The effect of rhythmic musical training on healthy older adults’ gait and cognitive function

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ABSTRACT

Purpose of the study: Older adults’ gait is disturbed when a demanding secondary cognitive task is added. Gait training has been shown to improve older adults’ walking performance but it is not clear how training affects their cognitive performance. This study examined the impact on gait, in terms of cost or benefit to cognitive performance, of training healthy older adults to walk to a rhythmic musical beat.

Design and Methods: In a mixed model design, forty-five healthy older adults over 65 years of age (M = 71.7 years) were randomly assigned to three groups. One group received a rhythmic musical training (MT) and their dual-task walking and cognitive performances were compared with a group who had music playing in the background (MP) but no training, and a third group who heard no music and received no training (NM). Outcomes in single (ST) and dual-task (DT) conditions were step-time variability and velocity for gait and correct cognitive responses for the cognitive task.

Results: The musical training group’s step-time variability improved in both the ST ($P < .05$) and in the DT ($P < .05$) after training, without adversely affecting their cognitive performance. No change was seen in the control groups.

Implications: Rhythmic musical training can improve gait steadiness in healthy older adults with no negative impact on concurrent cognitive functioning. This could potentially enhance ‘postural reserve’ and reduce fall risk.

Key terms: attention; dual-task; musical-training; cognition
Introduction

The ability to carry out two tasks simultaneously is achieved by efficient allocation of attention to both activities. Allocating attention is an executive function carried out within working memory (Baddeley, 1986) the system that oversees aspects of higher-level cognitive function (Coolidge & Wynn, 2005). The dual-task paradigm provides a means of examining the allocation of attention when carrying out two tasks simultaneously, by comparing the impact on performance relative to carrying out the two tasks singly (Baddeley & Hitch, 1974). There is almost always a ‘cost’, known as the dual task deficit (DTD) of dividing attention between two tasks no matter how ‘simple’ they are (Smith & Kosslyn, 2007).

Walking is a well-practised motor-action that involves some element of attention, but with increasing age, it becomes less automatic and more attention is required (Dubost et al., 2006; Lindenberger & Baltes, 2000). This is even more pronounced when walking is combined with a second activity such as talking. Decreased ability to allocate attention when carrying out two tasks, such as walking and talking simultaneously may be a marker of cognitive decline (Yogev-Seligmann, Rotem-Galili, Dickstein, Giladi & Hausdorff 2012a). It has been suggested that healthy older adults unconsciously adopt a ‘posture first’ strategy when simultaneously walking and carrying out a cognitively demanding task (Shumway-Cook, Woollacott, Kerns & Baldwin, 1997). That is, they naturally default to attending more to their gait than to the cognitive task, presumably to ensure their gait (Yoge-Seligmann et al., 2010). As such, reduced ability to effectively allocate attention can be detrimental to posture and balance, increasing the risk of falls (Siu, Choua, Mayrb, van Donkelaara & Woollacott, 2009).

When the cognitive load becomes very demanding, gait stability (which includes a measure of step-to-step variability) suffers (Hausdorff, 2005). This is important because dual-task situations, such as walking and talking, are common in everyday life. Finding ways to
improve older adults’ attention allocation could be beneficial both for ensuring gait stability and enhancing ‘postural reserve’, which is an individual’s ability to respond effectively to a postural threat (Yoge-Seligmann, Hausdorff & Giladi, 2012b).

Interventions to improve attention-allocation when walking and carrying out a cognitive task have been developed for people with Parkinson’s disease (PD). Some have shown that training older adults with PD to optimise their division of attention when walking and carrying out another activity can benefit their gait (Yoge-Seligmann, Giladi, Brozgol & Hausdorff, 2012c). Others demonstrate that rhythmic movement training increases gait regularity and automaticity, which, in turn, is linked to increased gait safety plus a reduction in fall risk (Bridenbaugh & Kressig, 2010). Auditory cues, sometimes embedded in music, have been particularly successful at training older adults with PD to walk more steadily (Rochester, Burn, Woods, Godwin & Nieuwboer, 2009; Satoh & Kuzuhara, 2008; Thaut, McIntosh, Rice, Miller & Rathbun, 1996; Trombetti et al., 2011). Matching auditory cues to their preferred walking pace optimises steady gait in people with PD (Arias & Cudeiro, 2008; de Bruin et al., 2010).

