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Effects of Meditation versus Music Listening on Perceived Stress, Mood, Sleep, and Quality of Life in Adults with Early Memory Loss: A Pilot Randomized Controlled Trial

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Abstract

Background—Older adults with subjective cognitive decline (SCD) are at increased risk not only for Alzheimer's disease, but for poor mental health, impaired sleep, and diminished quality of life (QOL), which in turn, contribute to further cognitive decline, highlighting the need for early intervention.

Objective—In this randomized controlled trial, we assessed the effects of two 12-week relaxation programs, Kirtan Kriya Meditation (KK) and music listening (ML), on perceived stress, sleep, mood, and health-related QOL in older adults with SCD.

Methods—Sixty community-dwelling older adults with SCD were randomized to a KK or ML program and asked to practice 12 minutes daily for 12 weeks, then at their discretion for the following 3 months. At baseline, 12 weeks, and 26 weeks, perceived stress, mood, psychological well-being, sleep quality, and health-related QOL were measured using well-validated instruments.

Results—Fifty-three participants (88%) completed the 6-month study. Participants in both groups showed significant improvement at 12 weeks in psychological well-being and in multiple domains of mood and sleep quality (p's ≤ 0.05). Relative to ML, those assigned to KK showed greater gains in perceived stress, mood, psychological well-being, and QOL-Mental Health (p's ≤ 0.09). Observed gains were sustained or improved at 6 months, with both groups showing marked and significant improvement in all outcomes. Changes were unrelated to treatment expectancies.

Conclusions—Findings suggest that practice of a simple meditation or ML program may improve stress, mood, well-being, sleep, and QOL in adults with SCD, with benefits sustained at 6 months and gains that were particularly pronounced in the KK group.

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Keywords

Alzheimer's disease; memory complaints; mind-body therapy; mood; quality of life; sleep; stress; subjective cognitive impairment

INTRODUCTION

Alzheimer's disease (AD) is a devastating neurodegenerative condition affecting an estimated 44 million adults worldwide, with prevalence projected to reach over 75 million by 2030 and 135.5 million by 2050 [1]. Onset is usually slow and insidious, typically preceded years earlier by subjective deterioration in memory. There is growing evidence that subjective cognitive decline (SCD), characterized by the subjective perception that one's memory is noticeably worse than a few years before, may represent a preclinical stage of AD, particularly when the decline is a cause for concern [2, 3]. SCD in older adults is a significant predictor of subsequent, accelerated cognitive decline and of incident mild cognitive impairment (MCI) and AD [3–7]; this association is particularly strong in those with SCD who express worry regarding their memory problems, and is not explained by depression, demographics, APOE4 status, or other AD risk factors [8]. SCD is also accompanied by neuropathological changes linked to AD pathogenesis, including elevated amyloid-β deposition [9–12], increased white matter lesions [13, 14], and reductions in hippocampal and grey matter volume [15–17].

SCD is associated with elevated risk not only for cognitive decline and incident dementia, but also for other burdensome health outcomes, including increased neuropsychiatric impairment [18, 19] and diminished quality of life (QOL) [20, 21]. SCD has been strongly linked to chronic psychological distress [22–24]; adults with SCD are also significantly more likely to report symptoms of sleep disturbance [18, 25], depression [19, 21, 25–27], and anxiety [21, 25, 27]. Chronic stress, along with mood and sleep disturbances, can lead, in turn, to accelerated cognitive decline, neurodegenerative changes, and deterioration of both physical and mental health [28–37]. Like subjective memory complaints [3, 4, 6, 27, 38], these psychosocial factors are significant, independent predictors of subsequent cognitive decline and progression to AD [4, 5, 34, 35, 39–51], with reported risk estimates similar to or greater than those for hypertension, diabetes, obesity, and other established risk factors [42, 52, 53], highlighting the importance of timely and effective intervention.

After decades of disappointing trials, there are still no effective treatments for preventing, delaying, or reversing cognitive decline. While emphasis is increasingly shifting to early intervention [2, 54], approved treatments for those with early memory loss, including those with SCD [18, 55, 56], are lacking. Moreover, although memory complaints have been consistently associated with adverse psychosocial outcomes and poor perceived health, those with SCD rarely seek care for their symptoms [24]. Yet this prodromal or preclinical period may comprise a critical therapeutic window for altering the vicious cycle of increasing psychological distress, sleep deficits, poor quality of life, and associated cognitive decline and neuropathogenic change. As indicated above, neuropsychological impairment is common in those with early cognitive decline, and can lead to profound negative changes in

both physical health and neurocognitive function [28–32, 34–36, 57]. Thus, interventions that address these psychosocial risk factors may hold promise for not only enhancing health and well-being, but for slowing and possibly preventing cognitive decline in those at risk for AD. Of particular interest in this regard are mind-body therapies, including music listening and meditation. There is growing evidence that both meditation and simple, passive music therapy can reduce stress and depression, enhance well-being, and improve sleep in a range of populations, including those with and at risk for cognitive impairment [36, 58–67]. However, despite the promise of these simple practices, rigorous controlled studies remain few, and none has yet investigated the potential efficacy of these relaxation practices for improving psychological and related outcomes in those with preclinical memory loss. In this parallel arm randomized controlled trial (RCT), we assessed the effects of two simple 12-week relaxation programs, Kirtan Kriya Meditation (KK) and music listening (ML) on perceived stress, sleep, mood, and health-related QOL in older adults with SCD.

METHODS

Participants

Adults, at least 50 years of age, concerned about memory problems and meeting the five essential SCD criteria outlined in recent expert reviews [18, 68] were recruited using flyers and brochures posted in Morgantown, West Virginia area health care, workplace, and community settings, including senior centers and retirement communities. The major eligibility criteria are listed in Table 1. We reviewed eligibility criteria with all potential participants during a pre-visit telephone interview; after gathering written consent, potential participants then underwent a comprehensive in person eligibility screen prior to the baseline assessment and randomization. Recruitment and enrollment began on a rolling basis in July 2013 and continued until our target enrollment was reached. The last participant completed the 6-month study by July 2014. The study was approved by the West Virginia University Institutional Review Board.

Outcomes

Baseline assessments were conducted immediately following participant provision of written informed consent. We collected information regarding demographic and lifestyle factors, medical history, including current medications and supplements, and body mass index (BMI, calculated as weight in kg/height in m^2). We evaluated change in specific psychosocial and other health-related factors linked to cognitive decline using well-established, validated self-report instruments. These factors included: Perceived stress (10-item Perceived Stress Scale (PSS) [69, 70]), sleep quality (Pittsburgh Sleep Quality Index (PSQI) [71]), mood (65-item Profile of Mood States (POMS) [72]), well-being (Psychological Well Being Scale (PWBS) [73]), and health-related quality of life (36-item MOS Short Form-36 (SF-36) [73]). We also assessed both subjective memory function and objective cognitive performance using three well-established instruments, including: The Memory Functioning Questionnaire (MFQ) [74], the Trail Making Test Parts A and B (TMT) [75], and the 90-second Wechsler Digit-Symbol Substitution Test (DSST) [76]. These instruments have been used in a wide range of adult populations, including those with early memory loss [72, 77–100]. All outcomes were measured at baseline, 12 weeks, and again at 3 months post intervention (26 weeks).

