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Dual-task Zumba Gold for improving the cognition of people with mild cognitive impairment: A pilot randomized controlled trial

Laurence Lloyd Parial, MA,[1,2] Patrick Pui Kin Kor, PhD,[1] Earl Francis Sumile, PhD,[3] Angela Yee Man Leung, PhD,[1,4*]

[1]Centre for Gerontological Nursing, School of Nursing, Hong Kong Polytechnic University, Hong Kong SAR, China

[2]College of Nursing, University of Santo Tomas, Manila, Philippines

[3]College of Nursing, University of the Philippines-Manila, Manila, Philippines

[4]World Health Organization Collaborating Centre for Community Health Services, School of Nursing, Hong Kong Polytechnic University, Hong Kong SAR, China

ORCIDs:

Laurence Lloyd Parial: 0000-0003-3793-9305

Patrick Pui Kin Kor: 0000-0002-9785-973X

Earl Francis Sumile: 0000-0002-7754-5944

Angela Yee Man Leung: 0000-0002-9836-1925

*Address correspondence to: Angela Y. M. Leung, PhD, Centre for Gerontological Nursing, School of Nursing, Hong Kong Polytechnic University, Hong Kong SAR, China. E-mail: angela.ym.leung@polyu.edu.hk

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The study protocol has been pre-registered in ClinicalTrials.gov (NCT04788238). The conditions of our ethics approval do not allow us to publicly archive or share the study data with non-members of the research team. Readers seeking access to relevant study materials (e.g., coding schemes, analytic methods, measurement tools) for possible replication should contact the corresponding author (Prof. Angela Leung) to discuss data sharing agreement.

ABSTRACT

Background and Objectives: Integrating mental activities with physical exercises (e.g., dual-tasking) may potentially improve cognition in older adults and people with mild cognitive impairment (MCI). This study investigated the preliminary efficacy of a new intervention called dual-task Zumba Gold (DTZ) on people with MCI to guide an adequately-powered full-scale trial.

Research Design and Methods: This is a two-arm pilot randomized controlled trial with 60 people with MCI assigned to a 12-week DTZ intervention or control group (health education). We hypothesized that DTZ would facilitate significant improvements in global cognition (primary outcome) and other psychological/physical measures at post-intervention (T1) and 6-week follow-up (T2). Generalized estimating equations with intention-to-treat approach were used to evaluate intervention effects. Post-intervention qualitative interviews explored the participants' program perceptions.

Results: Fifty-one participants completed the study, with no adverse events reported. DTZ participants showed significant improvements in global cognition ($p < .001$, $d = 0.75\text{-}0.78$), executive function ($p < .001$, $d = 0.28\text{-}0.33$), immediate recall ($p < .001$, $d = 0.50\text{-}0.54$), delayed recall ($p = .003$, $d = 0.66\text{-}0.71$), quality of life ($p = .027$, $d = 0.59\text{-}0.63$) and mobility ($p = .005$, $d = 0.53\text{-}0.56$) at T1 and T2. There were non-significant changes in working memory, depressive symptoms, blood pressure, body mass index, and waist circumference. Participants conveyed intervention acceptability, including challenges/barriers, enablers, and future recommendations.

Discussion and Implications: DTZ is a potentially feasible intervention for people with MCI that may improve cognition, quality of life, and mobility. A full-scale trial is recommended for confirmatory evaluation.

Clinical Trial Registration Number: NCT04788238

Keywords: Cognitive-motor training, Cognitive decline, Dance exercise, Pilot study

Introduction

Mild cognitive impairment (MCI) is a potential preclinical stage of dementia, characterized by measurable cognitive decline but preserved functional abilities (Irwin et al., 2018). While people with MCI are at risk for dementia, others could revert to normal cognition (Kasper et al., 2020). There is also an increasing prevalence of MCI among people aged ≥50 years, as the pathophysiological processes in dementia begin in midlife (Irwin et al., 2018). Early interventions to delay cognitive decline in these vulnerable populations are vital. However, there is insufficient evidence about the effectiveness of medications for MCI, making non-pharmacological approaches essential in its management.

Previous literature indicated that physical activity (PA) or cognitive interventions could facilitate small changes in executive function and delayed and working memory of people with MCI (Rodakowski et al., 2015; Teixeira et al., 2012). A meta-analysis noted that cognitive interventions enhanced global cognition, executive function, and delayed memory in people with MCI, while PA outcomes were limited to global cognition (Wang et al., 2014). Hence, researchers proposed that combining lifestyle interventions could promote better cognitive effects. In a landmark trial, the Finnish Geriatric Intervention Study to Prevent Cognitive Impairment and Disability (FINGER) revealed that multidomain interventions (PA, cognitive training, diet, vascular risk monitoring) improved cognition in people with dementia risk (Ngandu et al., 2015). Notably, a meta-analysis of non-pharmacological approaches for MCI found that cognitive stimulation and PA had the greatest effect on cognition (Wang et al., 2020). Thus, previous studies observed that integrating these two interventions provided better cognitive improvements in people with MCI than single approaches (Yang et al., 2020).

Dual-task training (e.g., concurrent performance of PA and mental exercises) has been suggested to improve cognitive performance in older adults (Wollesen et al., 2020).

According to the scaffolding theory of aging and cognition (Park & Reuter-Lorenz, 2009), the process of strengthening neural networks and forming synaptic connections is facilitated by enriching variables, including PA, cognitive training, and new learning. PA may stimulate brain-specific nerve growth, while cognitive training may activate the neurons/synapses to guide their functional integration, leading to synergistic cognitive effects (Gavelin et al., 2021). Hence, reviews found that dual-task interventions may significantly improve global cognition, including small to moderate changes in executive functions and memory (short-term, working, delayed memory) of people with MCI (Gavelin et al., 2021; Guo et al., 2020). Exercise may also promote psychological well-being in people with MCI by reducing depressive symptoms and improving quality of life (Leng et al., 2018); and impact cardiovascular parameters, including blood pressure (BP), body mass index (BMI), and waist circumference (WHO, 2019). Combined PA and cognitive training may also enhance mobility (Yang et al., 2020). By integrating two approaches into a single program, dual-task training may offer various benefits to people with MCI.