Improving gait steadiness could also benefit healthy older adults who do not currently have a gait or cognitive disorder. Training older adults to walk more steadily by making gait more rhythmic and automatic so that it requires less mental effort could free attentional resources, which potentially could be transferred to carrying out a secondary cognitive task (Luszcz, 2011; Moors & Houwer, 2006; Yoge-Seligmann, Hausdorff & Giladi, 2008).
**Methods**

**Ethics**

The study was approved by the University of St Andrews Teaching and Research Ethics Committee (UTREC). Participants had the opportunity to raise questions about the study before providing signed consent to participate.

**Participants**

Forty-five participants (28 women, 17 men), aged between 65-88 years (mean 71.7 years) were recruited. Inclusion criteria were physically and cognitively healthy adults over 65 years, able to walk unassisted, living independently and speaking English as a first language. They were assigned to one of three groups: the first 15 to a Musical Training group (MT; \( n = 15 \)), the next 15 to a Music Playing group (MP; \( n = 15 \)) and the final 15 to a No Music group (NM; \( n = 15 \)).

**Design**

The experiment used a mixed model design. The independent variables were time (pre- vs. post-intervention training) and group (MT vs. MP vs. NM). The dependent variables for gait were step-time variability and velocity in both single (ST) and dual task (DT) conditions. The dependent variable for cognition was the number of Correct Cognitive Responses (CCR).

**Materials**

A demographic questionnaire was constructed to collect self-reported health, mood and lifestyle measures. A battery of norm-referenced cognitive measures was assembled to provide a baseline assessment of participants’ functioning, including memory and executive functions (Table 1).
Equipment

The ‘Bigfoot’ footswitches and connected software were developed in the School of Psychology at the University of St Andrews. Bluetooth technology, housed in a PC ‘mouse’ in a box attached to the participant’s waist, was used to measure mean step-time, velocity, number of steps and step-time variability via two footswitches which were fastened to their heels with ‘Velcro’ strips and attached by wires to the box containing the ‘mouse’. The ‘Bigfoot’ equipment had previously been validated against video recording equipment and a stopwatch to measure CV and velocity (Maclean & Astell, 2012).

The music chosen for training was the ‘Bluebell Polka’, which has a 2/4 rhythm (two strong beats to each bar). The preferred walking pace of each of the participants in the Music Training and the Music Playing Groups was matched to the music using the ‘Amazing Slow Downer’ downloaded from www.ronimusic.com This software allowed the timing of the selected music to be slowed down or quickened from the 100% pace set on the original programme. The adjusted music was placed on a ‘loop’ and played continuously. The researcher could then mute and unmute the music at will, depending on the experimental condition.

Procedure

Participants were asked to attend wearing comfortable, flat shoes. Each participant first completed the demographic questionnaire, cognitive test battery and BDI. Participants then completed a short balance and mobility battery. They were then asked to walk along a 15m indoor walkway twice at their self-selected pace. The walkway was a flat corridor marked off
at either end with tape indicating the 15m walk plus 1m at either end to allow for acceleration and deceleration. The ST time and number of steps were averaged and used to adjust the pre-selected music to the participant’s preferred walking pace.

The ST cognitive condition was a one-minute seated test in which participants performed a Serial 7s test from a randomly generated three-digit number. They were allowed to practice and only the second score was recorded. The ST test was counter-balanced between the start and end of the experiment, for each group, to minimize possible practice effects during the DT.

