Arm movement improves performance in clinical balance and mobility tests

Article *in* Gait & Posture · March 2011

DOI: 10.1016/j.gaitpost.2010.12.005 · Source: PubMed

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Gait & Posture 33 (2011) 507–509

Contents lists available at ScienceDirect

Gait & Posture

journal homepage: www.elsevier.com/locate/gaitpost

Short communication

Arm movement improves performance in clinical balance and mobility tests

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ARTICLE INFO

Article history:
Received 5 May 2010
Received in revised form 26 November 2010
Accepted 7 December 2010

Keywords:
Arm movements
Clinical balance tests
Mobility
Falls prevention

ABSTRACT

Previous studies have suggested that arm movements can contribute to preventing the loss of balance or falls, and that aging affects the functions of arm movements. Clinical balance and mobility tests may be able to detect such aging effects. As the first step to approaching this question, the purpose of this pilot study was to investigate the effects of arm movements on the performance of clinical balance and mobility tests. Ten participants were evaluated in four clinical tests: (1) Maximal Step Length Test (MST), (2) Step Test (ST), (3) Timed Up and Go Test (TUG), and (4) Walk along an Elliptical Line (WEL). Each test was performed with free and limited arm movement and the outcomes were compared. Statistical analysis indicated a significant improvement in test performance when arms were used freely for three out of four tests (MST, ST and TUG), with inconclusive results on WEL. This pilot study showed improved performance on the clinical balance and mobility tests, suggesting that the contribution of arm movements is sufficiently large to be detected. This implies a feasibility for novel usage of clinical balance and mobility tests, i.e., to test the effectiveness of arm usage in balance and mobility.

1. Introduction

Falls are the most frequent cause of injuries among the elderly [1]. Falls among the elderly occur due to deterioration of various sensory and motor functions. It has been suggested that arms exhibit reactional movement in response to loss of balance during standing [2–4] and walking [5–7], and their deterioration related to aging has been investigated [2,3,5]. It has also been suggested that, in response to perturbations, arm movements contribute to preventing loss of balance or falls [3,5–7], and in reducing fall impacts following loss of balance [2,5]. Aging causes slowing [2,3] and reduction [2] of arm movements, and also changes the arm movements strategy, i.e., older adults exhibit a more 'protective' recovery strategy (to limit injury resulting from fall impacts following loss of balance) and younger adults exhibit a more 'preventive' strategy (to prevent loss of balance) [5].

To assess aging deterioration in postural balance and mobility, various clinical tests have been proposed [8–11], and significant relationships of these clinical balance and mobility tests with fall risk have been suggested [8,12,13]. Since arm movements are not evaluated in these clinical balance and mobility tests, the effectiveness of arm use can affect the performance of the clinical tests. If the arm restriction affects the performance of the clinical balance and mobility tests, the difference between restricted arm and free arm conditions may be used to evaluate the effectiveness and age-related deterioration of arm use in postural balance and mobility. However, it is not clear if the contribution of arm movements is sufficiently large to be detected by clinical balance and mobility tests. Therefore, the purpose of this pilot study was to investigate the effects of arm movements on the performance of clinical balance and mobility tests.

2. Methods

2.1. Subjects

Ten healthy volunteers, 5 males and 5 females, aged 52.9 ± 1.8 years (mean ± SD) height: 172.5 ± 9.2 cm (mean ± SD), weight: 79.8 ± 11.1 kg (mean ± SD) participated in this study. The participants had no background of neurological disease, no history or fear of falls, and no vestibular and/or somatosensory, cognitive or musculoskeletal impairments. All subjects gave written informed consent according to the principles of the Declaration of Helsinki, which was approved by the local institutional ethics committee.

2.2. Testing protocol

Standard clinical balance and mobility tests were conducted under two conditions: with limited and with free arm movements. To eliminate any learning effects, before data collection, participants were allowed to familiarize themselves with each test until they felt comfortable with performing the test. The participants were instructed to keep their arms flat against their body during one of the trials and to use them freely to their advantage during the other trial. The investigators ensured that the procedures were followed properly for all trials. The complete series of tests for each participant took approximately 15 min. The investigators were always available to assist the participants to complete the tests safely. All tests were completed without any interference from the investigators.

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0966-6362/$ – see front matter
doi:10.1016/j.gaitpost.2010.12.005

2.3. Clinical balance and mobility tests

The clinical balance and mobility tests were obtained from clinical and research tools [8,9]. Each test was performed with limited (arms at the side of the body) and free (natural) arm movements. The tests and measurements were:

- **Maximal Step Length Test (MST):** Beginning from a standing position, the participant was required to take a maximum step forward and return to the starting position, while keeping the other leg fixed [8]. Step time (tMST), step length (lMST), and speed of completion (sMST) were recorded.
- **Step Test (ST):** The participant was required to stand facing a wall, 5 cm from an 8.5 cm high block (41 cm x 72 cm) positioned against the wall, and to step on and off the block with both feet (one at a time) as many times as possible in 15 s. The total number of steps was counted [9].
- **Timed Up and Go Test (TUG):** Beginning from a sitting position, the participant was required to stand up, walk 10 feet forward, turn around, go back, and sit down on the chair. The time needed to execute the test was recorded [9,10].
- **Walk along an Elliptical Line (WEL):** Beginning from a standing position, the participant was required to walk along an elliptical path (major axis = 1.5 m, minor axis = 3 m) and return to the original position. The time needed to complete the task was recorded [11].

