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Yoga meditation (YoMed) and its effect on proprioception and balance function in elders who have fallen: A randomized control study☆

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ABSTRACT

Objective: Yoga has been shown to improve muscle strength, flexibility, and balance. However, the impact of meditation on dynamic factors such as gait, reactive balance and proprioception has yet to be examined. The purpose of this study was to test if a novel yoga meditation program (YoMed) is as effective as a standard proprioceptive training in improving proprioception, balance and power in older individuals who have fallen.
Design: Sixteen older persons were randomly assigned to either the YoMed Group (YM) or Proprioception Training Group (PT). Each group received 45 min of training, 3 days per week, for 6 weeks. Pretest and post-test outcome measures were used to quantify the comparative effects of the interventions.
Setting: Research Laboratory.
Interventions: Yoga meditation and proprioceptive training.
Main outcome measures: The Balance Error Scoring System (BESS), the Tenetti Balance and Gait Assessment, dynamic posturography, joint position sense, joint kinesthesia and leg extensor power.
Results: The primary findings of the study were that neither the YM or PT intervention groups showed statistical improvements in any variable with the exception of the dynamic posturography overall score (DMA), which showed a significant improvement by the YM group ($d = 1.238$; $p = 0.049$). Additionally changes in a number of variables that did not reach significance demonstrated effect sizes in the medium to high range.
Conclusion: These results indicate the potential for the YoMed program to be used as a clinical intervention in older individuals. Given these results a longer study using a larger sample size and individuals at higher risk of falling is warranted.

1. Introduction

One of the major factors affecting fall probability in older persons is proprioception. Researchers have observed that proprioception declines with age[1]; and, decreased proprioception has been linked to gait disorders, decreased independence and greater fall risk.[2] Proprioception is a sense that considers position, motion and equilibrium through the integration of physical and neurological stimuli. It includes the capacities to sense joint position and joint motion, which are dependent upon mechanoreceptors in the joint capsule and ligaments.[3] The mechanisms that reduce proprioception with age have been reported. Muscle receptors provide the primary feedback for joint position sense; however, the roles of the ligamentous and joint capsule receptors cannot be disregarded.[4–6] In their review of aging and the somatosensory system Shaffer and Harrison[7] report that an integration of basic science and clinical evidence suggests that aging results in changes in the morphology and related declines in function of muscle and joint sensory structures; loss of large myelinated sensory fibers and receptors in the periphery; and therefore, generates impaired proprioception, vibration sense and balance. Additionally, age-related muscle stiffness and reduced range of motion,[8,9] due to connective tissue restructuring and joint damage due to subclinical knee osteoarthritis,[10] may further decrease proprioception.

Falls can have severe consequences for elderly persons including,

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morbidity, mortality, and loss of independence.[11] Although proprioceptive training can be of considerable benefit in reducing fall probability in older individuals, the methods currently in use, such as wobble boards, Bosu balls, and complex agility drills, are equipment-dependent and often too challenging for sedentary elders.

Motor imagery (MI) and action observation are two tools that have been used in healthy individuals to improve acquisition of motor skills. MI uses mental practice of a specific motor pattern to train performance without physical execution of the task.[12,13] The areas of the brain activated during movement execution and motor imagery show significant overlap. They include: the premotor cortex, inferior and superior parietal lobes, and the supplementary motor cortex.[14] Motor Imagery has been shown to improve motor performance, albeit not to the level of actual physical practice. An example of this type of training is the Feldenkrais Method, which uses verbal instruction to guide individuals through specific movement sequences improving both movement performance and body awareness.[15] The impact of MI on physical performance has been demonstrated in a number of functionally-limited populations including older individuals,[16,17] stroke victims,[18,19] spinal cord injured persons,[20] and Parkinson's patients.[21] There is also evidence that MI can increase neuromuscular performance variables such as strength and power;[22] however, this remains controversial.[23]

Concerning balance and proprioception, Taube et al.[24] demonstrated the positive impact of MI when training balance with and without external perturbation in a younger population. In older subjects, aged 65–90, Hamel and Lajoie[25] reported that MI significantly reduced anterior-posterior and lateral sway and anterior oscillations; however, no significant differences were found for the Berg balance score or Activities-specific Balance Confidence (ABC) scale. Finally, there is considerable evidence of the superior effect of combining MI and physical activity.[26,27] Pertinent to the current study, Alsubiheen et al.[28] examined the combined effect of eight weeks of Tai Chi and MI on improving balance in 29 sedentary people 40–80 years of age, 17 healthy subjects and 12 with diabetic neuropathy. Both diabetic and healthy subjects made significant improvements in the ABC, single leg stand, and functional reach tests with no significant difference between groups. The diabetic group did show the most benefit, likely due to their already reduced level of proprioceptive feedback.