In the pre-intervention DT participants in all groups walked at their own pace whilst subtracting 7s out loud (DT) from an initial three digit figure, which was randomly generated for each DT condition. The DT walking conditions were carried out twice so that participants could practice the secondary cognitive task, with data from the second task recorded. The initial ST walking conditions were considered to be practice for the other pre and post–intervention ST walking conditions. All of the cognitive tasks (both ST and DT, practice and recorded) started with different 3-digit numbers.

Musical Training
The Musical Training Group was instructed to walk in time to the adjusted music. Participants were not told that the music had been adjusted to suit their preferred walking pace. Each participant walked up and down the 15m until they felt that they were walking naturally in time to the music. If clarification was required, they were told to walk in time to the music, until they were no longer thinking about the music or the walking. Participants in the MT group walked an average of 4 times until they felt they were walking comfortably to the music ‘without having to think about it’. The post-intervention conditions consisted of a
ST 15m walk with the adjusted music playing, followed by a DT 15m walk with the adjusted music playing.

The Music Playing Group carried out all the same conditions as the Musical Training Group without being trained to walk to the music. This group was told that there would be music playing in the background, but were not instructed to walk to the music. The same intervention (15 metres x 4 times) was used for this group as for the MT Group and, like the MT group, these participants were not told that the music had been adjusted to suit their preferred walking pace.

The No Music Group completed all the same conditions as the other two groups but there was no music playing throughout the experiment.

Each group completed the walking conditions in the same order to ensure everyone experienced the 4 x 15 metre walks at the same point in the experiment. The main gait parameters measured over 15m were: mean step-time (ms) variability, expressed as Coefficient of Variation (CV = M/SD) in ms and velocity expressed as m/s. The main cognitive parameters for each DT were: participants’ correct responses per second (calculated as the total number of responses divided by the time of each walk, multiplied by the proportion of correct answers to the total number of answers, thereby accounting for number of errors made) and number of steps taken per cognitive response, as a measure of the pace at which participants simultaneously walked and counted.

Statistical analyses

Responses to the questionnaires and standardised cognitive tests were scored and compared between groups using parametric analyses. Descriptive statistics indicated that the gait data were non-parametric. The Kruskal-Wallis was used to test for group effect and the Mann-Whitney (post-hoc) test was used to test for differences between pairs of conditions across the
groups. Wilcoxon signed-rank (post-hoc) test was used to compare results between pairs of conditions within groups. The statistical significance for the experiment was set at 0.05. Effect sizes were calculated and reported as $r$ values. Using G*Power Version 3.1, we calculated that 45 participants would be needed in this experiment, giving 0.8 power to detect a large effect size of 0.5.

**Results**

The 45 older adults were healthy, with the majority reporting only one age-related health condition plus very small numbers of hospital visits in the past twelve months alongside high self-reported general satisfaction with their health (Table 2). Eighteen out of the forty-five participants had never smoked, 29/45 reported a moderate level of alcohol intake (less than 7 units of alcohol per week) and 16/45 had a normal Body Mass Index (BMI: Table 2). Forty-one out of forty-five, walked every day and 43/45 self-reported being cognitively and physically active more than three times a week (Table 2). On the mobility measures, 12 out of the 45 healthy older adults, 4 in the MT group, 3 in the MP group and 5 in the NM group, chose not to attempt the heel-to-toe walk. This has previously been taken as an indicator of a fear of falling (Nakamura, Holm &Wilson, 1999), but closer inspection of the falls history of these 12 participants did not support this concern. Indeed, 9 of the 12 had had no falls in the previous year, 1 had had one fall and 2 had more than one fall. Additionally, another 8 people of the remaining 33 reported one or more falls in the past 12 months but they did not decline to complete the heel-to-toe walk.

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Insert Table 2 about here
The participants’ self-reported cognitive function was supported by their performance on the battery of cognitive measures (Table 2). All 45 participants were in the normal range of global cognitive function as measured by the MMSE and their pre-morbid IQs suggested they were an above average sample. None was suffering from depression as measured by the BDI (Table 2).