Following their first intervention practice session, participants completed the 6-item Credibility/Expectancy Questionnaire (CEQ) [101, 102] to assess expectation of benefit. Home practice logs were completed by participants daily; this adherence data was collected at the follow-up assessments. Finally, at 12 weeks and 3 months post-intervention, participants completed an exit questionnaire adapted from that used in our previous studies [98, 100, 103, 104], which included a question about their memory concerns relative to baseline (from 1 = 'much more concerned' to 5 = 'much less concerned'). All participant assessments and entry of outcome and baseline data were performed by research staff blinded to participant treatment assignment.

Randomization

To ensure equal distribution between treatment groups an allocation sequence was generated by the study statistician, who had no contact with the participants, using a randomly varying block randomization method [105]. The statistician prepared sealed opaque envelopes containing the group assignment, which were numbered sequentially on the outside. These numbered envelopes were given to the consenting team member, who gave the next envelope in sequence to each participant following collection of baseline data. The participant opened the envelope to discover his/her intervention group assignment. Eligible participants were randomized to the KK or ML group in a 1:1 ratio.

Interventions

Training—Each participant received 30–45 minutes of in-person training in the relaxation technique to which they were assigned. In addition, they received a short illustrated reference guide, a program CD, and a portable CD player for home use. The training, which was provided by a team member familiar with both programs and experienced in teaching a variety of relaxation techniques, included: Presentation of the instructions for each program (described below), introduction to the various CD tracks, operation of the CD player, and use of the practice log. The participant then performed their first practice session and recorded it on the log sheet while the trainer observed and provided any guidance required by the participant to perform the intervention at home with proficiency. Additionally, the trainer followed up with each participant by phone during the first week of the intervention, and periodically thereafter as needed by the individual, to address any questions or concerns arising during the course of the intervention.

Programs—Both interventions involved sitting comfortably, eyes closed, for 12 minutes a day, every day for 12 weeks (for a total of 84 sessions) and documenting each practice session daily on the practice log. Each participant was provided a program CD and instruction sheet, along with a portable CD player, to facilitate practice.

Kirtan Kriya (KK) meditation program

The KK program is a multifaceted exercise which engages several areas of the brain but is simple to learn and practice. Specifically, KK includes repeating a Kirtan or song (singing repetition of the 'Sa-Ta-Na-Ma' mantra), while performing a mudra or physical/motor component (touching each finger-tip to the thumb in sequence with the chant) and a 'visualization' (imagining the sound energy coming in through the top of the head and

exiting out between the eyebrows in an 'L' shape). The meditation CD contained a user-friendly introduction to the KK technique along with detailed instructions, and meditation tracks. Three of the five tracks contained the 12-minute guided meditation: Two of the tracks featured a female voice, one with ocean sounds in the background, the other without; the third guided track was led by a male. Participants were instructed to follow one of the guided tracks at least once a week to reinforce the in-person training. Two additional tracks provided only the timing cues needed for the participants to conduct the meditation session without guidance, one track with, and the other without, the background ocean sounds.

Music listening program

The ML program CD contained a 12 minute selection of relaxing instrumental music from each of six composers, Mozart, Bach, Vivaldi, Beethoven, Pachelbel, and Debussy. Participants were allowed to choose which musical selections they wanted to listen to on a daily basis, but were asked to try each composer at least once during the study.

Data analysis

All data analyses were conducted using IBM SPSS for Windows, Version 23. Differences in baseline characteristics by intervention group assignment and attrition status were assessed using chi square (for categorical variables), student independent samples *t* tests (for continuous variables with a normal distribution), or Mann-Whitney U tests (for ordinal or continuous variables with evidence of skewing). Potential differences between treatment groups in treatment expectancies, retention, and adherence were analyzed using chi-square (attrition) and one-way ANOVA (adherence, treatment expectancies). In preliminary assessments, within group changes over time at 12 weeks (the primary time point) and 3 months post-intervention were assessed using ANCOVA with baseline scores as covariates; between group differences in treatment outcomes were assessed using Repeated Measures ANOVA, with factors that differed at baseline ($p < 0.1$) included as covariates. Variables with a non-normal distribution were log-transformed for analysis, using the addition of a constant in the case of zero or negative values. We used multiple imputation to replace any missing data in our intention-to-treat (ITT) analyses [106, 107]. Effect sizes were calculated using Cohen's *d*. As this was an exploratory study, alpha was set at 0.05.

We also performed analyses limited to those most at risk for cognitive decline, including participants: With at least 2 AD risk factors; aged ≥60 years with SCD onset within the previous 5 years; with poorer baseline scores on the TMT-B (≥88 seconds, a cut-off predictive of subsequent cognitive decline and dementia in a recent study of memory clinic patients with MCI [108]) and the MFQ (<75th centile). We also evaluated the potential modifying influence of age (60+ versus <60 years), obesity, history of depression/anxiety, baseline cognition, and overall mood scores (< 50th versus ≥50th centile) and use of medications associated with memory change and/or depression/anxiety. To assess the potential relationship of treatment expectancy scores, change in measures of memory and cognition, and practice adherence to change over time in mood, stress, well-being and QOL, bivariate and age- and sex-adjusted correlations were performed using Pearson product-moment correlation.

RESULTS

Following consent and baseline screening, 60 eligible adults with SCD were enrolled in the study. Memory problems had been experienced for a mean of approximately 3 years (X = 35.42 ± 4.2 months) prior to enrollment. Study participants were predominantly non-Hispanic white (93%) and female (85%), with an average age of 60.6 ± 1.0 (range 50–84) years. The majority were employed at least part-time (73%), married or living with a partner (65%), and college-educated (58%). Prevalence of metabolic/vascular risk factors for AD was high in this sample, with 94% of participants reporting at least one, and 66% indicating a diagnosis of ≥2 of these chronic conditions (Table 2). Commonly reported conditions included obesity (48%), dyslipidemia (58%), hypertension (32%), and diabetes (15%). In addition, almost 60% of participants indicated a history of diagnosed depression or anxiety disorder. Mean CAIDE (Cardiovascular Risk Factors, Aging, and Dementia) score [109] was 8.2 ± 0.3, with only 13% scoring under 6, the cutoff used in selecting adults at risk for cognitive decline in the ongoing lifestyle intervention study in Finnish adults [110]. Clinically significant sleep impairment, defined as PSQI >5 [71, 111], was present in over 90% of participants at baseline.

Participants in the two groups did not differ significantly in demographic or lifestyle factors, BMI, or medical history (Table 2). Likewise, there were no significant between-group differences in baseline scores on mood, sleep, stress, well-being, or QOL measures (Table 3), in reported duration of memory problems, or in baseline measures of memory or cognitive functioning (p's > 0.1).

