Abstract This preliminary study examined the influence of various obstacle heights on the walkway in the timed “Up & Go” (TUG) test on test performance and reliability. Seventeen healthy young men participated in the original TUG test and in the TUG test with an obstacle (TUGO). In TUGO tests, subjects stood up from a chair, walked 5 m on a path that required stepping over an obstacle (0, 3, 5, 10 and 17 cm in height), turned 180°, returned to the chair stepping over the obstacle again and sat down. They were instructed to move as fast as possible. The following parameters were measured: total time required to complete the test, time needed to walk to the obstacle or return, time for turn, single support time pre- and post-stepping over the obstacle (pre- and post-single support times), and distances between each single support foot and the obstacle (pre- and post-single support distances). The total time required for TUGO tests showed very high intra-class correlation coefficients (0.96–0.99) and had significant relationships to that of the TUG test and all gait property parameters regarding time. The results of ANOVA showed that the total time required was significantly shorter with obstacle heights from 0 to 10 cm than it was at the 17 cm height. Turn time, pre-single support time and post-single support distance were longer with obstacle heights over 5 cm as compared to the 0 cm height. Post-single support time was significantly longer at the 17 cm height than at the other heights. Reliability of the TUGO test was very high. The total time required was significantly longer at the 17 cm obstacle height. Even at the relatively low 5 cm obstacle height, turn time, pre-single support time and post-single support distance were longer.

Key words TUG test • Obstacle • Young adults

Introduction

Among basic movements in daily life, movements of shifting the center of gravity or using lower limbs such as walking, standing up, sitting down and turning over the body position are frequently used. Functional physical mobility, in addition to dynamic balance ability, relates closely to the accomplishment. Particularly, walking is achieved by repeating advanced dynamic balance control as follows: shifting the center of gravity out of the support base, collapsing dynamic equilibrium and recovering equilibrium again [1]. Physical mobility declines with impairments of vestibular or visual organs [2–5], but it decreases with age even in healthy persons [6]. It is necessary to objectively assess the functional mobility in the elderly because the decline restricts various activities in daily life and quality of life [7].

The decrease of functional mobility is also a major factor in increasing fall incidence [8]. Moreover, control or cessation of physical activities due to the fear of falling and a decline of functional mobility accelerate, the decline of muscular function in the lower limbs, further enhance the risk of...
failing, and markedly decrease the quality of life [9–11]. Assessing mobility is, therefore, important also from a viewpoint of preventing fall accidents.

Podsiadlo and Richardson [12] developed the timed “Up & Go” (TUG) test to evaluate functional mobility by using basic mobility skills in daily life, and suggested that it was a useful screening test for identifying elderly who are apt to fall [12]. Shumway-Cook et al. [13] enforced the TUG test for community-dwelling older adults, and reported that the total time required differed between groups with or without a history of falls in the past 6 months.

Falls from tripping, which are a major problem in the elderly, frequently result in serious injury [14–17]. Pavol et al. [15] reported that 53% of fall accidents are due to tripping. The TUG test includes basic mobility tasks in daily life such as standing up, walking, turning, and sitting down, but introducing an obstacle as a cause of tripping is not considered. Chujo et al. [18] reported that obstacles on the walkway influence gait properties. Functional mobility to evade an obstacle in daily life may be measured by a modified version of the TUG test. This study examined the influence of various obstacle heights on the total time required for the TUG test.

Materials and methods

We selected 17 healthy young male adults of mean age 21.7 years (SD=2.4), mean height of 173.5 cm (SD=5.9) and mean body weight of 67.3 kg (SD=6.9). The subjects' physical characteristics were almost the same as the age-matched national standard value [19]. Before the measurements, the purpose and procedure of this study were explained in detail and informed consent was obtained from all subjects.

Experimental procedure

The following five obstacle heights were used in this study: 0 cm (no obstacle; control condition); 3 cm (typical height of the threshold of houses); 5 cm [17]; 10 cm; and 17 cm (one-step height of stairs). The obstacle was put just before the turning point 5 m from a chair. The trial order for each subject was assigned randomly using a random table.

The walking distance of the TUG test proposed by Podsiadlo and Richardson [12] was 3 m. In pilot studies we observed that subjects begin walking with an unnatural step while they adjusted the distance to an obstacle in the TUG test at 3 m because the walking distance was too short. We selected 5 m to observe in detail the gait properties during stepping over an obstacle (Fig. 1). Experiments were performed on a Walkway MG-1000.

All subjects were instructed to sit on a 46-cm high chair, stand up at the tester's start signal, walk 5 m on a path that included an obstacle, turn the body 180°, return to the chair stepping over the obstacle again, and sit down (Fig. 1). They were instructed to perform each movement as fast as possible. A tester measured the time from standing up until sitting down on the chair again with a stopwatch. The obstacle was 20 cm deep and 120 cm wide, and of a high contrast color (off-white) to the floor for best visibility. Subjects practiced once and performed three trials with a 1-min rest. A mean value of their three trials was used in further statistical analysis.

Parameters

The total times required for the original TUG test and for the TUG test with an obstacle (TUGO) were measured in 1/10 second units. To evaluate gait properties during stepping over an obstacle, we defined the pre-single support leg (foot) as the support leg just before stepping over and the post-single support leg as that just after stepping over (Fig. 2). Going time (from T1 to T2 in Fig. 2), returning time (from T5 to T6) and turning time (from T3 to T4) were calculated using data from the gait analysis system. Pre-single support time and distance were the time from T2 to T3 and the distance from T3 to the obstacle, respectively. Post-single support time and distance were the time from T4 to T5 and distance from T4 to the obstacle, respectively.

Statistical analysis

Trial-to-trial reliability of the total time required and parameters of gait for each obstacle height condition were examined using in-

![Fig. 1 The TUGO test. In this test, subjects: 1. Stand up from a chair; 2. Walk and step over the obstacle; 3. Turn 180° in an arbitrary direction; 4. Return to the chair and sit down again](image-url)