Cognition
Before training the three groups performed similarly at counting backwards in 7s both singly and when walking and counting (Table 3). Although the intervention training did not improve the MT group’s cognitive performance in the dual task, as it was expected to do, the MT group’s DT cognitive scores did not decrease as a result of the musical training’s impact on gait. The MP and NM groups also showed no change in their DT cognitive performance after the intervention.

Gait
In the dual-task condition, all three groups showed a significant dual-task deficit (DTD) in velocity in the pre-training conditions (Table 3; pre-training MT group $P < .05$, $r = -.52$, MP group $P < .001$, $r = -.62$, NM group $< .001$, $r = -.62$. In the post-training conditions the MP group $P < .001$, $r = -.61$ and the NM group $< .001$, $r = -.59$ had a DTD but the MT group’s post-training DT speed ($M = 1.08$) was not significantly different from the ST post-training performance ($M = 1.09$) $P > 0.05$. That is, after intervention training, the MP and the NM groups’ dual-task ‘cost’ was that both groups walked more slowly when performing the gait and cognitive tasks together, relative to when they walked without counting, but the MT group who, after training, showed no DT deficit speed, relative to the same ST condition.

Gait stability was examined by looking at CV of step-time variability between groups. At baseline, i.e. before training, the MT group’s CV ($Mdn = .130$) was significantly higher
(more unsteady) in both the ST (U = 53.5, P < .05, r = -.44) and DT (Mdn = .280; U = 49.5, P < .05, r = -.48) conditions than the MP group (Mdn = .050) (Table 3). The MT group’s gait was not significantly less steady than the NM group at baseline. After training, the step-time variability of the Musical Training group (Mdn = 0.130) improved significantly in the ST (Mdn = 0.060; T = 0, P < .05, r = -.62) whereas there was no significant change in CV in either the MP or NM groups’ dual-task step-time variability compared to the ST (Table 3).

The CV of the MT group in the DT condition also improved significantly after training (T = 16.5, P < .05, r = -.41; Table 3), whereas there was no change in either of the other two groups. The improvement in the MT group was such that after training, their gait became steadier in the DT (Mdn = 0.07) than it had been in the ST at baseline (Mdn = 0.13), when the walking task was performed alone. The significant improvement in DT CV was produced at no ‘cost’ to DT cognition, i.e. there was no decline in performance on the secondary cognitive task in the DT condition (Table 3).

Insert Table 3 about here

Insert Figure 1 about here

Attention Allocation

The magnitude of pre- to post-intervention change in step-time variability (CV) in the ST and DT conditions was compared between groups (Table 3). This revealed a significant group difference in the DT H (2) = 8.14, P < .05. Post hoc tests revealed that the MT group’s CV improved significantly more from pre- to post-training DT performance than either the MP group (U = 58, P < .05, r = -.34,) or the NM group (U = 55, P <.05, r = -.36; Figure 1).
To assess whether musical training freed up attention during the DT, we examined the percentage improvement or decline associated with the MT group’s ST and DT pre- and post-intervention training performances to provide a proxy measure of mental effort. The MT group’s gait variability in the ST (pre- to post-training) improved by 38.9% after musical training whereas it improved by 53.1% in the DT after musical training, with no concurrent detrimental effect to the performance in the cognitive task (Figure 2). If the amount of effort applied to gait is constant across the ST and DT, then the difference between the two conditions, 14.2%, could be seen as a measure of the participants’ mental effort in the DT that went on the secondary cognitive task (Figure 2).

The MT group’s pre-training gait in the DT was 43.7% less steady than in the ST (DTD). After training, it was only 26.7% less steady in the DT than in the ST (DTD). The steadier gait in the DT post-training suggests that 17% mental effort (the difference between ST-DT pre-training and ST-DT post-training performances) was ‘released’ by the musical training and re-directed back to gait. (Figure 2).