Each participant received the intervention as allocated. Participant retention was high; 92% of participants (27/30 KK, 28/30 ML) completed the 12-week intervention, and 88% (26/30 KK, 27/30 ML) completed the full 6-month study period. Reasons for dropout included: Family emergency (n = 1), time constraints (n = 2), and unknown/lost to follow-up (n = 4). Those who dropped out were similar to completers in demographics, lifestyle factors, BMI, and health history and did not differ on baseline measures of cognition, mood, stress, sleep, or well-being (p's ≥ 0.3). Adherence was also high, with participants completing an average of 93% of the 84 possible sessions in the first 12 weeks and 71% of sessions during the practice-optional, 3-month follow-up period. There were no between group differences at any time point in either adherence or retention (p's ≥ 0.4). Similarly, there were no significant differences between the two groups in any domain of treatment expectancy (all p's ≥ 0.2), and treatment expectancy scores were not correlated, at any time point, with change over time in stress, well-being, or in any domain of mood, sleep, or quality of life (p's ≥ 0.1). No adverse events were observed or reported.

Change over time in psychological status, sleep quality, and quality of life

As illustrated in Table 4, both the KK and ML groups showed significant improvements overall at 12 weeks in psychological well-being and multiple domains of mood and sleep quality. These improvements were sustained or further strengthened at 26 weeks. In addition, those assigned to the KK group demonstrated significant gains in perceived stress, and in the Mental Health component of QOL at both 12 and 26 weeks, including improvements in 3 of 4 constituent domains; the ML group, by contrast, showed modest

improvement in only one QOL domain at 12 weeks, that pertaining to pain (Table 4), but did demonstrate significant gains in 2 of the 4 mental health component domains at 26 weeks. With the exception of the QOL physical component, which did not change significantly with either intervention, overall effect sizes in the KK group ranged from moderate (QOL, Mental health component, sleep quality, psychological well-being) to large (mood, perceived stress) depending on the measure, whereas those in the ML group varied overall from small (psychological well-being, and QOL, mental health component) to moderate (perceived stress, mood, sleep quality). Relative to the ML group, the KK group demonstrated significantly or marginally significantly greater gains in perceived stress and mood (POMS) at 12 and 26 weeks; and in psychological well-being (PWBS) and the mental health component of QOL at 12 weeks (Table 4). The two groups did not differ in any domain of sleep quality at either time point.

ITT analyses using multiple imputation yielded similar results. Excluding from the analysis those who scored in the top 25% of the MFQ (total MFQ score ≥270) or those scoring poorly (≥88 seconds) on the TMT-B did not appreciably alter the findings. Similarly, findings did not differ significantly by obesity, gender, age (<60 versus 60+ years), history of depression/anxiety, current use of medications for depression or anxiety, number of AD risk factors (2+ versus <2), or baseline performance on mood, well-being, or sleep quality (<50th versus ≥50th percentile).

Baseline scores on perceived stress, mood, well-being, sleep quality, and overall QOL were significantly inter-correlated (r's ranging from 0.3 to 0.8). As illustrated in Table 5, improvements in mood, perceived stress, well-being, and the mental health component of QOL were likewise strongly interrelated at both 12 and 26 weeks (r's from 0.3 to 0.7), with the strongest correlations observed between changes in mood at both time points and those in stress and the mental health composite score (r's 0.5 to 0.7). Improvement in sleep quality at 12 weeks was significantly correlated with 12-week changes in stress, well-being, and both components of QOL, and with positive changes in stress, well-being and the QOL Physical Health composite score at 26 weeks; gains in sleep quality at 26 weeks were significantly related to improved well-being and QOL (both components) at both 12 and 26 weeks, and to improvements in mood at 26 weeks (Table 5). Adherence was not significantly related to change over time in any measure.

Relation of improvements in psychological status, sleep quality, and quality of life to gains in memory and cognitive function

As illustrated in Table 6, participant improvements in overall measures of mood, stress, sleep, well-being, or quality of life were significantly and positively associated with gains in subjective memory function. For example, improvements in overall mood (POMS) and reductions in perceived stress were significantly related to increases in MFQ total scores, and in certain MFQ domains, including Frequency of Forgetting and Seriousness of Forgetting, at both 12 and 26 weeks. Likewise, improvements in psychological well-being were significantly correlated with gains in subjective memory function, with these relationships appearing stronger for memory function gains at 26 weeks; the mental health component of QOL was also significantly related to gains in the MFQ at both time points

(Table 5). Improvements in overall sleep quality were significantly related to increases only in the MFQ retrospective memory function subscale. Similarly, concerns regarding memory at 6 months were strongly correlated with improvements in overall mood at both 12 and 26 weeks, with the mental health component of QOL at 12 weeks, and with psychological well-being scores at 26 weeks.

In contrast, relationships of change in performance-based measures to improvements in mood, stress, and well-being were relatively weak, and evident only for the TMT-A (mood at both time points, and perceived stress at 26 weeks) and the DSST (well-being at 26 weeks); similarly, improvements in overall OOL was related only to gains in the TMT-A, and only at 26 weeks. Sleep quality overall was not related to any performance-based measures, although improvements at 12 weeks in certain individual domains showed modest associations with gains in the TMT-A (sleep quality and daytime dysfunction, r's = −0.26; *p*'s < 0.06) and the DSST (sleep duration, r = 0.31, $p = 0.02$) at 6 months.

DISCUSSION

In this pilot randomized controlled trial of older adults with SCD, participants assigned to both the KK meditation and the ML groups demonstrated significant and sustained improvements in measures of mood, stress, sleep quality, well-being, and quality of life (mental health component), with improvements in most measures reflecting clinically significant differences [112, 113]. Overall gains were particularly marked in the KK group. Observed improvements were not explained by baseline treatment expectancies, suggesting that expectations of benefit did not significantly influence outcomes in this study. Likewise, we found no evidence of a modifying effect of depression or anxiety, age, gender, medication use, comorbidity, baseline scores on psychosocial or cognitive tests, or other factors, indicating that these simple mind-body practices may be suitable for a variety of populations experiencing early memory loss.

This study is the first to investigate the possible benefits of mind-body therapies for improving psychosocial outcomes in older adults with SCD, and helps to address the need for exploring effective interventions in this population. To date, the few completed trials assessing psychological and related endpoints in non-cognitively impaired adults at risk for AD have yielded mixed findings, and reported improvements have been modest. For example, in a recent 3 arm RCT in 44 older Israeli adults with memory complaints, participants showed only small, non-significant declines in loneliness, and no change in depressive symptoms following completion of a 10-week health promotion, cognitive training, or participation-centered course [114]. Similarly, in a 2008 RCT of an 18-month individualized home-based exercise program in adults with subjective memory impairment, participants showed no significant improvements, at any time point, in either depressive symptoms or QOL [115]. In a large ongoing RCT of Finnish adults at risk for cognitive decline, participants assigned to a 24-month intensive lifestyle intervention incorporating dietary counseling, exercise training, cognitive training, and vascular risk monitoring likewise showed no improvement in depressive symptoms [110], but appeared to demonstrate small gains in some QOL domains [116] (data published in abstract form).

