CHAPTER 3

METHODS

3.1 Participants

Forty-five participants (15 healthy young adults, 15 healthy older adults, and 15 older adults with balance impairment) were recruited into the study.

3.1.1 Inclusion criteria

1) For healthy young adults, aged between 20 and 30 years old

2) For healthy older adults, aged 65 years old and older who had Berg Balance Scale (BBS) $\geq$ 52 (out of a total of 56 points) (Appendix A) (24, 25)

3) For older adults with balance impairment, aged 65 years old and older who had BBS < 52 and had a self-report of one or more falls in the previous 12 months. Scoring less than 52 on the BBS is associated with a decline in the ability to maintain balance (45) and has been extensively used as a cut-off score to distinguish older adults with balance impairment from healthy older adults (25, 46-48)

4) Able to walk continuously at least 10 meters without any assistive devices

5) Able to follow simple instructions based on the cut-off point of the Mini-Mental State Examination-Thai 2002 (MMSE-Thai 2002; Appendix B) (49)

3.1.2 Exclusion criteria

1) Severe neurological, musculoskeletal, cardiopulmonary problems that might affect gait performance (such as cerebrovascular accident, Parkinson's disease, severe osteoarthritis, and Chronic Obstructive Pulmonary Disease)

2) Uncorrected visual impairment

3) Severe auditory impairment (such as hearing loss)

4) Severe depressive symptom based on the cut-off point of the Beck Depression Inventory (BDI; Appendix C) (50, 51)

5) Taking alcohol 24 hours before testing

The study was approved by the Faculty of Associated Medical Sciences research ethic committee and written informed consent was obtained from each participant prior to enrollment into the study.

3.2 Procedures

Following informed consent, participants completed a personal data collection form providing age, sex, education level, medical history, current co-existing medical conditions, self-reported history of falls and history of imbalance, and list of prescription medications (Appendix D). A fall was defined as "an unplanned, unexpected coming to rest on the ground or nearby supporting surfaces such as a chair, a counter, or a wall" (6, 16). Imbalance was defined as "a trip, slip, or other loss of balance in which recovery occurred to prevent a fall" (52). Prior to being admitted into the study, participants had undergone a balance test using the Berg Balance Scale, a global cognitive test using the Mini-Mental State Exam-Thai 2002, and an emotional well-being test using the Beck Depression Inventory (BDI).

Persons were eligible for the study if 1) they scored more than 16/23 (for illiterate people), more than 20/30 (for finished primary education level people), and more than 23/30 (for finished secondary education level people) on the MMSE-Thai2002 (49), and 2) they scored less than 30/63 points on the BDI (50, 51).

Participants admitted into the study were first instructed to perform the secondary tasks while seated. For the counting backward by 1 and by 3s tasks, the participants were asked to count backward by 1 (i.e. the "counting backward by 1" task) and 3s (i.e. the "counting backward by 3s" task) as fast and as accurate as they could from any randomly chosen two digit number within thirty seconds while seated. For the tray carrying task, they were asked to sit while carrying a tray with a full glass of water (3 mm. from the edge of the glass) with their dominant hand without spilling any water on the tray within thirty seconds. For the walking tasks, they were asked to walk between two strips of tape (normalized to each participant as 50% of their anterior superior iliac spine width) for 8 meters on the GAITRite (CIR system, USA) electronic walkway at their self-selected walking speed under four conditions: 1) walking without any secondary tasks; 2) walking while performing the "tray carrying" task; 3) walking while performing the "counting backward by 1" task; and 4) walking while performing the "counting backward by 3s" task. Start and stop lines were marked on the floor 2 meters from each end of the 4 meter GAITRite walkway to eliminate the effects of acceleration and deceleration. For the walking while performing tray carrying task, each participant was asked to walk while carrying a tray with a full glass of water (3 mm. from the edge of the glass) with their dominant hand without spilling any water on the tray. For the walking while performing counting backward tasks, participants were instructed to count backward by 1 (i.e. the

"counting backward by 1" task) and 3s (i.e. the "counting backward by 3s" task) from any randomly chosen two digit number (Figure 7).

