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Research paper

Effect of visual acuity in older females on energy expenditure during obstacle navigation

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ABSTRACT

Objectives: To investigate the effects of good and poor visual acuities in older females on energy expenditure during obstacle navigation under different three conditions.
Methods: Nineteen older females living in the community were enrolled in the present study. Ten participants had a binocular visual acuity worse than or equal to 0.4 (logarithm of the minimum angle of resolution (logMAR) (poor binocular visual acuity [PBVA]) and the other nine had a binocular visual acuity better than or equal to 0.3 logMAR (good binocular visual acuity [GBVA]). An accelerometer was attached over the L3 spinous process and each participant walked at a self-determined speed, under three different conditions (bare foot, wearing socks, and navigating obstacle while wearing socks) on a GAITRite® mat. Differences in gait velocity and energy expenditure were analyzed using the independent *t*-test for comparisons between groups. The gait velocity and energy expenditure of the GBVA and PBVA groups, derived under the three test conditions, were analyzed via one-way repeated-measures analysis of variance.
Results: The gait velocity of the GBVA group was significantly faster than that of the PBVA group under the bare foot, wearing socks, and navigating obstacles while wearing socks. Whereas the energy expenditure of the GBVA group was significantly less than that of the PBVA group under the bare foot, wearing socks, and navigating obstacles while wearing socks. In addition, the gait velocity and energy expenditure of the groups differed significantly among the three experimental conditions.
Conclusions: The present study suggests that visual acuity in the older female influences both gait velocity and energy expenditure during obstacle gait. In addition, elderly subjects with PBVA exhibited inefficient walking patterns compared with those with GBVA, remarkably when foot sensory input was distorted and obstacles were present.

1. Introduction

Recent studies of population trends have indicated that longevity is increasing and the ratio of older adult population will rise worldwide. Thus, the demand for good quality of life in older age has increased [1,2]. Walking is an essential component of independent daily living and is very important in terms of quality-of-life. Effective walking characteristics include: efficient energy utilization, stability, and the ability to adapt to obstacles induced environments [3,4].

During walking, afferent sensory input plays an important role in adapting to challenging environments. The sole is an essential contributor to proprioceptive input and this sensory input provides information with respect to the contact surface in the service of maintaining postural control. Sensory information from the ankle also plays an important role during the regulation of appropriate step cycle duration and the avoidance of obstacles [5]. Before navigating an obstacle, vision allows us to identify obstacle such as height, depth, contrast of the distant edge, and size and recognized visual information is used for planning and controlling adaptive gait [6]. In addition, vision helps individuals stabilize balance by continuously providing information about their position and movement of body segments in the environment to the central nervous system [7]. Although the importance of vision in the maintenance of postural control increases with age [8], vision is a common problem in older adults [9]. Age-related degenerative changes caused by common eye diseases such as:

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cataracts, glaucoma, and macular degeneration, are leading causes of visual impairment which becomes one of the most important risk factors for falls in older people [8–10].

Previous studies have attempted to reveal the role of vision associated with balance and locomotor task in healthy subjects. In order to investigate effects of vision on balance and locomotion, visibility was intentionally manipulated. For example, participants were asked to close their eyes [11,12] and wear goggles [6,13].

These studies showed that decreased visual information of an environment resulted in increased gait variability and decreased accuracy of fine tuning lower limb trajectories. Even though many studies investigated the role of vision to maintain balance during locomotor tasks, these studies did not consider poor binocular visual acuity (PBVA) in normal person and diverse sensory conditions such as disrupted somatosensory input from the feet.

Improved methods of monitoring gait velocity and energy expenditure of physical activity help to indicate the efficiency of functional movement and movement pattern. When moving, humans utilize the pendulum properties of legs and the elastic properties of muscles [14]. Physical activity is any body movement created by the musculoskeletal system which results in energy expenditure [15]. Because acceleration is proportional to the net external force involved, and is therefore directly reflective of energy expenditure, measurement of physical activity via acceleration is preferred to physical activity assessment via measures of velocity [16]. The advantages of an accelerometer include a small size, accuracy, and the ability to continuously record data [17]. Thus, clinicians can readily evaluate the energy expenditure of older people during performance of functional exercise [15,18]. The preferred step rate seems to be associated with conservation of energy expenditure [14]. Walking slower or higher than the optimal speed increases the energy expenditure of walking [3].