Previous dual-task interventions for people with MCI involved performing cognitive exercises during balance board walking, agility ladder training (Park et al., 2019), and cycling (Donnezan et al., 2018). Others involved virtual reality training using platform-based stepping and videogames (Wollesen et al., 2020). However, their requirement for advanced equipment and complex routines may not be appropriate in low-resource communities. It is imperative to explore dual-task interventions that are practical and sustainable, which could be easily incorporated in communities where people with MCI reside.

Zumba is an aerobic dance program combining whole-body movements with Latin/international music (Zumba Fitness LLC, 2021). Zumba is implemented in 180 countries, including the Philippines, which holds the world record for the largest Zumba class (Guinness World Records, 2018). A study involving healthy older adults noted that attendance in standard Zumba classes improved their quality of life and visuospatial memory (Stonnington et al., 2020). However, the high impact and vigorous intensity of traditional Zumba may not be suitable for most older adults or those with functional limitations. Zumba Gold is the modified version for people ≥50 years, with moderate intensity and lower impact (Dalleck et al., 2015). Nevertheless, there is inadequate information about the effects of Zumba Gold on older adults, with the literature limited to feasibility studies involving people with chronic kidney disease (Bennett et al., 2012) or Parkinson's disease (Delextrat et al., 2016). With its low-impact and exercise-based movements, Zumba Gold may be a suitable approach for dual-task training in people with MCI.

There are other existing knowledge gaps about dual-task interventions for people with MCI. Previous studies suggested that dual-task approaches might have comparable cognitive improvements with PA (Xu et al., 2021) or cognitive training alone (Gavelin et al., 2021). A recent meta-analysis also found that health education classes with regular follow-up for promoting lifestyle modification (e.g., adequate exercise, nutrition, smoking/alcohol prevention) could be effective in improving the cognition of people with MCI (Xu et al., 2021). Hence, health education alone is considered a useful approach for promoting cognitive health among people with MCI (Kasper et al., 2020). Further investigation is needed to determine the effects of dual-task training compared to these current interventions. There were mixed results on the ideal duration of integrated approaches for people with MCI. Guo et al. (2020) suggested that interventions at ≤12 weeks produced optimal cognitive effects, while Gavelin et al. (2021) observed non-significant differences when comparing ≤12-week with >12-week interventions. Meanwhile, there is scarce information on the long-term effects of non-pharmacological interventions on people with MCI, with most studies not having follow-up beyond post-intervention. Diamond and Ling (2016) noted it was unclear whether cognitive benefits from PA could last for one month or more. A review from the World

Health Organization (2017) also found most cognitive-based interventions for people with MCI had six-week to one-year follow-up, with limited evidence showing sustainable effects of these programs.

Performing aerobic PA with music may stimulate cognitive processes in people with with MCI (Hewston et al., 2021). However, the cognitive load in aerobic dancing may not be adequate to obtain comparable cognitive outcomes with partnered ballroom dancing (Hewston et al., 2021) or more significant mental benefits than walking (Merom et al., 2016). Notably, sufficient mental challenge in PA is vital to yield substantial cognitive effects (Diamond & Ling, 2016). Previous studies found that enriching the cognitive demands in Tai chi (Kayama et al., 2014) and exergaming (Eggenberger et al., 2015) provided better cognitive outcomes in older adults than regular programs. Hence, integrating mental exercises into the Zumba Gold dance may be a promising approach to facilitate physical and cognitive training. We found that a dual-task program through Zumba Gold was feasible in a small group of people with MCI (Parial et al., 2021). Consequently, it is imperative to investigate the potential outcomes of this new intervention through a pilot randomized controlled study to inform a large-scale trial.

The present study aims to assess the preliminary efficacy of dual-task Zumba Gold (DTZ) among people with MCI, which could provide effect size estimates for power calculation in a full-scale trial. We hypothesized that DTZ participants would have significant improvements in global cognition (primary outcome), executive function, memory, depressive symptoms, quality of life, mobility, and body measures immediately after the intervention and at 6-week follow-up, versus the control group.

Methods

Study design

This study adopted a prospective, single-blinded, parallel-group, pilot randomized controlled trial (RCT) design, wherein participants were randomized to either the intervention (DTZ program) or control group (health education with self-reported PA). The trial was registered at Clinicaltrials.gov (NCT04788238) and conducted from April to October 2021 in Plaridel (Bulacan province), Philippines. The report was guided by the CONSORT 2010 extension for pilot trials (Eldridge et al., 2016).

Participants

Inclusion criteria were aged ≥55 years and with MCI, following Petersen (2004) criteria: (1) subjective report of changes in memory/cognition; (2) objective cognitive impairment, based on Montreal Cognitive Assessment (MoCA) score of ≤25 (Nasreddine et al., 2005); (3) normal function in daily activities, via Katz (1983) ADL scale; and (4) no dementia diagnosis. Individuals were excluded for: (1) medical diagnosis of any neurological/ psychiatric disorder; (2) uncontrolled heart disease, cancer, severe musculoskeletal disorder, gross sensory impairment; (3) inability to perform basic cognitive tasks (e.g., spelling, counting); (4) engagement in any group PA program within the last three months; and (5) intake of medications (sedatives, antiepileptics, antidepressants) that may affect cognition. Antidepressant intake was excluded since its impact on older adults' cognition is inconclusive, with some suggesting protective effects (Burke et al., 2018), while others indicating negative outcomes (Moraros et al., 2017).