Three different instructions were given for all dual-task conditions: 1) focus on both tasks equally; 2) focus on narrow walking task; and 3) focus on the secondary task. The second and third conditions were randomly assigned to the participants. For the "focus on both tasks equally" condition, the participants were asked to pay the same amount of attention on the gait task and secondary task. For the "focus on narrow walking task" condition, they were asked to focus primarily on the narrow walking task by walking without stepping onto or outside each strip of tape. Finally, for the "focus on the secondary task" condition, they were asked to allocate most of their attention to the secondary tasks by not spilling any water during the tray carrying task and by counting backwards as fast and as accurate as they could during the counting backward task. Three trials of each task prioritization were performed in each condition. With 3 prioritization conditions for each dual-task walking condition, a total of 30 walking trials were performed for each participant. Before performing the tests, two practice trials of single-task walking task were given to allow participants to become familiar with the walking task. In addition, enough rest was provided between testing sessions. To ensure safety, a belt was placed around each participant's waist for easy grasp by a research assistant who walked beside the participants during all walking trials.

A digital camera that records at 10 Hz was used to record the number of missteps during the "narrow walking" task. An MPEG-1 Audio Layer 3 player was also used to record the verbal responses on the "counting backward by 1 and 3s" task.
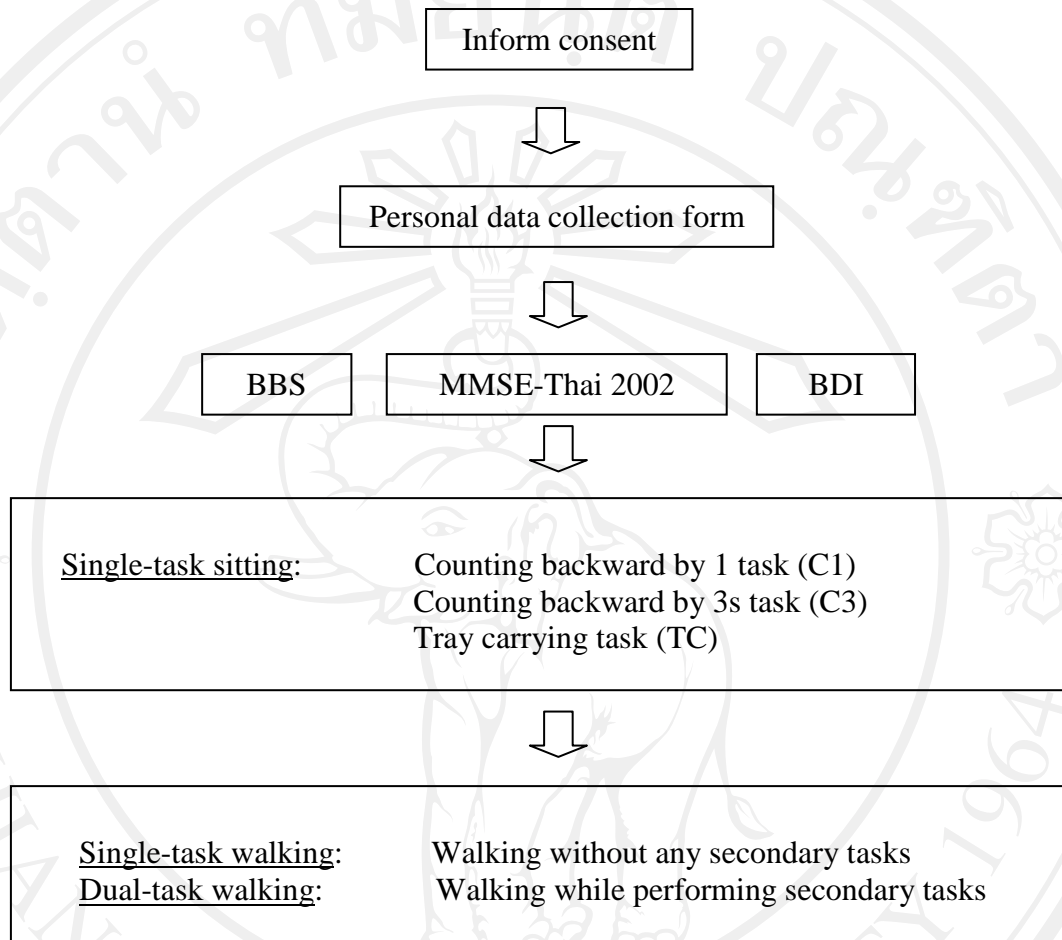
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Single-task sitting: Counting backward by 1 task (C1)
                            Counting backward by 3s task (C3)
                            Tray carrying task (TC)