Discussion

As predicted, the gait of the musical training (MT group) became steadier after the intervention training, as demonstrated by a significant improvement in CV between pre- and post-training conditions in both the single and dual tasks and no DTD in velocity after intervention training. In other words, gait velocity after training did not decline in the DT relative to the ST. These two results for gait cannot be attributed simply to hearing music, as there was no change in the gait of the MP group who had music playing in the background as they walked and counted. The results also cannot be explained as a practice effect as there
was no improvement in the gait of the NM group who completed the walking and counting conditions with no music playing. Moreover, the only change in gait between ST and DT, pre to post-training, across the three groups, was the improvement in the MT group’s DT step-time variability (CV), which became steadier in the DT than in the initial baseline ST. At baseline the MT group’s CV gait was less steady in both the ST and DT pre-training stages than the other two groups, reflecting the variable nature of gait. This is also seen in the non-normal distribution of scores found in all of the gait conditions, which reflect the variability of gait speed and steadiness between individuals (Hausdorff, 2005).

The results indicated that the MT group was a group of older community-dwellers, with no known physical or cognitive impairments, randomly selected and allocated to experimental groups and, as such, constitute a representative sample. Taken together, these results suggest that musical intervention training improves gait stability, whilst having music playing (controlling for the musical rhythm) and simply walking (controlling for the music) as interventions have no effect on steadiness of gait. We anticipated that if musical training improved gait stability by making it more automatic, this would free up controlled attentional processing, which could in turn be transferred to performance of the more difficult cognitive task (Schneider & Shiffrin, 1997). Between the pre- and post-training conditions, there was no significant difference in the cognitive performance of the MT group, demonstrating neither decline nor improvement as their gait became steadier.

Finding a way to quantifying the mental effort exerted on either the walking or the secondary cognitive task is a major challenge (Yoge-Seligmann et al., 2012a). It may be possible to examine this by measuring the magnitude of change between pairs of conditions. Looking at the group that showed significant change after training (MT group), we can make two observations about the magnitude of change between pairs of conditions. Firstly, the difference between the ST pre- and ST post-training conditions suggests that the musical
training ‘saves’ 38.9% mental effort when walking. The size of improvement between the DT pre and DT post-training conditions suggest that 53.1% of mental effort is saved by musical training when walking and counting. The difference between the two ‘savings’ indicates that 14.2% of mental effort was used to count in the DT. Secondly, the improvement between the ST pre-intervention (walking only) and the DT pre-intervention (walking and counting) and ST post-intervention (walking to music) and DT post-intervention (walking and counting to music) gait variability demonstrates that the MT group had 17% extra mental effort to spare, due to the musical training, which could have been used for the cognitive task but wasn’t. This suggests that the freed-up attention (17%) was not automatically allocated to the cognitive task but possibly, unconsciously, re-directed to the primary walking task.

There are two possible explanations for the Musical Training group’s correct cognitive responses (CCR) remaining unaffected by the musical training. Firstly, during the DT, the MT group participants, had reached their cognitive performance ceiling (Tehan & Mills, 2007) and no amount of freed-up attention could have increased the number of cognitive responses produced by them. We suggest, therefore, that the extra attention freed by the intervention training, for the MT group, was unconsciously allocated back to gait. An alternative suggestion is that the MT group, being cognitively healthy, would naturally adopt a posture first strategy in any situation where gait was threatened. In this case, it is possible that, because the cognitive task was demanding, the threat to gait was maintained in the DT and any extra attention, freed-up by the musical training and which might have produced an improvement in CCRs, was, instead, unconsciously allocated to improve gait stability. This added attention to gait could be what was observed in the MT group’s improved DT post-intervention CV.
We also anticipated that the cognitive performance of the two groups who did not receive music training would remain unchanged and this was the case. Since their gait did not become any steadier either, this suggests that they were unaffected by the experimental intervention.