For a small to moderate effect size in global cognition (Gavelin et al., 2021) in the main RCT, with 90% power and two-sided 5% significance, Whitehead et al. (2016) suggested a sample size of 15 to 25 per group. Supposing an attrition rate of 20% (Xu et al., 2020), the participant number was 30 per group (N = 60).

Recruitment, randomization, and blinding

We employed convenience sampling to recruit participants from a community center in the municipality from April to May 2021. The local physician provided a list of older residents potentially eligible for the study. We also distributed posters and leaflets for better information dissemination and subject enrollment. Then, research assistants made telephone calls to potential participants to introduce the study aims and arrange schedules for further discussion. We provided information sheets to secure the participants' informed consent. A witness, such as a participant's family member/legal guardian, was also asked to sign the consent. In collaboration with the physician, a trained research assistant facilitated eligibility screening.

Simple randomization was utilized for group allocation. Through a computer-generated randomization (Stata version 13) by an independent statistician, participants were assigned to either the intervention or control group in a 1:1 ratio. An independent research assistant unsealed the opaque envelopes containing the codes of randomized groups and informed the participants of their assignment once all baseline assessments were completed. The outcome assessor who was not involved in treatment administration was blinded to the group allocation.

Interventions

Dual-task Zumba Gold

The DTZ intervention was conducted in the covered outdoor gymnasium of the community center for 12 weeks (thrice-weekly on non-consecutive days for 60 minutes) from May to August 2021. We arranged three classes with a maximum of 10 participants/session. The venue had open ventilation and ample space for accommodating all participants while keeping them one to two meters apart. A professional Zumba Gold instructor trained by Parial (also a certified Zumba facilitator) delivered the DTZ classes. Two project assistants monitored the participants' responses during the sessions. We also conducted two pre-implementation classes to help participants adapt to the new dual-task approach. Further details about the development and contents of the DTZ protocol were previously published (Parial et al., 2021).

The DTZ (Supplementary Table 1) started with a 10-minute warm-up, incorporating attention/orientation training. This included asking questions to participants about orientation to person (identifying their names), time (date, month, or year), and place (current location). Zumba Gold dancing for 40 minutes following this integrated the cognitive tasks of executive function (forward and backward serial counting); perceptual-motor ability (doing arm clock positions based on prompts); memory (forward and backward recall of word/number series); and complex attention (forward and backward spelling). Participants performed each task as a group, followed by individual participation by having the tasks transition from one person to another (e.g., serial counting) or identifying members to execute the activities (e.g., arm-clock exercises, recall, spelling). An ID number (e.g., 1 – 10) was pre-assigned to each participant, and when the instructor called a number, the participant performed the cognitive task while dancing as project assistants verified their execution. This strategy aimed to further stimulate attention, as each number served as a prompt for one participant to perform the assigned tasks (Wollesen et al., 2020). Nevertheless, the instructor/assistants communicated with the participants by their names throughout the program, including the pre- and post-sessions.

Together with new movement sequences, the mental tasks progressed every four weeks. The sessions also had alternate periods of dancing and dual-tasking (e.g., DTZ–dancing–DTZ–dancing) to minimize cognitive fatigue. For tailoring purposes, participants were given a choice to perform while chair-seated or dance in place rather than moving in different directions. A 10-minute cool-down with memory training ended each session, enabling participants to review the completed tasks. Rest periods were provided every 10 to 15 minutes, with water offered during breaks. Participants were also provided with light snacks/drinks and travel allowance to and from the venue.

Control group

Health education is a prevalent program across Asian communities for disease prevention in older adults (Pardoel et al., 2021). By focusing on lifestyle modification, health education could also improve cognition in people with MCI (Xu et al., 2021). Thus, using this as the comparator in this study may provide preliminary evidence on the efficacy of the newly developed DTZ intervention.

The control group received health education on dementia risk reduction, which highlighted the importance of physical activities and lifestyle factors (e.g., diet, smoking/alcohol use) for preventing cognitive decline (WHO, 2019). Participants were instructed to perform moderate physical/leisure activities (e.g., brisk walking, household chores, home workouts, cycling) for 60 minutes at three times/week, but were advised not to join any structured group exercise program. Since regular follow-up in cognitive health education programs is vital (Xu et al., 2021), a booklet was given to the participants to self-record their engagement in the recommended activities every week, which was reviewed by a registered nurse during the follow-up sessions (every four weeks for 60 minutes).

The control group received an introductory DTZ session after completion of all follow-up assessment procedures. The participants then received the DTZ through the community center, which was supported by the project team on program planning and implementation.

Ethical considerations

Ethical approval was secured from the Hong Kong Polytechnic University (HSEARS20200717002) and the University of Santo Tomas-College of Rehabilitation

Sciences (SE-2020-011). Study participation was voluntary, and eligible individuals who refused to join were not deprived of any community services. In line with the current public health situation, all invited participants were vaccinated for COVID-19. Safety assessment included monitoring any untoward incidents during each session and measuring participants' vital signs before and after the activity. Before each class, participants were asked to report any symptoms experienced during their rest days.

Outcome measures

Study outcomes were evaluated at baseline (T0), immediately after the intervention (T1), and at 6-week follow-up (T2). For further details on the outcome measures, see Supplementary Table 2.