Single-task walking: Walking without any secondary tasks
Dual-task walking: Walking while performing secondary tasks

Figure 7 Procedures of the study

3.3 Outcome measures

3.3.1 Independent variables

3.3.1.1 Group:

1) Healthy young adults (HYA)

2) Healthy older adults (HOA)

3) Older adults with balance impairment (OABI)

3.3.1.2 Secondary task characteristic:

1) Manual task (i.e. tray carrying task; TC)

2) Easy cognitive task (i.e. counting backward by 1; C1)

3) Difficult cognitive task (i.e. counting backward by 3s; C3)

3.3.1.3 Instructional set:

1) Focus on both tasks equally condition (FB)

2) Focus on the narrow walking task condition (FN)

3) Focus on the secondary task condition (FS)

3.3.2 Dependent variables

Dependent variables were the averaged score for the following parameters

3.3.2.1 Primary outcome measures: Gait parameters

1) Gait speed (m/s): the distance covered in a given amount of time, which is obtained after dividing the distance traveled by the ambulation time

2) Stride length (m): the distance between the heel points of two consecutive foot prints of the same foot

3) Step width (m): the distance perpendicular to the line of progression between two successive heel- strikes

4) Swing time (s): the time elapsed between the last contact of the current footfall to the first contact of the next footfall

5) Cadence (steps/min): number of steps within a given time

6) The rate of missteps (steps/min): number of stepping onto or outside each strip of tape within a given time

Gait speed, stride length, step width, swing time, and cadence were measured using the GAITRite system automates.

3.3.2.2 Secondary outcome measures

1) Tray carrying task parameter:

The rate of spilling water: the number of times that the participant spilled

water within a given time

2) Counting backward task parameters:

The rate of verbal responses: the average number of responses to

mathematics questions within a given time

The rate of accuracy responses: the average number of correct responses

divided by the total number of answers given

3.4 Equipment

1)   Personal data collection form

2)   GAITRite system, (CIR system, USA) is a carpet 460 cm long with an

active sensor area of 366 cm long and 61 cm wide with sensor pads (12.7

mm apart from each other) and a sampling frequency of 80 Hz.

3)   Stopwatch (JS-307)

4)   Measuring tape

5)   Stool (a height of 16 centimeters)

6)   Chair (a height of 45 centimeters)

7)   Masking tape

8)   Digital video camera (Fujifilm FinePix F450)

9)   MPEG-1 Audio Layer 3 player (Creative MuVo TX FM)

10) Tray with a glass of water

11) Training belt

3.5 Sample size

To estimate the number of participants to be recruited into the study, the sample size was calculated using G*Power based on Siu's studies (24, 25). Using a power of 0.8, a small effect size, and a 0.05 alpha level, the estimated total sample size was 39. With a 10% attrition rate, 45 participants were recruited into this study.

3.6 Statistical analysis

Descriptive statistics were used to describe the demographic features in the study participants. A 3-way mixed-effect repeated measures analysis of variance (ANOVA) was used to determine the 3 groups (healthy young adults, healthy older adults, older adults with balance impairment) $\times$ 3 task characteristics (manual, cognitive-easy, cognitive-difficult) $\times$ 3 prioritizations (focus on both tasks equally, focus on gait task, focus on secondary task) interaction effect. Post hoc analyses of significant interaction effect were conducted using pairwise comparisons with a Bonferroni correction. To examine the effects of secondary task on gait parameters under each walking condition, a 2-way mixed effects repeated measures ANOVA was performed, using a Bonferroni adjustment. The significant level was set at $p < 0.05$. All statistical analysis was performed in SPSS (SPSS, Inc., Chicago, IL, USA).

3.7 Location

This study was conducted in the Laboratory room at the Department of the Physical Therapy, Faculty of Associated Medical Sciences, Chiang Mai University.