Consistent with findings of previous observational studies [18, 19, 21–27], neuropsychiatric impairment was elevated in this population. Most participants indicated clinically significant sleep impairment at baseline, with mean PSQI scores similar to or exceeding those in adults with insomnia [117] or multiple chronic conditions [118]. In addition, mean baseline quality of life was comparable to or lower than that reported in adults with a range of serious chronic conditions, including prostate cancer, diabetes, multiple sclerosis (mental health component), and epilepsy and substantially lower than the general U.S. population means [112, 119]. Likewise, mean participant scores on all domains of the POMS, a well established and widely used measure of mood disturbance, were significantly worse than reported norms for older adults [120], and similar to or higher than those in adults with HIV, cancer, heart failure, and other serious chronic disorders [121–126]. Similarly, participants indicated overall high levels of stress, with baseline PSS scores again comparable to or higher than those reported in patients with a variety of serious conditions, including advanced coronary artery disease [127], multiple sclerosis [128], and cancer [129].

The significant and sustained improvements in psychological status, sleep, and QOL following the practice of meditation and music listening may have important implications for addressing not only the neuropsychiatric impairment common in those with SCD, but also the decline in cognitive function. In this study, both groups showed marked and sustained gains in all measures of memory and cognitive performance (p's < 0.05, data not shown) as well as in all psychosocial outcomes. Moreover, positive changes in perceived stress, affect, and well-being in this study were significantly and directly correlated with improvements in subjective memory function and, albeit more modestly, to certain gains in objective cognitive performance, suggesting a possible functional relationship between changes in psychosocial status and those in cognitive function. This relationship is likely bidirectional and synergistic. For example, growing evidence suggests that neuropsychiatric impairment in those with early memory loss can itself increase risk of accelerated cognitive decline, neuropathological change, and progression to AD. Like MCI and AD, SCD has been strongly linked to chronic psychological distress [22–24], elevated depressive [19, 21, 25–27], and anxiety symptoms [21, 25, 27], and sleep disturbance [18, 25], factors shown to increase risk for accelerated cognitive decline and neurodegenerative changes [28, 31, 32, 34–36], and ultimately, conversion to MCI and AD [4, 5, 34, 35, 39–51, 130, 131]. Conversely, perceived deterioration in one's cognitive functioning can itself be a significant source of fear and distress [132, 133], potentially leading to increased symptoms of depression and anxiety, reduced quality of life, and impaired sleep, further contributing to a vicious cycle of increased psychological disturbance, worsening QOL, accelerated cognitive decline, and accompanying adverse neurological changes. Compounding these changes, adults with memory complaints are also significantly more likely to experience subsequent deterioration in physical health, dependency, and institutionalization [134].

However, despite the often substantial psychological and functional challenges associated with SCD, those with memory complaints rarely seek help for their concerns [24, 135]. This reluctance to seek care is likely due in part to the widespread fear and related stigma surrounding AD [136–139], coupled with the recognized absence of effective treatments [56, 138]. Thus, identifying low cost, sustainable, non-stigmatizing therapies that can effectively address both neuropsychiatric and cognitive concerns early, when intervention is likely to be

most effective, is of clear importance. Of particular promise are therapies such as meditation and ML that can promote multiple beneficial changes implicated in cognitive impairment and that likely operate via multiple pathways, including those detailed above.

For example, meditation and ML may reduce distress, improve well-being, and enhance cognitive function by selectively activating specific neurochemical systems and brain structures associated with positive mood, emotional regulation, attention, and memory, and promoting related beneficial neurostructural changes [63, 140–143]. For instance, recent studies suggest that meditation can promote favorable changes in CNS dopaminergic and other neurochemical systems [144, 145], and increase blood flow, oxygen delivery, and glucose utilization in specific regions of the brain associated with mood elevation, memory, and attentional processing, including the hippocampus, prefrontal cortex, and anterior cingulate gyrus [94, 141, 146–148]. Long-term meditation practice has also been associated with cortical thickening and increased grey matter volume in brain regions involved in attentional performance, memory, sensory processing, and interoception [149–151], apparently offsetting typical age-related cortical thinning and grey matter loss [149, 151, 152]. While data regarding CNS changes with music are more limited, neuroimaging studies likewise suggest that music therapy, including ML, activates pathways in brain areas involved in emotional reward and regulation, attention, memory, and other associated functions, including the prefrontal cortex, insular and cingulate cortex, hippocampus, and amygdala [63, 66, 143].

Recent studies in dementia caregivers [153] also suggest that meditation may buffer the effects of stress-induced cellular aging by directly or indirectly promoting telomere maintenance, and in this way, protecting immune function and decreasing neuronal loss and other degenerative changes associated with both mood impairment and cognitive decline. Decreases in telomerase activity and telomere length have been linked to both chronic distressful states and cognitive impairment [154–166] and shown to predict cognitive decline in both clinical and non-clinical populations [167, 168]. Likewise, recent research in healthy adults [169–171], lonely older adults [172], and depressed dementia caregivers [173, 174] suggest that meditation may also buffer or reverse multiple stress-related changes in specific gene expression pathways implicated in the development and progression of AD, including those regulating oxidative stress, inflammation, cellular aging, and other factors contributing to impaired brain structure and function, and ultimately, to cognitive decline [175–181]. While gene expression studies of music therapy are sparse, recreational music has been shown to modulate genomic stress induction signatures [182], suggesting that ML may have beneficial effects on the transcriptome as well.

In addition, KK meditation may affect psychosocial status and cognition via other pathways as well. For example, KK is a multi-modal meditation practice involving multiple tasks and sensory modalities (chanting with progressive changes in volume, sequenced finger movements, visualization, and coordinated breathing). Participants in the KK program are thus learning new motor, sensory, and physical skills, a process that has been associated with improvements in cognitive function and associated positive neurostructural changes[183]. KK also involves training in maintenance of attention and focus, set shifting, and multi-tasking, which could, in turn, improve several domains of executive function, including

working memory and cognitive flexibility. While reasons for the greater improvements in the KK versus ML group are unknown, observed differences may in part reflect the multi-modal nature of KK meditation, as well as the more active nature of this practice.

There is evidence that non-KK meditation practices, including other forms of mantra meditation, such as Transcendental Meditation (TM) and SOHAM meditation, and interventions involving mindfulness/open-monitoring meditation may also be beneficial for populations with or at risk for memory loss. For example, data from matched cross-sectional studies of experienced meditation practitioners versus non-meditators have suggested that the practice of mindfulness/open-monitoring meditation (including Vipassana, Zen, and Mindfulness) may increase cortical thickness and delay age-related cortical thinning and grey matter loss in brain regions associated with attention, memory, and other functional domains adversely affected in MCI and AD [149–151]. Likewise, while prospective neuroimaging studies of meditation in older adults remain few, two small controlled trials in meditation naïve older adults with MCI [184] and healthy young and middle-aged adults [185] suggest that Mindfulness-based Stress Reduction (MBSR), an intensive, 8-week multi-component program, may increase functional connectivity and reduce grey matter atrophy in brain regions affected in AD. Similarly, recent small trials in young and middle-aged adults suggest that the practice of both mindfulness meditation [186] and other forms of meditation [146, 148] may activate and enhance cerebral blood flow to areas of the brain involved in memory, attention, learning, and emotional regulation. These findings are consistent with neuroimaging data from recent studies of KK in older memory impaired adults [94], depressed dementia caregivers [187] and experienced practitioners [188].