Global cognition (primary outcome) was assessed through MoCA (score: 0 – 30), the recommended tool for MCI assessment (Dominguez et al., 2013; Nasreddine et al., 2005). Executive function, particularly cognitive flexibility, was evaluated via Trail Making Test Part B (TMT-B) (Arbuthnott & Frank, 2000). TMT-B score is obtained from the test completion time (maximum 300 seconds). The Digit Span Test (DST) measured immediate recall and working memory, through its forward (score: 0 – 14) backward modes (score: 0 – 12), respectively (Wechsler, 1987). Meanwhile, delayed recall was assessed through the Memory Index Score of MoCA (MoCA-MIS), which is an efficient alternative to story recall tests (score: 0 – 15) (Kaur et al., 2018). Except for TMT-B, higher scores in all these tests indicate better cognitive performance. As some items in MoCA overlapped with TMT-B and DST, we tried to minimize potential learning/interference effects by providing a mental break (at least one minute) and a separate drill before the subsequent tests.

Depressive symptoms were evaluated through the 15-item Geriatric Depression Scale-Short Form (GDS-SF) (Sheikh & Yesavage, 1986), with lower ratings implying better mood/emotional status. Quality of life was measured through the 14-item Perceived Well-Being (PWB) Scale (Reker & Wong, 1984), with higher scores suggesting better quality of life. To assess mobility, the Short Physical Performance Battery (SPPB) (Guralnik et al., 1994) was employed, which measures performance on three tasks (standing balance, gait speed, chair rise; score: 0 – 12). As PA may impact cardiovascular status related to cognitive health (WHO, 2019), non-invasive body measures such as BP, BMI, and waist circumference were evaluated.

Post-intervention interviews

We invited ten participants for focus groups (5 participants/group) to obtain their program perceptions, including positive/negative feedback and suggestions for improvement. Three dropouts were also approached for individual interviews to explore their insights/reasons for withdrawal. We purposively selected equal proportions of participants with high (≥80%) and low DTZ attendance rates (<80%). Two research assistants conducted the interviews (Supplementary Information), which ended upon data saturation, or when no new findings were discovered. The interviews were audio-recorded with participants' permission.

Data analysis

Descriptive statistics were used to summarize the subjects' characteristics, while Chi-square test, Mann-Whitney U test, and independent t-test were employed to compare the baseline differences between groups. Changes in the clinical outcomes across time (T0 – T1 – T2) and between-group comparisons were analyzed using generalized estimating equations (GEE). GEE could facilitate an inclusive analysis of variables with/without normal distribution and provide more robust estimates on small samples using the intention-to-treat (ITT) approach. Analysis was performed while controlling sociodemographic variables, such as age, sex, education, and presence of CV-related comorbidities. Sensitivity analysis was also conducted to compare ITT and per-protocol approach. Effect sizes were reported using Cohen's *d* (≥0.2 = small; ≥0.5 = moderate; ≥0.8 = large). The quantitative analysis was facilitated through SPSS version 25 (Armonk, NY: IBM Corp) at 5% statistical significance.

For qualitative analysis, we transcribed the interviews verbatim. Inductive content analysis was used to depict the participants' specific perceptions about DTZ (Hsieh & Shannon, 2005). Two research team members (LLP and EFS) iteratively read the transcripts and openly coded the statements. The codes were clustered into subcategories and then compressed into categories and themes. We compared/contrasted the individual analyses and discussed as a group to confirm the findings. We utilized NVivo 12 for data management and organization.

Results

Participant characteristics

A total of 124 people were invited, and 98 of them participated in the eligibility assessment. Of these, 77 met the inclusion criteria, with 60 individuals consenting to participate (Figure 1). The recruitment rate was 61.2% (60/98). Participants had a mean age of 63.8 years (*SD* = 5.24), and majority were females (76.7%) and married (70.0%). Around half of the participants had a secondary level of education (53.3%) and self-reported PA of < 3 times/week (55%). Some participants were diagnosed with hypertension (33.3%), dyslipidemia (6.7%), and diabetes (1.7%), while others had non-CV conditions, such as arthritis/joint pains and asthma (23.2%). There were no statistically significant between-group differences in the outcome measures at baseline (Table 1).

Table 1 here

Participant retention and adherence

The retention rate for the intervention group is 83.3%, while the control group is 86.7%. The average attendance in the 12-week DTZ was 73.2% (*SD* = 24.4), whereas the control group reported achieving 77.7% (*SD* = 29.6) of their recommended activities. Program adherence (i.e., ≥80% session attendance) is 73%. The overall study attrition rate is 15% (9/60).

Program safety

No adverse events, such as dizziness, falls, chest pain, or severe difficulty breathing, were noted during/after the sessions. During the pre-implementation classes, a few participants without regular PA reported mild leg pains. Subsequently, no persistent bodily pains were reported/observed during the regular sessions. No sustained BP elevation were noted, with participants having a mean systolic BP of 127.8 (*SD* = 4.79) and diastolic BP of 86.7 (*SD* = 6.25) after the sessions.

Effects of dual-task Zumba Gold

DTZ had significant group-by-time interaction effects on global cognition (Wald $\chi 2$ = 26.88, $p < .001$) (Table 2). The improvement of global cognition was significantly greater in the intervention than the control group at both T1 (β = 1.84, 95% CI [1.40, 2.29]) and T2 (β = 1.97; 95% CI [1.23, 2.71]). Further analysis of MoCA subcomponents (Supplementary Table 3) showed that attention (Wald $\chi 2$ = 28.24, $p < .001$) and memory (Wald $\chi 2$ = 9.94, p = .007) had the largest improvements. Significant changes were also found in executive function (Wald $\chi 2$ = 18.67, $p < .001$; T1: β = -16.37, 95% CI [-24.26, -8.47]; T2: β = -18.88, 95% CI [-28.13, -9.63]), immediate recall (Wald $\chi 2$ = 16.97, $p < .001$; T1: β = 1.08, 95% CI [0.56, 1.61]; T2: β = 1.02, 95% CI [0.37, 1.68]), and delayed recall (Wald $\chi 2$ = 11.89, p =

.003; T1: β = 1.77, 95% CI [0.72, 2.83]; T2: β = 1.99, 95% CI [0.78, 3.20]) at both time points. DTZ participants had moderate to large improvements in global cognition (*d* = 0.75 – 0.78) and delayed recall (*d* = 0.66 – 0.71); while executive function (*d* = 0.28 – 0.33) and immediate recall (*d* = 0.50 – 0.54) had small to moderate changes. However, the effects of DTZ on working memory were not significant (Wald χ2 = 3.81; *p* = .149).

