Performance of older adults under dual task during stair descent

Cui Zhang [a, b, *, 1], Wei Sun [a, b, 1], Qipeng Song [b, c], Houxin Gu [b], Dewei Mao [a, c]

[a] *School of Kinesiology, Shanghai University of Sport, Shanghai, China*
[b] *Sports Biomechanics Lab, Shandong Institute of Sport Science, Shandong, China*
[c] *School of Sport and Health, Shandong Sport University, China*

ARTICLE INFO

ABSTRACT

Background: Stair walking, especially in dual-task conditions, is a challenging daily routine for older adults. The purpose of this study is to investigate gait and postural control and explore the possible reasons for the fall risk encountered by healthy older adults under dual-task conditions during stair descent.
Methods: Thirty healthy older female adults (aged 67 ± 1 years, standing height of 1.64 ± 0.17 m, body mass of 66.01 ± 4.27 kg, and education of 8.92 ± 0.95 years) were randomly recruited from local communities and instructed to perform stair descent in a step-by-step manner on a standardized staircase under single-task (stair descent) and dual-task (stair descent with subtraction in series of three) conditions. Multivariate analysis of variance with repeated measures was performed to test the significance of multiple comparisons of kinematic variables in the single- and dual-task conditions. A paired *t*-test with Bonferroni adjustment was performed when a significant difference was detected.
Results: Gait speed, foot clearance, and hip flexion angle at the cross of the support leg decreased considerably, and step width increased remarkably among the healthy older adults under the dual-task condition relative to the situation in the single-task condition during stair descent.
Conclusion: The gait performance and posture control of the healthy older female adults were disturbed by the second cognitive task. These adults implemented a compensation strategy to enhance their body stability under the dual-task condition during stair descent.

Introduction

By 2050, approximately 400 million people worldwide will be over 80 years old.[1] Aging decreases mobility,[2] and this decrement leads to a decline in the number of daily activities, including level walking and going up and down stairs, that an individual can perform. This effect decreases the quality of life[3] and even contributes to falls[4] and death.[5] This scenario is likely to be burdensome for families and societies in developing and developed countries.

Stair walking is a routine activity and one of the five most difficult tasks for old adults.[6] More than four million old adults are treated for stair-related injuries in emergency departments annually in the United States, and 70.6% of them are women.[7] Compared with stair ascent, stair descent is more challenging[8] and requires greater mobility,[2] lower extremity strength,[9] and better balance control.[10] Daily stair descent which usually performs under dual-task conditions is particularly complicated.

A dual task typically requires performing a primary task while carrying out a concurrent secondary task.[9] It involves attention, working memory, executive functions, and other processes,[11,12] all of which can overload the cognitive function of the brain.[12] The cognitive function of adults decreases with age.[13] Therefore, performing dual tasks, especially during stair descent, is formidable for older adults.

Previous studies have found that under dual-task conditions, the motor and cognitive performance of younger adults decreases,[14] and the working memory and executive function of older adults decrease.[15] The hallux and heel trajectory of older adults also decrease.[11] However, the gait and posture control of older adults under dual-task conditions during stair descent have not been

* Corresponding author. School of Kinesiology, Shanghai University of Sport, 200 Hengren Road, Yangpu District, Shanghai, China.
E-mail addresses: grace_zc@sohu.com (C. Zhang), sunwei841024@163.com (W. Sun), songqipeng@163.com (Q. Song), 94761346@qq.com (H. Gu), deweimao@sina.com (D. Mao).
[1] Wei SUN and Cui ZHANG contribute to this work equally.

investigated, although these would contribute to the identification of the motion characteristics and mobility and stability deficits of older adults in such circumstances and could help prevent stair-related falls among such individuals.

The purpose of the present study is to investigate gait and postural control characteristics and explore the possible reasons for the fall risk encountered by healthy older adults under dual-task conditions during stair descent. The first hypothesis is that healthy older adults would perform a slower gait speed, narrower step width, and shorter single support time under a single-task condition than under a dual-task condition during stair descent. The second hypothesis is that healthy old adults would perform less foot clearance, greater pelvic and thorax movement, and less joint flexion of the swing leg under a dual-task condition than under a single-task condition during stair descent.

Materials and methods

Participants

Thirty healthy female older adults with right foot dominance, education of more than six years, and a Mini-mental State Examination score of more than 27 and without heart disease, joint replacements in lower extremities, arthritis, diabetes, visual deficits, vestibular deficits, falls in the last three years, or any type of neuromuscular problem that could prevent them from meeting the project requirements were recruited from three communities in Jinan, China (age of 67.0 ± 1.0 years, standing height of 1.64 ± 0.17 m, body mass of 66.01 ± 4.27 kg, and education of 8.92 ± 0.95 years). The participants enrolled voluntarily in this study and were blind to the hypotheses. The use of human participants in this study was approved by the Internal Review Board of Shandong Sport University. Each participant signed a written consent form before data collection.

Protocol

The experiment was conducted in a laboratory. Each participant was required to wear the same tight shirts, shorts, and standard shoes (Fig. 1). The participants were instructed to perform a 5 min warm up by walking at a self-selected speed, followed by stair

descent in a step-by-step manner under the two experimental conditions described below randomly. A standardized staircase (five steps in total, 17.00 cm riser × 29.00 cm tread × 150 cm width), which was used in a previous study,[10] was utilized (Fig. 2). The participants were given 1 min of rest between trials. Three trials were provided to enhance the familiarity of the participants with the protocol.

Experiment conditions

Two experimental conditions were assigned to each participant in a random order.

1) Single-task condition: Each participant was asked to perform stair descent at a self-selected speed.
2) Dual-task condition: Each participant was asked to perform stair descent while performing subtraction in a series of three from randomly selected numbers (a computer-generated list in the range of 100−300) aloud. The numbers were spoken out in native language by an instructor at the beginning of descent. The answers were recorded by an instructor while a participant was on the third step of the staircase.

Data collection

Thirty-five reflective markers were placed on selected critical body landmarks of each participant (Fig. 1). The 3D trajectories of the reflective markers on the participants at the third step of the staircase were recorded at a sampling rate of 100 Hz by eight infrared cameras (VICON, Oxford Metrics Ltd., Oxford, United Kingdom). Three successful trials were obtained for each condition. A successful trial was defined as that in which the participant continuously descended from the top of the staircase to the ground without pausing, adjusting his/her steps, calculating aloud, and losing any markers.

Data reduction

The raw 3D trajectories of the reflective markers were filtered using a fourth-order Butterworth low-pass digital filter at a cutoff frequency of 13 Hz.[16] The 3D trajectories of the hallux, heel, thorax, pelvis, hip joint, knee joint, and ankle joint were extracted with a

Fig. 1. 35 markers placed on participant.