Current understanding of gait suggests that it depends on the integrity of various aspects of cognition, particularly the higher-level executive functions of which attention-allocation is one (van Iersel, Kessels, Bloem, Verbeek & Olde-Rikkert, 2008). Working memory regulates the attentional flow, which allows gait to be either consciously under control (‘effortful’) or unconsciously automatic (‘effortless’) (Schneider & Shiffrin, 1997; Stuart-Hamilton, 2012). The MT group’s improved gait performance suggests that rhythmic training may tap into the ability of the working memory to flexibly process demands for attention and allocate it according to a changing situation, for example when a secondary cognitive task becomes more demanding (Baddeley, 1996; Yogev-Seligmann et al., 2008). Our findings support the suggestion that walking while listening to music may render gait more ‘automatic’ for healthy older adults who would usually unconsciously favour gait in a DT.

The performance outcomes from this group of physically and cognitively healthy older adults have relevance both for other healthy older adults and those with impairment in gait and/or cognition. In the first case, ‘postural reserve’ is an important factor affecting task prioritisation during gait and cognition and which also decreases with age and disease. Improving healthy older adults’ gait by making it more rhythmic through musical training, whilst maintaining cognitive capability, could result in enhanced postural reserve. Secondly, if musical training frees up attention, this could be beneficial to older adults with cognitive impairment, who naturally adopt a ‘posture second’ strategy, whereby they allocate attention equally to gait and cognition, thus increasing their risk of falling (Bloem, Grimbergen, van Dijk & Munneke, 2006). Therefore, musical training to make gait more rhythmic could be a
preventative intervention for fall risk for older adults who are adversely affected by ‘walking when talking’ (Lundin-Olsson, Nyberg & Gustafson, 1997).

This experiment was conducted in a controlled environment over a flat surface, with healthy older adults, but it has the potential to be applicable to in a more ecologically valid and complex environment, such as outdoors or in the home. Further research is required to establish the practical application and therapeutic value to practitioners of these findings.

**FUNDING**

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REFERENCES


### Table 1

**Description of Baseline Cognitive and Mood Tests**

<table>
<thead>
<tr>
<th>Cognitive Test</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mini-Mental State Examination (MMSE) (Folstein, Folstein &amp; McHugh, 1975)</td>
<td>The MMSE provides a brief measure of global cognitive function that is scored out of 30 with norm-referenced adjustments for participants over 80 years of age (Spreen &amp; Strauss, 1998).</td>
</tr>
<tr>
<td>Trail Making Test A and B (TMT A &amp; TMT B: AITB, 1944 (Reitan &amp; Wolfson, 1993)</td>
<td>TMT A and B provide a measure of executive functions assessed through speed in seconds to complete both parts (Delta TMT – B minus A).</td>
</tr>
<tr>
<td>Symbol Digits Modalities Test (SDMT) (Smith, 1982)</td>
<td>SDMT provides a measure of processing speed where participants match as many numbers to symbols as possible in 90 seconds.</td>
</tr>
<tr>
<td>Digit Span Forwards and Backwards (DS/F &amp; DS/B) (Thorndike, Hagen &amp; Sattle, 1987)</td>
<td>These tasks provide a measure of Working Memory by repeating short strings of numbers both forwards and backwards. The score is based on the number of items correctly repeated</td>
</tr>
<tr>
<td>Test Name</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Immediate and Delayed Story Recall</td>
<td>Story Recall provides a measure of episodic memory by asking participants to recall immediately and after a 30-minute delay story as much detail as possible from a story read aloud to them. Scoring comprises total number of ideas correctly recalled immediately out of 25 and the percentage of ideas recalled after the delay.</td>
</tr>
<tr>
<td>(Wechsler, 1987)</td>
<td></td>
</tr>
<tr>
<td>National Adult Reading Test - 2nd Edition</td>
<td>The NART provides a measure of estimated pre-morbid intelligence through reading a list of progressively difficult and phonetically irregular English words. The total number of errors is converted to a Full Scale IQ equivalent.</td>
</tr>
<tr>
<td>(Nelson &amp; Willison, 1991)</td>
<td></td>
</tr>
<tr>
<td>Beck Depression Index (BDI) (Beck, Steer &amp; Brown, 1996)</td>
<td>The BDI screens for the presence of clinical depression, where scores above 13 indicate clinically significant problems.</td>
</tr>
</tbody>
</table>
Table 2