However, prospective clinical trials have yielded less consistent findings regarding the effects of non-KK meditation forms on cognitive indices in older adults. Of the few trials of non-KK mantra meditation [189, 190], mindfulness meditation [191–195] and other meditation practices [196] in older adults that have assessed cognitive function, most have shown minimal or no improvement [190–195], including two recent large RCTs of MBSR in generally healthy elders [191, 193]. To date, only two published trials of non-KK meditation have included adults with memory complaints, and only one specifically targeted this population. A four arm RCT of TM and mindfulness meditation in 73 senior home residents demonstrated significant and sustained improvements with TM and to a lesser extent mindfulness, in several cognitive indices [189], and an RCT of MBSR in 14 adults with MCI showed no improvement in any cognitive measure (and worsening on one measure) [194].

Likewise, observed effects on neuropsychiatric impairment and QOL in older adults, including those with memory loss, have tended to be modest, with several studies showing limited or no improvement with either insight meditation [191–194] or TM [190]. In contrast, preliminary trials to date of KK meditation in dementia caregivers [153, 197] and adults with early memory loss [94] have shown improvements in both cognitive function and psychosocial status consistent with those observed in the current study. However, clinical intervention trials of older adults with memory loss remain sparse, and sample sizes for most published trials to date, including those of KK, have been small, limiting conclusions. While findings of the current study further support the promise of KK for adults with SCD, additional rigorous research in larger populations is warranted to further investigate the

potential benefits of KK and other meditation practices for adults with and at risk for memory loss.

Strengths and limitations

Strengths of this study include the rigorous, randomized study design, measurement of multiple domains of psychosocial status and quality of life, the recruitment of participants from community-based settings, and the high retention and adherence rates in both groups. Data on treatment expectancy also permitted us to examine the possible influence of this factor on change in outcomes, and to control for potential placebo effects.

Our ability to capture an at-risk population was enhanced by our use of a questionnaire to ascertain SCD that was based on prior expert reviews and risk analyses [3, 6, 8, 198], and further enriched by eligibility criteria which included concerns regarding memory problems, a factor shown to further increase the risk for MCI and AD. The baseline TMT-B scores of more than 40% of participants were in the range suggesting high risk for accelerated cognitive decline and conversion to MCI/dementia [108, 199]. Our sample was also characterized by high prevalence of known AD risk factors, as well as mean MFQ baseline scores comparable to those of adults with amnestic MCI [200], and substantially lower than those reported in community-based samples [201], suggesting we did indeed capture a population at risk for cognitive decline.

However, this pilot trial also has several limitations including a relatively small sample size, and a relatively well-educated, young, motivated study population with SCD, possibly limiting generalizability to populations with other types of memory loss. It is possible that some participants may have had undiagnosed MCI, as while we did assess cognitive function and memory, we did not perform diagnostic cognitive testing in our sample.

It is possible that social desirability concerns may have biased findings toward the positive. However, this would presuppose that participants were able to remember their responses on a large battery of tests taken 3 or 6 months prior, and would not, in any case, explain the observed differences between groups or the improvement in performance-based measures of cognition. In addition, we were careful to encourage participants to be honest in their assessments, and assure them that data entry and analysis would be only of deidentified data. Nonetheless, we cannot completely rule out the potential influence of social desirability bias. Because the study lacked a usual care control group, we were unable to assess the possible effects of time trends on change over time. However, numerous studies in adults at risk for cognitive impairment have shown psychological status and quality of life to remain unchanged or deteriorate over time in the absence of effective intervention [110, 115, 116, 202–208], suggesting that simple time trends are unlikely to explain the improvements observed in this study. In addition, participants could not be blinded to treatment assignment. However, expectancy scores were similar between groups and unrelated to outcomes.

We did not exclude those currently under treatment for, or with a history of, depression or anxiety. While this could potentially explain some of the perceived memory decline in some participants, history of depression was unrelated to baseline cognitive scores and we found no evidence of a modifying or confounding effect of either history of depression or use of

antidepressant medication, suggesting these factors did not influence our findings. Given that both anxiety and depression are strong predictors of subsequent cognitive decline and dementia in previously cognitively intact adults [5, 34, 45, 51], adults with depressive symptoms are an at risk group that arguably should not be excluded from intervention studies for improving cognitive function. In fact, depression is included in at least two AD risk scales for non-demented adults [209].

CONCLUSIONS

Findings of this preliminary RCT suggest that practice of KK meditation or a simple ML program can promote significant and sustained improvements in perceived stress, mood, well-being, sleep, and quality of life in adults with SCD. Observed gains in this study were particularly pronounced in the KK group. Clearly, additional high quality trials are warranted to further investigate the potential benefits of these simple mind-body programs for older adults with early memory loss; to determine the long term effects of KK and ML on psychosocial status, QOL, and cognitive function; and to investigate potential underlying mechanisms of action.

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Table 1

Major eligibility criteria

Major Inclusion Criteria	Major Exclusion Criteria
Adults at least 50 years old with (a) MCI or (b) SCD, defined as: **a.** Physician confirmed diagnosis of mild cognitive impairment (MCI) at least 6 weeks ago and current exam within the past 12 months **b.** Subjective cognitive decline (SCD) meeting the following criteria:[1] **1.** presence of subjective cognitive deficits within the past 6 months; **2.** frequency of memory problems at least 1×/wk; **3.** able to give an example in which memory/cognitive problems occur in everyday life; **4.** belief that one's cognitive capacities have declined in comparison with 5 or 10 years previously; and **5.** absence of overt cognitive deficits or dementia diagnosis **6.** concerns/worries regarding memory problems	Practiced meditation or other relaxation technique within the past year Recently (within the last 6 weeks) changed dosage of cholinesterase inhibitors (e.g., donepezil (Aricept), galantamine (Razadyne), rivastigmine (Exelon)) or psychotropic medication (e.g., anti-psychotics, tricyclics, SSRIs, MAOIs, anti-panic or anti-anxiety agents) History of psychotic or schizophrenic episodes, major neurologic diagnosis (Parkinson's, stroke, brain injury, epilepsy) or other condition that might impair cognition or confound assessments (e.g., cardiovascular event within the past 6 months (myocardial infarction, unstable angina, hospitalization for congestive heart failure, bypass surgery or angioplasty (coronary or carotid), TIA) History of chemotherapy treatment within the past 10 years
For those with MCI, a study buddy willing to attend all assessment visits; For those with SCD and concerned about their ability to fully understand consent or complete questionnaires, study buddy willing to attend baseline visit and other assessments if needed	Recent (within the last 3 months) serious physical trauma or diagnosis of serious chronic health condition requiring medical treatment and monitoring (e.g., uncontrolled hypertension, serious endocrine or pulmonary disorder, renal disease, active cancer treatment)
Willing and able to complete the intervention and all assessments	Not English-speaking
Willing to avoid new treatments other than the assigned intervention	Participant in another intervention study within the past 30 days

[1] Based on Abdulrab et al. [68], Reisberg et al. [18], and Jessen et al. [3].