Non-significant changes were observed in the participants' depressive symptoms (Wald χ2 = 2.59; *p* = .274). Meanwhile, the intervention facilitated changes in quality of life (Wald χ2 = 7.24, *p* = .027) at T1 (β = 4.12, 95% CI [1.00, 7.23]) and T2 (β = 4.43, 95% CI [1.09, 7.79]). Mobility also had significant changes (Wald χ2 = 10.61; *p* = .005) at both time points (T1: β = 0.43, 95% CI [0.14, 0.72]; T2: β = 0.43, 95% CI [0.17, 0.70]). Quality of life (*d* = 0.59 – 0.63) and mobility (*d* = 0.53 – 0.56) had moderate improvements. However, overall changes in systolic BP were non-significant (Wald χ2 = 4.53; *p* = .104). BP reductions occurred at T1 (β = -3.11, 95% CI [-6.05, -0.16]) but were not sustained at T2 (β = -2.76, 95% CI [-6.03, 0.51]). BMI (Wald χ2 = 3.26; *p* = .196) and waist circumference (Wald χ2 = 1.66; *p* = .435) had non-significant changes at both time points.

Table 2 here

Sensitivity analysis, which compared ITT (*n* = 60) and per-protocol approach (*n* = 51, study completers), showed non-significant differences in the results (Supplementary Table 4).

Qualitative feedback

We identified three themes reflecting the participants' perspectives about DTZ: (1) a feasible and beneficial program; (2) challenges and barriers in participation; and (3) program enablers and future recommendations (Supplementary Table 5).

Participants conveyed that the implementation of DTZ was tailored to their needs and preferences, offering physical, psychological, and cognitive benefits. However, they expressed initial difficulties in simultaneously performing cognitive tasks with dancing, executing backward mental exercises, and following some physical movements. They considered managing these challenges through regular program participation. Notably, some participants, including dropouts, verbalized feeling embarrassed to commit mistakes during the group sessions. Meanwhile, participants noted program enablers, including task repetition with gradual progression, safety monitoring, facilitator support, and family encouragement. For future DTZ implementation, they recommended having more young and old participants and adequate government/community support.

Discussion

To our knowledge, this is the first study evaluating the potential effects of a dual-task aerobic dance intervention for people with MCI. Results showed that the novel DTZ program may enhance cognition, quality of life, and mobility in people with MCI. The intervention had good retention and adherence rates, comparable to previous RCTs among people with MCI (Xu et al., 2020). Interviewed participants expressed program acceptability, also citing subjective health improvements. Dance-based activities are popular among middle-aged and older adults in Asia, who are commonly attracted to group activities in outdoor spaces (Dominguez et al., 2018). Hence, DTZ could be an interesting strategy for engaging people with MCI in physical and cognitive training. This is especially important in communities where resources and professional healthcare providers are not readily available.

Nevertheless, participants also experienced challenges with this new intervention. Some participants expressed dual-tasking difficulties during initial sessions, which were eventually managed through continuous participation. Task repetition with gradual progression could improve stimuli processing among older people, promoting better dual-task performance (Diamond & Ling, 2016). The study did not observe significant adverse events, although participants without regular PA might require further support to minimize postactivity body pains. This includes additional guidance at pre-implementation and adequate time for warm-up/cool-down periods. Although socialization may contribute to program adherence, some participants felt uncomfortable exercising in a group. Some older adults may feel embarrassed in doing complex PA with their peers, leading to participant withdrawal (Kraft et al., 2015). Hence, re-orienting participants before DTZ classes, coaching during sessions, and immediately obtaining post-training feedback, are crucial to ensure that activities are continuously adapted to their abilities and limitations. Allowing participant interaction at pre-implementation may also promote a non-threatening environment. Such support could help improve the confidence of people with MCI in joining multicomponent programs like DTZ.

In line with these findings, we plan to organize specific classes for participants with similar profiles (e.g., baseline PA pattern, sex) in the main trial to better facilitate program tailoring. For instance, sedentary people may require longer warm-up periods when starting PA; and men may be more comfortable joining PA programs with their peers (Kraft et al., 2015). Identifying individuals with comparable abilities and grouping them for the sessions could help adapt the activities and provide more practical support to participants, which could minimize program attrition. While participants also suggested having both younger and older individuals in the sessions, we plan to recruit more people from the older cohort (e.g., ≥75 years) in the main trial. As MCI reversion may decrease with age (Kasper et al., 2020), including these individuals in the main RCT could reinforce the generalizability and clinical significance of the findings.

Results showed that DTZ improved the participants' global cognition. Recent meta-analyses indicated that dual-task interventions, compared to inactive controls, had large effects on the global cognition of older adults and those with MCI (Wollesen et al., 2020; Xu et al., 2021). The observed changes were also higher than the suggested minimal clinically important difference of MoCA (1.22) (Wu et al., 2019). Particularly, large improvements in attention contributed to these changes, which may be due to the stimulation of divided and sustained attention as participants performed two activities simultaneously (Diamond & Ling, 2016). DTZ also had preliminary effects on executive function (i.e., cognitive flexibility), consistent with prior studies of combined interventions for older adults with/without MCI (Guo et al., 2020). DTZ participants were asked to perform movements, process mental tasks, and respond to instructor's prompts simultaneously. Hence, they were trained to adapt flexibly when physical and cognitive exercises were performed together. Reinforcing mental flexibility is vital since it contributes to higher-order cognitive functions, including planning, reasoning, and problem-solving (Diamond & Ling, 2016).