2.4. Statistics

Statistical comparison was performed using paired *t*-tests to compare the mean performance using SPSS v.17.0 software (SPSS Inc., Chicago, IL, USA).

3. Results

The results (Fig. 1) show significant improvements with free arm movements in three of the four tests (five out of the six test measures). The average tMST decreased by 0.47 s (16.4%) when participants were free to use their arms ($t = 3.217$, $p = 0.01$). The lMST increased by 12 cm (10.8%) when arms were used freely ($t = -5.840$, $p < 0.0001$). The sMST had the biggest improvement (40%) when arms were used freely ($t = -3.199$, $p = 0.01$). The results on the ST showed an increase of 3.6 steps (29.8%) during the test period ($t = -3.478$, $p = 0.007$). Performance on the TUG test improved; the time decreased by 0.73 s (11.2%) with active arm use ($t = 3.803$, $p = 0.004$). Only the results on the WEL test did not show statistically significant change ($t = 1.101$, $p = 0.300$), though the group average value was smaller by 0.38 s (5.3%) with free arm use compared to limited arms.

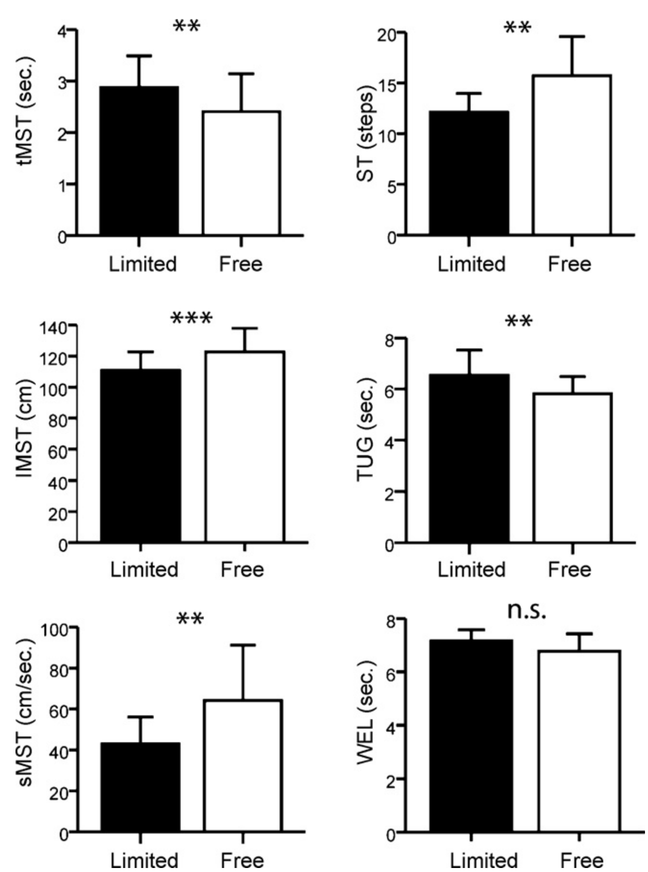

Fig. 1. Clinical balance and mobility test performance with limited and free arm movements. The values indicate the group averages and the error bars indicate the standard errors of the group mean. Legend: $^{**}p \leq 0.01$; $^{***}p \leq 0.001$; n.s.: not-significant.

4. Discussion

This study demonstrated that, except for the WEL test, the performance scores on the clinical balance and mobility tests improved when arms were used freely. This suggests that the contribution of arm movements in the performance of clinical balance and mobility tests is sufficiently large to be detected. The results imply that arm usage can affect the performance on these clinical tests, and can be detected by comparing the test results during restricted arm and free arm conditions. This implication can be utilized through a novel use of clinical balance and mobility tests to evaluate the effectiveness of arm use. It also suggests potential for training to improve use of arms in daily activities. An examination of this paradigm among the elderly populations should also be performed.

Previous studies have demonstrated that each performance measure appropriately assesses specific functions of balance ability. Improvements in the MST time, distance and speed indicate improved balance and mobility, and reduced risk of falls [8,12]. Decreased time on the test suggests a more effective change-of-support stepping strategy [3]. Increased step length suggests an increase in the participants' step comfort region and possibly region of stability. An increase in the ST score suggests a quicker recovery mechanism during the changes in the base of support in dynamic balance [12], which decreases the risk of falling [13]. The faster execution of the TUG test with free arm movements suggests that arms assist during one or some of the tasks of standing up, sitting down, walking or turning [10]. Our results clearly demonstrated that the arm movements can improve the performance of clinical balance and mobility tests.

In the current study, the WEL test did not show significant improvement, although there was a positive trend. It has been known for a long time that arm movement amplitude increases with walking velocity [14]. Further, recent studies have suggested that arm movements increase walking stability in steady walking [15] and balance recovery from trips [5]. Based on these previous studies, the maximum speed had been expected to increase with free arms but the results were not conclusive. Arm movement may not be critical for improvement in walking with maximum speed.

The limitation that the restricted arm condition was instructed but not measured or controlled in any physical way was seen as appropriate because these tests would normally be done in the clinic rather than in the lab. Likewise, the adequacy of the familiarization period was believed but not demonstrated. Therefore, further investigation on the contribution of arm movements is warranted.

Acknowledgements

The authors gratefully acknowledge Dr. Ken Norwich, University of Toronto, for his advice on the manuscript. We also acknowledge the Natural Sciences and Engineering Research Council (NSERC) of Canada (Grant No. 54196), for supporting this work.

Conflicts of interest statement

The authors have no conflicts of interest or financial relationships that could bias this work.

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