Table 2

Participant baseline characteristics: Pilot feasibility RCT of a 12-week Kirtan Kriya meditation (KK) versus a 12-week music listening (ML) program in 60 adults with subjective cognitive decline

	Overall (*N* = 60)		KK (*N* = 30)		ML (*N* = 30)		*p*
	n	**%**	***n***	**%**	***n***	**%**	
Demographic characteristics							
Age (range 50 – 84 years)							0.92
50–59 years	30	50.00%	15	50.00%	15	50.00%	
60–69 years	21	35.00%	10	33.33%	11	36.67%	
70+ years	9	15.00%	5	16.67%	4	13.33%	
Mean years ± SE	60.58 ± 1.01		60.93 ± 1.56		60.23 ± 1.32		0.73
Gender							0.71
Female	51	85.00%	26	90.00%	25	96.67%	
Male	9	15.00%	4	10.00%	5	3.33%	
Race/Ethnicity							
Non-Hispanic White	56	93.33%	27	10.00%	29	23.33%	0.25
Minority	4	6.67%	3	13.33%	1	36.67%	
Education							0.12
12 years or less	10	16.67%	3	10.00%	7	23.33%	
Some post-high school education	15	25.00%	4	13.33%	11	36.67%	
4 years of college or more	35	58.33%	23	76.67%	12	40.00%	
Mean years ± SE	15.43 ± 0.29		16.17 ± 0.37		14.70 ± 1.33		0.01
Employment status							0.65
Employed full time	39	65.00%	20	66.67%	19	63.33%	
Employed part time	5	8.33%	3	10.00%	2	6.67%	
Other	16	26.67%	7	23.33%	9	30.00%	
Marital status							0.55
Married/co-habiting	39	65.00%	19	63.33%	20	66.67%	
Divorced	15	25.00%	7	23.33%	8	26.67%	
Widowed/separated/single	6	10.00%	4	13.33%	2	6.67%	
Lifestyle and health-related factors							

	Overall (*N* = 60)		KK (*N* = 30)		ML (*N* = 30)		*p*
	n	**%**	***n***	**%**	***n***	**%**	
Smoking status							0.78
Never smoked	38	63.33%	19	63.33%	19	63.33%	
Former smoker	19	31.67%	10	33.33%	9	30.00%	
Current smoker	3	5.00%	1	3.33%	2	6.67%	
Caffeinated beverage consumption							0.36
0–8 oz/d	13	21.67%	6	20.00%	7	23.33%	
9–16 oz/d	18	30.00%	7	23.33%	11	36.67%	
17–24 oz/d	11	18.33%	8	26.67%	3	10.00%	
25+ oz/day	18	30.00%	9	30.00%	9	30.00%	
Mean oz consumed/day±SE	21.92 ± 4.15		22.34 ± 7.07		21.51 ± 3.19		0.85
Physical activity							0.95
None	15	25.00%	8	26.67%	7	23.33%	
10–140 min/week	29	48.33%	14	46.67%	15	50.00%	
150+ min/week	16	26.67%	7	23.33%	8	26.67%	
Mean minutes/week±SE	111.64 ± 14.61		107.89 ± 15.89		115.78 ± 24.82		0.44
Mean times/week±SE	2.79 ± 0.29		3.02 ± 0.41		2.57 ± 0.41		0.78
Body mass index (BMI): Mean ± SE	29.94 ± 0.94		29.17 ± 1.16		31.33 ± 1.34		0.23
History of diagnosed							
Diabetes	9	15.00%	4	13.33%	5	16.67%	0.72
Hypertension	19	31.67%	8	26.67%	11	36.67%	0.41
cholesterol	35	58.33%	19	63.33%	16	53.33%	0.43
Depression	23	38.33%	13	43.33%	10	33.33%	0.43
Anxiety disorder	17	28.33%	9	30.00%	8	26.67%	0.77
Depression or Anxiety disorder	35	58.33%	18	60.00%	17	56.67%	0.95
Number of cardiometabolic AD risk factors * *Mean ± SE*	1.83 ± 0.16		1.77 ± 0.23		1.90 ± 0.22		0.68
Number major AD risk factors ** *Mean ± SE*	2.42 ± 0.18		2.37 ± 0.27		2.47 ± 0.25		0.79
Number of medications (regular use) linked to memory changes ǂ							0.71
None	32	53.33%	16	53.33%	16	53.33%	
One	14	23.33%	6	20.00%	8	26.67%	
Two	13	21.67%	7	23.33%	6	20.00%	

	Overall (*N* = 60)		KK (*N* = 30)		ML (*N* = 30)		*p*
	n	**%**	***n***	**%**	***n***	**%**	
Three or more	2	3.33%	1	3.33%	1	3.33%	
History of hormone replacement therapy ǂ ǂ	19	37.25%	8	30.77%	11	44.00%	0.61

* Including diabetes, hypertension, high cholesterol, obesity, cardiovascular disease.

** Also including history of depression or anxiety disorder.

ǂ Including the following: Statins, narcotic analgesics, steroids, benzodiazepines, beta blockers, antihistamines, anticonvulsants, tricyclic and other non-SSRI/SNRI antidepressants.

ǂ ǂ Percentages calculated in women only.

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Table 3

Participant duration of memory concerns and baseline scores on memory and cognitive function tests, and on sleep, stress, mood, well-being, and quality of life questionnaires