DTZ seemed to benefit memory, particularly immediate and delayed recall. Dancing alone might stimulate memory, as participants learn choreography and imitate instructor's actions (Hewston et al., 2021). Apart from remembering dance steps, integrating memory exercises in DTZ may have reinforced recall skills. Although DTZ did not seem to improve working memory (ability to temporarily store and manipulate information), further investigation is suggested. Since working memory involves more than information storage, programs to improve this domain might need extended implementation (Wollesen et al., 2020). For instance, Eggenberger et al. (2015) found significant improvements in older adults' working memory after a 24-week virtual reality videogame dancing. The sample size in this pilot trial might also be inadequate to detect statistically significant changes in this domain.

However, the current findings should be interpreted with caution. First, we utilized health education with self-reported PA as the control group. Hence, a direct comparison of the PA in control group with the PA in the intervention group could not be established. A critical consideration for future studies is to use multi-arm active controls (i.e., cognitive training or different types/intensity of PA) to compare the effectiveness or cost-effectiveness of DTZ with single modules. Given the relationship among the cognitive measures used, potential learning effects on the secondary outcomes cannot be ruled out. Moreover, practice effects from repeated cognitive testing might partly influence the improvements in both intervention and control groups. With the lack of validated alternate versions of cognitive measures for the study population, testing the equivalence and utility of existing tools in other languages is imperative to guide future trials.

Meanwhile, DTZ did not facilitate significant improvements in depressive symptoms. While there is limited investigation of this outcome in previous studies, longer periods may be required to reduce older adults' depressive symptoms. For instance, non-depressed people with MCI had significantly reduced GDS scores after a 24-week dual-task intervention (Park et al., 2019). With the participants' relatively low baseline GDS-SF scores, the likelihood of detecting substantial changes was also minimal. Contrastingly, Murrock and Graor (2014) observed that a 12-week exercise-based dance significantly improved the mood of depressed older adults. Depression in people with MCI is associated with poorer mental performance and higher rates of dementia progression, affecting engagement in complex tasks and subsequent cognitive outcomes (Leng et al., 2018). Thus, involving people with MCI and depression in future studies would contribute knowledge to these existing gaps.

DTZ may enhance quality of life in people with MCI. Qualitative findings also showed participants reporting improved subjective well-being. Engagement in PA or cognitive training might reinforce feelings of independence and enhanced functioning among cognitively-impaired individuals, which could improve quality of life (Donnezan et al., 2018). A review found that Zumba dancing could enhance the quality of life of healthy and overweight adults (Vendramin et al., 2016). In comparison, our findings showed that a cognitively-enriched dance program might improve the quality of life of people with MCI.

This is important as research is scarce about the impact of dual-task programs on the quality of life of people with MCI. Involving more diverse groups (e.g., those with functional limitations, frailty, or depression) and qualitative investigations in future trials would help explore the perceived benefits of various people with MCI from this dual-task program.

Mobility seemed to improve following DTZ, consistent with previous dual-task interventions on people with MCI (Donnezan et al., 2018; Park et al., 2019). The rhythmic aerobic steps and whole-body movements may enhance physical performance, while cognitive training may reinforce stimuli processing for better movement (Gavelin et al., 2021). Literature suggests a positive relationship between cognition and mobility, as attention and executive function could improve motor coordination and postural control (Yang et al., 2020). This evidence is noteworthy, as our results showed that DTZ facilitated significant improvements in these cognitive domains. Since people with MCI may experience mobility decline, these results contribute knowledge to the potential physical effects of DTZ.

DTZ did not significantly improve the participants' non-invasive cardiovascular measures. Systolic BP significantly reduced at T1 but not at T2, while BMI and waist circumferences had non-significant changes at both time points. Compared to regular Zumba with moderate-to-vigorous PA, Zumba Gold has moderate intensity (Dalleck et al., 2015). Thus, the higher intensity in traditional Zumba, which may not be appropriate for older people, could have contributed to the body measure improvements among younger participants in prior studies (Vendramin et al., 2016). Participants' BMI were also within the normal range for the Filipino population (i.e., 18.5 to 22.9). Exploring if DTZ could improve the body measures of people with considerable cardiovascular risk profiles (e.g., elevated BP, BMI, waist circumference) would be clinically relevant in future studies. Moreover, the benefit of incorporating lifestyle modification (e.g., nutrition) in DTZ may be investigated in future studies. This may also contribute knowledge to the value of adding components to physical and cognitive interventions (e.g., FINGER) (Ngandu et al., 2015).

While traditional partnered dancing for ≥10 months could enhance cognition in people with MCI (Dominguez et al., 2018; Hewston et al., 2021), DTZ may offer comparable outcomes within a shorter duration (i.e., 3 months) and lesser resource requirements (e.g., instructors, dance partners). Although originally from Latin America, Zumba is also implemented in North America, Europe, and Asia (Zumba Fitness LLC, 2021). Latin-based dancing is also a category in the quadrennial Asian Games. Zumba involves international music that instructors can adapt to local programs. Thus, DTZ also included popular English/Filipino songs that participants could relate to for better engagement. With the lower impact, simpler steps, and slower pacing, DTZ might also be applicable to people with no prior experience in Zumba dancing. Moreover, DTZ could be implemented in communities by Zumba Gold instructors, who are certified to deliver the age-appropriate program to older people (Zumba Fitness LLC, 2021). Training more instructors in the DTZ approach could enable people from other settings to participate and obtain possible benefits. Compared to previous dual-task programs (Park et al., 2019; Donnezan et al., 2018), the current intervention did not require gym/exercise equipment, as it can be facilitated by a trained Zumba Gold instructor using basic audio facilities. This is an important consideration in low-resource settings. Consistent with the participants' feedback, we aim to train more Zumba Gold instructors to deliver DTZ in the main trial. We also plan to collaborate with more community/government organizations to recruit more participants, including men. As participants mentioned, government support is crucial to facilitate the integration of DTZ as a community-based program for people with MCI.

