvement in walking distance with music is unclear. While it is less than the 3- to 6-min improvements following several weeks of PR,[16,28] the current study was confined to a single application of music. There is potential for a greater effect with more frequent exposure to music and repeated completion of this test. Equally, it is possible that the positive effects may wear off with repeated exposures. The relative change (19%) must be put into the context of the hyperbolic relationship between walk speed and endurance time. This relationship can be simplified to a model with two parameters: critical speed and distance reserve. It is unlikely that listening to music during a single session would affect aerobic power, a target of aerobic training during PR, and effectively increase the critical power observed after PR.[16] More likely, the increasingly uncomfortable sensations during high-intensity exercise, as suggested by Puente-Maestu et al,[38] are related to the distance reserve parameter. In this scenario, an increased endurance time, at any high intensity, would be proportional to the increase in the effect on the distance reserve and consistent with relative change (19%) observed.

The reduced perception of dyspnea was not reflected by corresponding changes in HR or oxygen saturation during or at the end of the endurance walk test, suggesting that these physiologic factors were not significantly influenced during the music listening. In the absence of comprehensive measurement of cardiorespiratory responses and sensory processes of the brain during music listening, it is difficult to identify the underlying physiologic mechanisms responsible for a reduction in dyspnea and improvement in exercise time, especially without significant increase in HR and leg fatigue and decrease in oxygen saturation at the end of the exercise. With an increase in endurance time, peak HR should increase and oxygen saturation decrease unless the exercise was stopped early in the symptom progression. This appears to be the case while listening to music. A simple explanation is that the increase in endurance time was not practically great enough to affect these physiologic signals beyond the noise of natural variability or that they reached their steady state or maximum and nadir, respectively. Another explanation may be that providing an external attention focus during exercise reduces the awareness of dyspnea sensation experienced with increasing effort,[39,40] which appears to be captured with the MDP in the current study. A previous study in people with COPD reported a reduction in perception of the unpleasantness of dyspnea, without a corresponding change in Sp_{O_2} or HR, and has suggested that the influence of psychological factors on dyspnea perception may operate independently of the physiologic mechanisms.[15] Differences in perception of dyspnea intensity and distress in individuals with COPD during walking, as well as healthy volunteers undertaking cycling, have been previously reported.[41,42] In this study, while the MDP noted significant differences in sensory perception and a significantly greater level of overall calmness when listening to music, there was no difference in the affective dimension of dyspnea. The affective dimension may be influenced by the choice of music; use of a participant's own music might have evoked change in this domain. Regarding the underlying mechanisms responsible for the observed responses to music listening during this walking test in COPD, further clarity is required.

A study limitation is that no sham music intervention in the form of white noise was applied. A previous study comparing music with silence or gray noise during a treadmill walking test demonstrated a lack of difference in exercise time, change in heart rate, or level of exertion between silence and gray noise.[29] However, a three-way comparison between white or gray noise, silence, or music during the endurance walk test applied in the current study should be confirmed. Although the effect of music listening on participant mood was measured, a comparison of baseline mood prior to undertaking the two test conditions was not included. However, standardization of the test instruction and procedure, location, time of day of testing, and consistency of the test administrator provides a design in which randomization should have limited the impact of baseline mood. While there was only one test completed for each condition, previous work has established that there is no order effect with this test.[16] While including measurement of cardiorespiratory responses would provide greater knowledge regarding the underlying mechanisms, this was not the main focus of this study. These additional measurements would have been cumbersome, increasing demands on the participant and perhaps a worthwhile investment only after the presence of a significant effect of music listening is established. The influence of test administrator bias was minimized by using a standardized script for instruction and encouragement. Moreover, participants were not informed as to the purpose of the study and were provided with the possibility of listening to music during both exercise tests to avoid an expectation bias. Participants were also asked about other distraction preferences (location of exercise environment, preference for exercising with others, ability to control temperature if exercising indoors) to further minimize expectation bias. The use of self-selected music, incorporating individual preference in style and artist as well as autonomy in musical preference, is a strength in this study. This may be more important in the next phase of evaluating the impact of music during repeated training sessions. Other options for distraction during exercise training include listening to podcasts or audio books, which could be examined as part of a future study.

Listening to music during a constant ground walking speed endurance test, reflective of the type of exercise prescription applied in PR, improved endurance time and reduced the perception of dyspnea. Such information informs the possible role of music as an adjunct to exercise training during pulmonary rehabilitation for people with COPD.

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