An additional mechanism which produces similar responses in the nervous system to an actual movement is action observation. This type of training uses the putative mirror neuron system within the premotor and parietal cortices, and superior temporal sulcus of the right hemisphere, where the same neurons fire for an observed movement that fire for the physical performance of that movement.[29–32] Although the premotor and parental cortices are areas in which the firing of mirror neurons are most commonly observed, the supplementary motor area and motor cortex may also be involved when the observations are associated with impending analogous movements.[33] There is also information supporting the inclusion of the occipitotemporal cortex over the premotor cortex as a cite for the mirror neuron system[34]; and additional evidence that the cerebellum is part of the system.[35] A number of studies have demonstrated that observing a movement pattern can increase neuromuscular performance[36] and motor skill acquisition.[37,38] similar to physical performance; and movement initiation[39] and targeting of specific muscles[40] have been seen with observational learning.

The positive results produced by MI and action observations in clinical and non-clinical populations have led to the hypothesis that these techniques should be considered as tools for the improving function in individuals whose neuromuscular capacity is compromised through aging and disease.[41–43] Therefore, the use of both techniques in sequential combination, action observation followed by MI, may be especially valuable with older individuals where MI capacity is much lower when associated with an internal (imagining oneself performing a movement) compared to an external (imagining another performing the movement) perspective.[44] In this population, the use of action observation may "pave the way" for the more effective application of MI as a rehabilitative or preventative tool.

In this study we compared an accepted proprioceptive training program[45] to a yoga meditation program (YoMed), which concentrated on body awareness using action observation, MI, and physical performance in a sample of older fallers. The goal of the study was to test if the YoMed program is as effective in improving proprioception, balance and lower limb power as a proven proprioceptive training program. To our knowledge, no research has attempted to study the effect of yoga meditation on the physical aspects of proprioception and balance; although a number of retrospective studies have examined body awareness in yoga practitioners compared to non-practitioners.[46–48] The purpose of this study was to observe the effect of this unique program, YoMed, on proprioception and balance in older fallers and to compare its effectiveness to a traditional proprioceptive training protocol.

2. Materials and methods

2.1. Participants

Thirty-five subjects were recruited from the University staff and faculty and individuals living in the communities surrounding the University campus. The University's Internal Review Board for the Use and Protection of Human Subject approved the study. All subjects were informed of the potential risks and benefits associated with the study and provided written consent prior to participation. Eligibility criteria included: being between 50 and 90 years of age, having fallen within the past year, and having no uncontrolled cardiovascular or neuromuscular disease. Potential participants were also excluded from the study if they had been part of a formal training program that targeted lower body strength, balance or proprioception within the past six months; if they had been advised by a physician to not exercise; or if they regularly practiced yoga at least twice per week within the past six months. A health status questionnaire was used to determine if a prospective participant met all criteria.

A consort chart showing the flow of participants through the study is presented in Fig. 1. After recruitment, subjects were assessed for eligibility and filled out appropriate consent forms. Following consent, subjects were randomized into groups using an online random number generator (https://www.random.org/). Fifteen of the individuals were randomly selected to participate in the YoMed (YM) group (M = 2, F = 13) and fifteen participants were randomly assigned to the proprioception training (PT) group (M = 5, F = 10). The random number generator allowed randomization via atmospheric noise. The given values of 1 and 2, which corresponded to the YM and PT groups respectively, were set as minimum and maximum values within the generator. Once a participant was admitted to the study the generator algorithm was run with the previous stated parameters and participants were assigned either a 1 or 2, thereby determining which group intervention they would receive. Table 1 presents descriptive data for the sixteen older persons completed the study (YM = 6, PT = 10).

2.2. Intervention

The YM group met 45 min per day, 3 days per week, for a total of 6 weeks at a local yoga studio. During the training session, subjects were first guided through a 15-min body scan while in a seated meditation position. The body scan protocol used closed eyes and MI that brought awareness to the subject's present body position. The body scan began at the feet and worked upward. Students were asked to draw a mental image of the position of each segment, toes, foot, leg, thigh, core, thorax, upper arm, lower arm neck and head, and the angles of the joints between those segments, bilaterally. This was followed by a series of 18 gentle poses (Fig. 2). During the initial six sessions, the poses were demonstrated by the instructor (SW) and subjects moved to the position using observation of the instructor action and verbal cuing. Prior to