*Participant Demographic Characteristics and Physical and Cognitive Functions at Baseline*

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Music Training Group</th>
<th>Music Playing Group</th>
<th>No Music Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Participants</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Gender (male/female)</td>
<td>4/11</td>
<td>6/9</td>
<td>7/8</td>
</tr>
<tr>
<td>Age (years)</td>
<td>73.2 (±5.36)</td>
<td>69.1 (±3.37)</td>
<td>72.9 (±6.490)</td>
</tr>
<tr>
<td>Self-reported chronic medical conditions</td>
<td>1.67</td>
<td>1.53</td>
<td>2</td>
</tr>
<tr>
<td>Self-reported nights in hospital in previous year</td>
<td>1.13</td>
<td>1.07</td>
<td>1.07</td>
</tr>
<tr>
<td>Self-reported falls in previous year</td>
<td>1.33</td>
<td>1.2</td>
<td>0.53</td>
</tr>
<tr>
<td>Never Smoked</td>
<td>3/15</td>
<td>6/15</td>
<td>9/15</td>
</tr>
<tr>
<td>Less than 7 units of alcohol a week</td>
<td>7/15</td>
<td>6/15</td>
<td>11/15</td>
</tr>
<tr>
<td>BMI indicates overweight or obese</td>
<td>9/15</td>
<td>11/15</td>
<td>9/15</td>
</tr>
<tr>
<td>Walking every day</td>
<td>14/15</td>
<td>13/15</td>
<td>14/15</td>
</tr>
<tr>
<td>Cognitive activities at least 3 times/week</td>
<td>14/15</td>
<td>15/15</td>
<td>14/14</td>
</tr>
<tr>
<td>Exercise at least 3 times a week</td>
<td>15/15</td>
<td>13/15</td>
<td>15/15</td>
</tr>
<tr>
<td>Satisfied with health status</td>
<td>14/15</td>
<td>13/15</td>
<td>10/15</td>
</tr>
<tr>
<td>Number of complete stand-up/sit-downs</td>
<td>9.35 (± 2.12)*</td>
<td>12.17 (±2.89)</td>
<td>11.83 (±4.02)</td>
</tr>
<tr>
<td>Time taken in Heel-To-Toe Walk</td>
<td>42.32 (± 9.87)</td>
<td>48.84 (± 19.48)</td>
<td>55.45(±18.61)</td>
</tr>
<tr>
<td>Measure</td>
<td>MT (10/14)</td>
<td>NT (12/15)</td>
<td>MP (10/15)</td>
</tr>
<tr>
<td>---------------------------------------------</td>
<td>------------------</td>
<td>------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>Number who completed Heel-To-Toe walk</td>
<td>10/14</td>
<td>12/15</td>
<td>10/15</td>
</tr>
<tr>
<td>Balance on one leg time (seconds)</td>
<td>15.54 (±10.5)</td>
<td>20.99 (±9.9)</td>
<td>19.29 (±11.06)</td>
</tr>
<tr>
<td>Mini Mental State Examination</td>
<td>28.4 (±1.18)</td>
<td>29.1 (±1.28)</td>
<td>28.7 (±1.83)</td>
</tr>
<tr>
<td>Beck’s Depression Inventory</td>
<td>1.2 (±1.38)</td>
<td>1.33 (±1.98)</td>
<td>0.47 (±0.74)</td>
</tr>
<tr>
<td>Estimated Pre-Morbid IQ</td>
<td>119.6 (±4.32)</td>
<td>117.33 (±5.52)</td>
<td>117.5 (±7.72)</td>
</tr>
<tr>
<td>Digit Score/Forwards</td>
<td>10.6 (±2.09)</td>
<td>10.4 (±2.7)</td>
<td>10.6 (±2.6)</td>
</tr>
<tr>
<td>Digit Score/Backwards</td>
<td>6.87 (±1.8)</td>
<td>8.2 (±2.4)</td>
<td>8.6 (±2.9)</td>
</tr>
<tr>
<td>Delta/Trail Making Test</td>
<td>50.5 (±28.3)</td>
<td>48.1 (±25.4)</td>
<td>34.1 (±19.3)</td>
</tr>
<tr>
<td>Symbol Digit Modalities Test</td>
<td>39.9 (±7.2)</td>
<td>43.6 (±10.8)</td>
<td>47.0 (±9.3)</td>
</tr>
<tr>
<td>Immediate Recall (Story)</td>
<td>11.1 (±3.8)</td>
<td>11.4 (±2.92)</td>
<td>9.9 (±5.3)</td>
</tr>
<tr>
<td>Delayed Recall (% of Immediate Recall)</td>
<td>94.3 (±14.6)</td>
<td>102.8 (±13.9)</td>
<td>83.9 (±26.6)**</td>
</tr>
</tbody>
</table>