	KK (*N* = 30) *Mean (SE)*	ML (*N* = 30) *Mean (SE)*	*p*
Memory Functioning Questionnaire			
Total	241.83 (9.92)	253.43 (10.07)	0.31
Frequency of Forgetfulness	138.50 (5.43)	146.77 (5.26)	0.28
Seriousness of Forgetting	64.83 (3.83)	73.87 (4.30)	0.15
Retrospective Memory Functioning	11.70 (0.63)	11.64 (0.62)	0.82
Mnemonic Use	21.92 (1.60)	21.48 (1.92)	0.35
Digit Symbol Substitution Test	50.57 (1.74)	50.20 (1.83)	0.89
Trail-making Test (TMT)			
TMT-A	33.76 (1.08)	34.63 (2.18)	0.73
TMT-B	85.54 (7.14)	90.59 (7.64)	0.53
Months Experiencing Memory Problems (range 5 to 180 months, median = 24 months)	36.30 ± 7.08	34.18 ± 4.47	0.80
Perceived Stress and Sleep Quality			
Perceived Stress Scale	17.37 (1.16)	15.33 (1.32)	0.25
Pittsburgh Sleep Quality Index	9.38 (0.50)	8.68 (0.60)	0.33
Mood and Well-being			
Profile of Mood States			
Total	36.03 (5.69)	21.36 (5.96)	0.10
Tension/Anxiety	8.20 (1.23)	5.97 (1.15)	0.19
Confusion	6.87 (0.84)	5.07 (0.86)	0.11
Depression	11.60 (1.74)	8.54 (1.72)	0.18
Anger/Hostility	10.23 (1.29)	7.60 (0.95)	0.12
Vigor	16.60 (1.14)	14.50 (1.10)	0.19
Fatigue	13.63 (1.20)	11.00 (1.16)	0.19
Psychological Well-being Scale	77.80 (1.97)	81.83 (2.15)	0.18
Health related Quality of Life (SF-36)			
Mental Health Composite Score	65.74 (3.18)	69.07 (3.52)	0.48
Physical Health Composite Score	69.00 (3.64)	68.08 (3.81)	0.86
Role Emotional	70.00 (6.26)	70.00 (6.66)	1.00
Emotional Well-being	68.13 (2.98)	74.40 (2.91)	0.15
Social Function	79.17 (3.46)	82.92 (3.47)	0.45
Energy/Vitality	45.67 (3.54)	49.00 (4.47)	0.56
Physical Function	76.50 (4.07)	75.00 (4.31)	0.57
Role Physical	67.50 (6.13)	67.50 (7.00)	1.00
Pain	68.81 (3.58)	69.02 (3.82)	0.82
General Health	64.04 (4.10)	64.46 (3.77)	0.65

Table 4

Change over time in perceived stress, sleep, mood, well-being and quality of life in adults with subjective cognitive decline

	KK Meditation						Music Listening								
	Change at 12 weeks (Mean ± SE)	***p****	**ES**	**Change at 26 weeks (Mean ± SE)**	***p****	**ES**	**Change at 12 weeks (Mean ± SE)**	***p****	**ES**	**Change at 26 weeks (Mean ± SE)**	***P****	**ES**	***P*‡**	***P*‡ ‡**
Stress, mood, well-being and sleep quality															
Perceived Stress Scale	−3.69 (1.13)	0.003	0.6	−5.69 (1.01)	0.00001	1.0	−2.61 (1.44)	0.08	0.4	−3.63 (1.39)	0.01	0.5	*(*)*	*
Profile of Mood States															
Total	−26.38 (4.79)	0.001	0.9	−31.04 (4.31)	<0.00001	1.0	−13.32 (6.00)	0.035	0.4	−19.74 (4.89)	0.0004	0.6	*	*(*)*
Tension/Anxiety	−4.46 (1.37)	0.003	0.7	−6.04 (1.13)	0.00001	0.9	−2.21 (1.28)	0.095	0.3	−3.67 (1.14)	0.004	0.6	*(*)*	
Confusion	−4.65 (1.38)	0.00002	1.1	−4.85 (0.87)	0.00001	1.1	−2.21 (0.93)	0.025	0.5	−3.74 (0.84)	0.0001	0.8	*(*)*	
Depression	−5.46 (1.34)	0.0004	0.6	−6.42 (1.36)	0.00007	0.7	−2.00 (1.59)	0.22	0.2	−3.19 (1.10)	0.008	0.4	*	*(*)*
Anger/Hostility	−4.85 (1.38)	0.002	0.7	−4.81 (1.24)	0.0007	0.7	−2.43 (1.12)	0.04	0.5	−2.85 (0.99)	0.008	0.5	*(*)*	
Vigor	1.69 (1.10)	0.13	0.3	3.04 (0.87)	0.002	0.5	1.25 (1.03)	0.24	0.2	1.96 (1.10)	*0.087*	*0.3*		
Fatigue	−5.27 (0.87)	0.000003	0.8	−5.88 (0.89)	<0.00001	0.9	−3.21 (1.30)	0.02	0.5	−4.33 (1.21)	0.001	0.7		
Psychological Well-being Scale	5.54 (1.57)	0.002	0.6	5.38 (1.83)	0.007	0.5	2.29 (1.10)	0.05	0.2	2.93 (1.61)	0.09	0.2	*	
Pittsburgh Sleep Quality Index															
Total score	−1.24 (0.45)	0.01	0.5	−1.00 (0.59)	0.09	0.4	−1.18 (0.42)	0.01	0.4	−1.32 (0.43)	0.006	0.5			
Sleep latency	−0.39 (0.16)	0.02	0.6	−0.16 (0.16)	0.35	0.2	−0.57 (0.15)	0.0006	0.7	−0.48 (0.25)	0.01	0.6			
Sleep disturbance	−0.24 (0.10)	0.03	0.4	−0.30 (0.11)	0.01	0.5	−0.07 (0.11)	0.54	0.1	0.00 (0.12)	1.00	0.0			
Sleep duration	−0.08 (0.12)	0.54	0.1	−0.08 (0.15)	0.60	0.1	−0.43 (0.21)	0.05	0.4	−0.33 (0.18)	0.07	0.3			
Daytime dysfunction	−0.19 (0.11)	0.09	0.3	−0.12 (0.13)	0.36	0.2	0.00 (0.15)	1.00	0.0	−0.30 (0.14)	0.04	0.4			
Use of sleep medications	−0.46 (0.14)	0.003	0.5	−0.31 (0.14)	0.04	0.3	−0.04 (0.10)	0.71	0.1	−0.33 (0.16)	0.05	0.4			
Health related Quality of Life (SF-36)															
Mental Health Component	8.77 (3.13)	0.01	0.5	8.85 (3.25)	0.01	0.5	4.43 (3.46)	0.21	0.2	6.82 (3.28)	0.05	0.4	*		
Physical Health Component	3.15 (3.69)	0.40	0.2	2.00 (2.97)	0.50	0.1	4.17 (3.29)	0.22	0.2	1.90 (3.13)	0.55	0.1			
Role Emotional	12.82 (6.15)	0.05	0.4	5.13 (9.00)	0.57	0.2	10.71 (8.23)	0.20	0.3	14.81 (6.74)	0.04	0.4			
Energy/Vitality	10.00 (3.57)	0.01	0.5	13.46 (2.93)	0.0001	0.7	4.82 (3.05)	0.13	0.2	6.67 (3.09)	0.04	0.3	*(*)*	*(*)*
Emotional Well-being/Mental Health	9.85 (2.85)	0.002	0.6	9.54 (2.46)	0.001	0.6	4.86 (2.84)	0.10	0.3	1.63 (3.12)	0.61	0.1	*(*)*	*(*)*
Social Function	2.40 (4.80)	0.61	0.1	7.21 (3.41)	0.045	0.4	−2.68 (4.13)	0.52	0.2	4.17 (3.83)	0.28	0.2		
Physical Function	−3.08 (3.54)	0.39	0.2	2.12 (2.20)	0.35	0.1	0.71 (3.03)	0.82	0.0	−0.37 (3.53)	0.92	0.0		