Preliminary results showed that the cognitive benefits of DTZ might be maintained for at least six weeks after the intervention. These are clinically valuable as changes in global cognition, executive function, and memory are predictors of MCI progression to dementia (Belleville et al., 2017). Although practice effects from short retest intervals might contribute to these results, improvements were significantly higher in the intervention than in the control group, suggesting potential gains beyond practice effects. A full-scale trial is recommended based on the current findings. We propose a minimum sample size of 126 in the future RCT (based on small effect size in executive functions) to identify significant changes in other secondary outcomes, including working memory. Based on cutoff values of cognitive measures, MCI reversion may not be immediately detectable after 12 weeks for people with low baseline scores. Thus, stability of MCI (e.g., significant improvements in cognitive scores or no decline versus controls) is an important consideration in future analysis. We plan a longer follow-up period (e.g., 6 months to 1 year) in the main trial to observe any improvements or deterioration among the participants after the intervention.

Study limitations and future directions

The study has some limitations. First, the small sample size, female-dominated participation, and single community recruitment in this pilot trial limit the generalizability of the results. The future definitive trial could involve a larger and more diverse sample of people with MCI to ascertain the efficacy of DTZ in various groups. To minimize potential practice effects from repeated cognitive testing, using validated alternate forms in future studies would be vital. Moreover, assessment of brain activity (e.g., electroencephalography, functional MRI) may provide clearer evidence to explain the physiological changes from DTZ, which may not be readily detected by traditional cognitive testing.

Since health education with self-reported PA served as the control arm, participant blinding was impossible and performance bias cannot be ruled out. Comparisons of DTZ with PA (e.g., standard Zumba Gold) or cognitive training are imperative to determine the superiority of this new intervention over single approaches. Although not assessed in this study, establishing the cost-effectiveness of DTZ compared to other single or multidomain interventions is another important gap to be filled. A longer follow-up is also warranted to confirm the maintenance effects of DTZ, a current gap in most dual-task programs for people with MCI. Establishing the interventions' long-term effects could also determine the need for booster sessions. Currently, there is scarce information on the importance, timing, and dosage of booster sessions in physical/cognitive training for older adults and people with MCI.

Conclusion

DTZ is a novel intervention that may provide cognitive and physical benefits to people with MCI. This study suggested that DTZ may enhance global cognition, executive function, and immediate/delayed recall in people with MCI. Participants' quality of life and mobility also improved following the intervention. However, the impact of DTZ on working memory, depressive symptoms, and body measures (BP, BMI, and waist circumference) was limited, requiring further investigation. A future large-scale RCT is imperative to ascertain the effectiveness of this intervention on various groups/profiles of people with MCI.

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Table 1. Characteristics of the participants and outcome measures at baseline

Characteristics	Total (N=60)	Intervention Group (n=30)	Control Group (n=30)	χ^2/t	p -value
Age (Mean, SD)	63.80 (5.24)	63.33 (4.54)	64.27 (5.91)	-0.69^	0.495
Gender (n, %)				0.37#	0.542
Male	14 (23.3)	6 (20.0)	8 (26.7)		
Female	46 (76.7)	24 (80.0)	22 (73.3)		
Education level (n, %)				0.28#	0.872
Elementary	17 (28.3)	8 (26.7)	9 (30.0)		
Secondary	32 (53.3)	17 (56.7)	15 (50.0)		
College or above	11 (18.3)	5 (16.7)	6 (20.0)		
Marital status (n, %)				1.71#	0.634
Single	2 (3.3)	1 (3.3)	1 (3.3)		
Married	42 (70.0)	23 (76.7)	19 (63.3)		
Separated/divorced	4 (6.7)	1 (3.3)	3 (10.0)		
Widow/widower	12 (20.0)	5 (16.7)	7 (23.3)		
Self-reported PA (n, %)				0.60#	0.438
<3x/week	33 (55.0)	16 (53.3)	17 (56.7)		
≥3x/week	27 (45.0)	14 (46.7)	13 (43.3)		
Comorbidities (n, %)					
Hypertension	20 (33.3)	9 (30.0)	11 (36.7)	0.30#	0.584
Diabetes mellitus	1 (1.7)	0 (0.0)	1 (3.3)	1.02	0.313
Dyslipidemia	4 (6.7)	3 (10.0)	1 (3.3)	1.07	0.301
Others (arthritis, asthma)	13 (23.2)	8 (26.7)	5 (16.7)	0.88	0.347
None reported	25 (44.6)	12 (40.0)	13 (43.3)	0.07	0.793
Study outcomes (Mean, SD)					
MoCA	20.43 (2.05)	20.67 (1.88)	20.20 (2.22)	-1.28#	0.199
TMT-B	214.65 (57.85)	226.28 (56.54)	203.03 (57.71)	1.58^	0.120
DST-Forward	5.95 (2.11)	5.57 (1.76)	6.33 (2.52)	-1.12^	0.262
DST-Backward	1.32 (0.98)	1.50 (0.90)	1.13 (1.04)	-1.74#	0.082
MoCA-MIS	10.07 (2.70)	10.17 (2.32)	9.97 (3.07)	-0.17#	0.864
GDS-SF	3.57 (1.93)	3.63 (2.09)	3.50 (1.80)	-0.09#	0.928
PWB	73.57 (8.69)	72.20 (9.64)	74.93 (7.55)	-1.22^	0.226
SPPB	11.10 (0.77)	10.93 (0.83)	11.27 (0.69)	-1.61#	0.107
Systolic BP	125.23 (8.98)	125.40 (7.99)	125.07 (9.99)	0.14^	0.341
Body mass index	22.64 (2.24)	22.81 (2.42)	22.38 (2.08)	-0.72#	0.473
Waist circumference	79.35 (5.26)	79.73 (5.25)	78.97 (5.33)	-0.78#	0.438