#Values are mean (± Standard Deviation)

* Significant difference between the MT and the MP group, \( p < .05 \)

**Significant difference between NM and MP groups, \( p < .05 \)
Table 3.  
**Group Performance in Gait and Cognition Tasks – Single and Dual Task, Pre and Post-Intervention Training**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Music Training Group (n = 15)</th>
<th>Music Playing Group (n = 15)</th>
<th>No Music Group (n = 15)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Median (range)</td>
<td>Median (range)</td>
<td>Median (range)</td>
</tr>
<tr>
<td></td>
<td>Single Task</td>
<td>Dual Task</td>
<td>Single Task</td>
</tr>
<tr>
<td>Velocity</td>
<td>Pre-Trg</td>
<td>Post-Trg</td>
<td>Pre-Trg</td>
</tr>
<tr>
<td></td>
<td>1.22 (.77)</td>
<td>1.09 (.87)</td>
<td>1.06 (;)</td>
</tr>
<tr>
<td></td>
<td>1.15 (; ;)</td>
<td>1.16 (; ;)</td>
<td>1.25 (.83)</td>
</tr>
<tr>
<td>Step-time variability</td>
<td>Pre-Trg</td>
<td>Post-Trg</td>
<td>Pre-Trg</td>
</tr>
<tr>
<td>CV</td>
<td>0.130 (;)</td>
<td>0.060 (;)</td>
<td>0.282 (;)</td>
</tr>
<tr>
<td></td>
<td>(.62)</td>
<td>(.61)</td>
<td>(.99)</td>
</tr>
<tr>
<td>Correct Responses</td>
<td>Pre-Trg</td>
<td>Post-Trg</td>
<td>Pre-Trg</td>
</tr>
<tr>
<td></td>
<td>0.324 (1.15)</td>
<td>0.352 (1.15)</td>
<td>0.323 (1.28)</td>
</tr>
<tr>
<td></td>
<td>0.361 (.56)</td>
<td>0.348 (.65)</td>
<td>0.296 (.60)</td>
</tr>
</tbody>
</table>

‡ Significant change from ST to DT, *P < .05*  
‡‡ † Significant changes from ST to DT, *P < .001*  
† ‡ Significant difference between MT’s ST pre-training CV and MP group’s ST pre-training CV, *P < .05*  
§ † Significant difference between MT’s DT pre-training CV and MP and NP groups’ DT pre-training CV, *P < .01*  
* * † Significant change from ST pre to post-training, *P < .05*  
* * * † Significant change from DT pre to post-training, *P < .05*
Figure 1. Changes across groups between median DT pre and post-training step-time variability

*Change significant at $P<.05$

ms = milliseconds

CV = Coefficient of Variation (Standard Deviation/Mean)
Figure 2. The musical training group’s median step-time variability in ST and DT, pre and post-training walking conditions.

CV = Coefficient of Variation (Standard Deviation/Mean)

ms = milliseconds