	KK Meditation						Music Listening								
	Change at 12 weeks (Mean ± SE)	***p****	**ES**	**Change at 26 weeks (Mean ± SE)**	***p****	**ES**	**Change at 12 weeks (Mean ± SE)**	***p****	**ES**	**Change at 26 weeks (Mean ± SE)**	***P****	**ES**	***P*‡**	***P*‡ ‡**
Role Physical	11.54 (8.57)	0.19	0.4	0.96 (7.86)	0.91	0.0	2.68 (8.37)	0.75	0.1	1.85 (7.30)	0.80	0.1		
Pain	0.48 (3.75)	0.90	0.0	1.25 (3.91)	0.75	0.1	8.13 (3.00)	0.01	0.4	0.00 (3.65)	1.00	0.0		
General Health	4.62 (3.10)	0.15	0.2	3.65 (2.16)	0.10	0.2	5.18 (3.07)	0.10	0.3	6.11 (3.57)	0.10	0.3		

*Repeated measures ANOVA.

‡Between group difference, 12 weeks.

‡ ‡Between group difference, 26 weeks.

*$p < 0.05$.

(*) $p < 0.1$.

ES, effect size; SE, standard error.

Table 5

Relation between changes over time in mood, sleep, well-being, and quality of life in adults with subjective cognitive decline

Change from baseline	Change over time at 12 weeks						Change over time at 26 weeks					
	Mood	Stress	Well-being	Sleep Quality	QOL, Mental Health	QOL, Physical Health	Mood	Stress	Well-being	Sleep Quality	QOL, Mental Health	QOL, Physical Health
At 12 weeks												
Mood (POMS)		0.53‡ ‡	−0.40‡		−0.59‡ ‡	−0.22(*)	0.58‡ ‡	0.35**	−0.29*		−0.37**	
Perceived stress (PSS)	0.53‡ ‡		−0.45‡	0.37**	−0.46‡		0.50‡ ‡	0.72‡ ‡	−0.433**		−0.37**	
Emotional well-being (PWBS)	−0.40‡	−0.45‡		−0.32*	0.35‡	0.30*	−0.29*	−0.24(*)	0.70‡ ‡	−0.28*		
Sleep quality (PSQI)		0.37**	−0.31*		−0.31*	−0.38**		0.32*	−0.28*	0.62‡ ‡		−0.35**
Health-related QOL (SF-36)												
Mental Health Component	−0.59‡ ‡	−0.46‡	0.35**	−0.31*		0.43‡	−0.42**	−0.29*	0.27*	−0.29*	0.43‡	0.31*
Physical Health Component	−0.22(*)		0.30*	−0.38**	0.43‡					−0.37**		0.77‡ ‡
At 26 weeks												
Mood (POMS)	0.58‡ ‡	0.50‡ ‡	−0.29*		−0.42**			0.66‡ ‡	−0.47‡	0.35‡	−0.68‡ ‡	
Perceived stress (PSS)	0.35**	0.72‡ ‡	−0.24(*)	0.32*	−0.29*		0.66‡ ‡		−0.41**		−0.39**	
Emotional well-being (PWBS)	−0.29*	−0.433**	0.70‡ ‡	−0.28*	0.27*		−0.47‡	−0.41**		−0.28*	0.43‡	
Sleep quality (PSQI)			−0.28*	0.62‡ ‡	−0.29*	−0.37**	0.35‡		−0.28*	1	−0.29*	−0.32*
Health-related QOL (SF-36)												
Mental Health Component	−0.37**	−0.37**			0.43‡		−0.68‡ ‡	−0.39**	0.43‡	−0.29*		
Physical Health Component				−0.35**	0.31*	0.77‡ ‡				−0.32*		

(*) $p < 0.1$.

* $p < 0.05$.

** $p < 0.01$.

‡ $p < 0.001$.

‡ ‡ $p < 0.0001$.

POMS, Profile of Mood States; PSQI, Pittsburgh Sleep Quality Index; PSS, Perceived Stress Scale; PWBS, Psychological Well-being Scale; QOL, Quality of Life.

Table 6

Relation of changes over time in memory and cognitive function to those in mood, sleep, well-being and quality of life in older adults with subjective cognitive decline

Change from baseline	Change over time at 12 weeks								Change over time at 26 weeks								
	MFQ Total	MFQ Retro Mem	MFQ Forget	MFQ Seriousness	MFQ Mnemonic	TMT A	TMT B	DSST	MFQ Total	MFQ Retro Mem	MFQ Forget	MFQ Seriousness	MFQ Mnemonic	TMT A	TMT B	DSST	Memory concerns
At 12 weeks																	
Mood (POMS total)	−0.26**		−0.33‡	−0.19*		0.17(*)			−0.33‡		−0.43**	−0.27**		0.25(*)			−0.45‡
Perceived stress (PSS)	−0.30**	−0.31**	−0.24*	−0.18*					−0.28**		−0.38**	−0.28**		0.23(*)			
Emotional well-being (PWBS)		0.18(*)	0.29**			−0.17(*)			0.26**	0.25*	0.36**	0.16(*)				0.16(*)	
Sleep quality (PSQI)		−0.29*								−0.29*	−0.23(*)						
HrQOL (SF-36)																	
Mental Health Component	0.36**		0.37**	0.24(*)	0.26*	−0.24(*)			0.30*		0.37**			−0.26(*)			0.31*
Physical Health Component					0.45‡								0.37**				
At 26 weeks																	
Mood (POMS total)	−0.27**	−0.16(*)	−0.30**	−0.23*	−0.20*				−0.35‡	−0.29**	−0.40**	−0.26**					−0.31*
Perceived stress (PSS)	−0.37‡ ‡	−0.25*	−0.22*	−0.28**	−0.16(*)				−0.26**	−0.25*	−0.35*	−0.23*					
Emotional well-being (PWBS)	0.24*	0.22*	0.35**						0.36‡	0.24*	0.44‡	0.23*	0.25*			0.18(*)	0.33*
Sleep quality (PSQI)		−0.33*								−0.37**							
HrOOL (SF-36)																	
Mental Health Component			0.29*	0.33*					0.29*	0.25(*)	0.29*		0.26*	−0.27*			
Physical Health Component					0.41**								0.28*				

(*) $p < 0.1$.

* $p < 0.05$.

** $p < 0.01$.

‡ $p < 0.001$.

‡ ‡ $p < 0.0001$.

DSST, Digit Symbol Substitution Test; Freq, frequency; MFQ, Memory Functioning Questionnaire; MFQ domains: Forget, Frequency of Forgetting; Mnemonic, Use of Mnemonics; Retro Mem, Retrospective memory; Seriousness, Seriousness of forgetting; HrQOL, Health-related quality of life; PWBS, Psychological well-being Scale; POMS, Profile of Mood States; PSQI, Pittsburgh Sleep Quality Index; PSS, Perceived Stress Scale; TMT, Trail-making Test.