Therefore, the purpose of this study was to investigate the effects of good and poor visual acuities in older females on energy expenditure during obstacle navigation under different three conditions (bare foot, wearing socks, and navigating obstacle while wearing socks).

2. Materials and methods

2.1. Subjects

The sample size in this study was determined from a pilot study with 6 subjects. G-power 3.1.2 software (Franz Faul, University of Kiel, Kiel, Germany) calculated a required sample size of 16 subjects (good binocular visual acuity [GBVA] = 8 subjects, poor binocular visual acuity [PBVA] = 8 subjects) with a significant level of .05, power of .95, and effect size of 1.96 (calculated by mean and standard deviation from the pilot study). In the pilot study, the PBVA group consisted of subjects 79.33 ± 1.53 years of age (mean $\pm$ standard deviation [SD]) with an average height and weight of 146.93 ± 0.68 cm and 50.80 ± 6.68 kg, respectively, and left side visual acuity (VA) and right side VA of 0.53 ± 0.06 and 0.53 ± 0.15, respectively. The GBVA group consisted of subjects 77.0 ± 5.57 years of age (mean $\pm$ SD) with an average height and weight of 147.07 ± 3.74 cm and 50.17 ± 4.30 kg, respectively, and left side VA and right side VA of 0.23 ± 0.06 and 0.2 ± 0.01, respectively.

A total of 19 elderly females living in Gyeongsangnam-do, South Korea, participated in the present study. The elderly females were recruited by word of mouth and telephone. The PBVA group ($n = 10$) consisted of individuals with corrected binocular visual acuity (BVA) worse than 0.4 logarithm of the minimum angle of resolution (logMAR), and the GBVA group ($n = 9$) consisted of individuals with corrected BVA of better than 0.3 logMAR [19]. The inclusion criteria were as follows: (a) older than 65 years of age with corrected above BVA of 0.4 logMAR or below BVAs of 0.3 logMAR; (b) the ability to walk independently without any assisting device; and, (c) a score of over 24 on the Korean Version of the Mini-Mental State Examination. The exclusion criteria were as follows:

- any past or present neurological disorder;
- the presence of any musculoskeletal disease that interfered with daily activities;
- any significant visual, auditory, and vestibular impairment;
- the use of drugs that could influence the results of the present study;
- participation in any regular exercise program within the past 6 months.

Each subject provided their informed consent before participating in the study. This study was approved by the Inje University Faculty of Health Sciences Human Ethics Committee.

2.2. Apparatus

2.2.1. The GAITRite System

Gait velocity was measured using the GAITRite System (CIR Systems, Easton, PA, USA), which is a reliable tool used to assess temporal and spatial gait parameters [20]. The system's active area was 61 cm wide and 366 cm long. The sensors were placed 1.27 cm apart, providing a total of 13,824 sensors and covered with a roll-up carpet that provided an active measurement area activated by mechanical foot pressure on the mat. Data from the activated sensors were collected by a computer at a sampling rate of 80 Hz. Gait parameters were identified and calculated automatically. After two practice trials under barefoot condition, we measured the walking velocities of all participants under three experimental conditions (bare foot, wearing socks, and obstacle while wearing socks), and mean values from three trials under each condition were used in data analysis.

2.2.2. The Fitmeter Accelerometer

A tri-axial accelerometer (FitLife, Suwon, Korea) was used to measure energy expenditure during walking under three different conditions. The accelerometer was $35 \times 35 \times 13$ mm in dimensions and weighed 13.7 g (Fig. 1). The sensor range was from -8 G to 8 G, and could be modified using inbuilt software (Fitmeter Manager 2, version 1.2.0.14). We removed gravity acceleration from the raw data included x, y, and z coordinates of acceleration due to energy expenditure. Moreover, we calculated the single vector magnitude by summing the acceleration of the three axes. We selected a measurement range of $\pm$ 2 G. The accelerometer was fixed, using double-sided adhesive tape, over the L3 spinous process [21]. Data were collected at a sampling rate of 32 Hz and the values summed over specified time periods.

Fig. 1. Fitmeter Accelerometer.