Notes. MoCA = Montreal Cognitive Assessment; TMT-B = Trail Making Test, Part B; DST = Digit Span Test; MoCA-MIS = Montreal Cognitive Assessment = Memory Index Score; GDS-SF = Geriatric Depression Scale-Short Form; PWB = Perceived Well-being Scale; SPPB = Short Physical Performance Battery; BP = Blood pressure.

Table 2. Generalized estimating equations (GEE) results of the comparison of preliminary outcomes between the intervention and control groups

Measures	Intervention Group (n=30)	Control Group (n=30)	Group-by-Time interaction effects			Effect size (T0-T1; T0-T2)
	Mean (SE)	Mean (SE)	Wald χ^2	β (95% CI)	p	d
MoCA +						
T0	20.67 (0.34)	20.20 (0.40)				
T1	22.82 (0.41)	20.51 (0.49)	26.88	1.84 (1.40, 2.29)	<.001	0.75
T2	22.90 (0.42)	20.47 (0.49)	(p < .001)	1.97 (1.23, 2.71)	<.001	0.78
TMT-B -						
T0	226.28 (10.15)	203.03 (10.36)				
T1	206.04 (10.84)	199.15 (10.65)	18.67	-16.37 (-24.26, -8.47)	<.001	0.28
T2	204.35 (10.36)	199.98 (11.46)	(p < .001)	-18.88 (-28.13, -9.63)	<.001	0.33
DST-Forward +						
T0	5.57 (0.32)	6.33 (0.43)				
T1	6.70 (0.28)	6.38 (0.44)	16.97	1.08 (0.56, 1.61)	<.001	0.54
T2	6.66 (0.28)	6.40 (0.45)	(p < .001)	1.02 (0.37, 1.68)	.002	0.50
DST-Backward +						
T0	1.50 (0.16)	1.13 (0.19)				
T1	1.92 (0.18)	1.17 (0.26)	3.81	0.38 (-0.10, 0.86)	.116	0.32
T2	1.80 (0.19)	1.02 (0.21)	(p < .149)	0.41 (-0.01, 0.84)	.058	0.38
MoCA-MIS +						
T0	10.17 (0.42)	9.97 (0.55)				
T1	12.02 (0.42)	10.04 (0.55)	11.89	1.77 (0.72, 2.83)	.001	0.66
T2	12.06 (0.39)	9.87 (0.60)	(p = .003)	1.99 (0.78, 3.20)	.001	0.71
GDS-SF -						
T0	3.63 (0.38)	3.50 (0.32)				
T1	2.64 (0.29)	3.18 (0.35)	2.59	-0.67 (-1.60, 0.27)	.164	0.37
T2	2.56 (0.23)	3.23 (0.26)	(p = .274)	-0.79 (-1.79, 0.20)	.117	0.60
PWB +						
T0	72.20 (1.73)	74.93 (1.36)				
T1	76.37 (1.41)	74.99 (1.13)	7.24	4.12 (1.00, 7.23)	.010	0.59
T2	76.53 (1.35)	74.83 (1.21)	(p = .027)	4.43 (1.09, 7.79)	.009	0.63
SPPB +						
T0	10.93 (0.15)	11.27 (0.12)				
T1	11.36 (0.14)	11.27 (0.15)	10.61	0.43 (0.14, 0.72)	.003	0.53
T2	11.32 (0.15)	11.22 (0.13)	(p = .005)	0.43 (0.17, 0.70)	.001	0.56
Systolic BP -						
T0	125.40 (1.43)	125.07 (1.79)				
T1	122.04 (1.80)	124.82 (1.82)	4.53	-3.11 (-6.05, -0.16)	.039	0.32
T2	122.60 (1.84)	125.02 (1.42)	(p = .104)	-2.76 (-6.03, 0.51)	.098	0.30
Body mass index -						
T0	22.81 (0.43)	22.38 (0.37)				
T1	22.62 (0.42)	22.48 (0.36)	3.26	-0.29 (-0.61, 0.03)	.071	0.14
T2	22.66 (0.43)	22.51 (0.38)	(p = .196)	-0.28 (-0.63, 0.08)	.129	0.13
Waist circumference -						
T0	79.73 (0.94)	78.97 (0.96)				
T1	79.31 (0.88)	78.99 (0.78)	1.66	-0.44 (-1.12, 0.24)	.208	0.09
T2	79.34 (0.89)	79.07 (0.81)	(p = .435)	-0.48 (-1.99, 1.03)	.535	0.10

Notes. T0 = baseline; T1 = immediate post-intervention; T2 = 6-week follow-up; MoCA = Montreal Cognitive Assessment; TMT-B = Trail Making Test, Part B; DST = Digit Span Test; MoCA-MIS = MoCA Memory Index

Score; GDS-SF = Geriatric Depression Scale-Short Form; PWB = Perceived Well-being Scale; SPPB = Short Physical Performance Battery; BP = Blood pressure.

[+] Higher scores mean better status/performance

[-] Lower scores mean better status/performance

Figure 1. CONSORT Flow Diagram of the study