CHAPTER 3

Methods

3.1 Participants

Twenty-two older adults were recruited into the study through flyers posted in the surrounding communities and by an announcement through community leaders and primary health care providers. The study was approved by the Faculty of Associated Medical Sciences research ethics committee, Chiang Mai University and written informed consent was obtained from each participant prior to enrollment into the study.

3.1.1 Inclusion criteria:

1) aged 65 years or older
2) able to walk continuously at least 10-meters without the assistance of another person or a walking aid
3) able to follow instructions

3.1.2 Exclusion criteria:

1) an unstable medical condition such as uncontrolled hypertension or diabetes
2) present with severe neurological, musculoskeletal, cardiopulmonary problems such as cerebrovascular accident, Parkinson's disease, severe osteoarthritis, or Chronic Obstructive Pulmonary Disease
3) visual impairment uncorrectable with conventional lenses
4) lower limb amputation or arthroplasty
5) taking alcohol 24 hours before testing
6) had any injuries to the lower extremities that could affect their ability to walk

3.2 Procedures

Eligible participants were informed about the study purposes and testing protocol prior to signing an informed consent. Following informed consent, participants completed a personal data collection form providing information on age, sex, education level, medical history, and list of prescription medications (Appendix A). Then, leg length was measured from greater trochanter to lateral malleolus.

Gait was assessed simultaneously with two systems: GAITRite and smartphone-based accelerometer. All participants were asked to walk barefoot along a 10-meter walkway at their self-selected comfortable walking speed. Two markers placed on the ground were used to indicate the start and end of the 10-meter path, with the GAITRite (CIR Systems Inc., Sparta, NJ, USA) walkway placed in the middle of this path. To measure steady state gait, only the middle 4.27 m active sensor area was used to examine the gait parameters to eliminate the effects of acceleration and deceleration.

During all walking trials, participants carried a smartphone (Vivo X5, Android OS) in one of five locations (Figure 3.1):

1) body: attached to the body above third lumbar vertebrae in a horizontal orientation;
2) bag: in a shoulder bag (size 15 x 18 cm) placed in a horizontal orientation;
3) belt: on a belt attached above the front right pant pocket in a horizontal orientation;
4) hand: in the right hand, held in the telephone speaking position;
5) pocket: in the front right pant pocket in a vertical orientation.

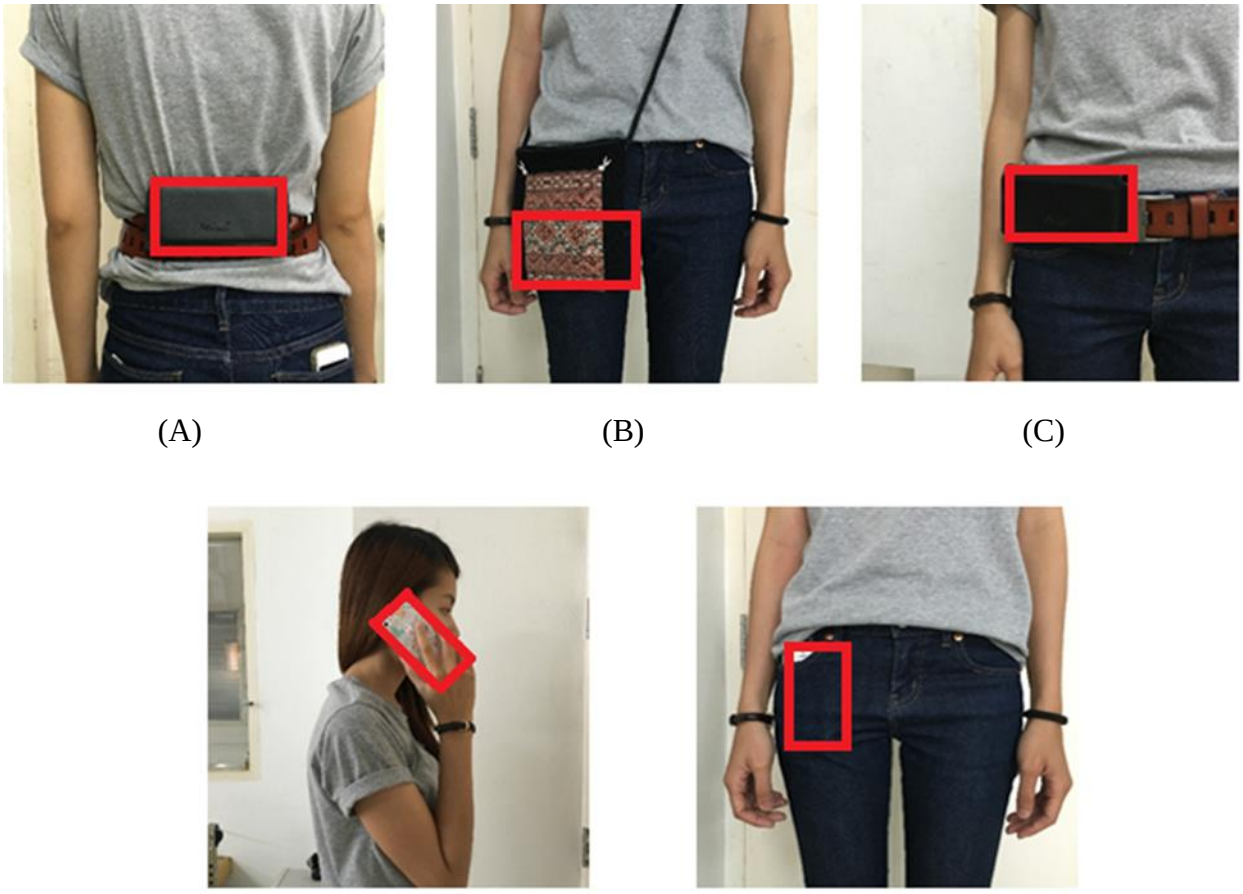

Figure 3.1 Location of smartphone: (A) body, (B) bag, (C) belt, (D) hand, and (E) pocket (33)

The location of the smartphone was randomized. With two trials performed for each phone location, a total of 10 trials were performed by each participant. Moreover, enough rest was also provided between trials. To determine the validity for individual footsteps, the participants were asked to start walking with their right foot. The investigator counted their steps from the start to the end of the walkway in each trial. Only those steps that were collected concurrently with GAITRite and the smartphone-based accelerometer were analyzed. In addition, a digital video camera was used to record all walking trials. Both GAITRite and the smartphone-based accelerometer were reset after each walking trial. A flow chart of the study procedure is shown in Figure 3.2.

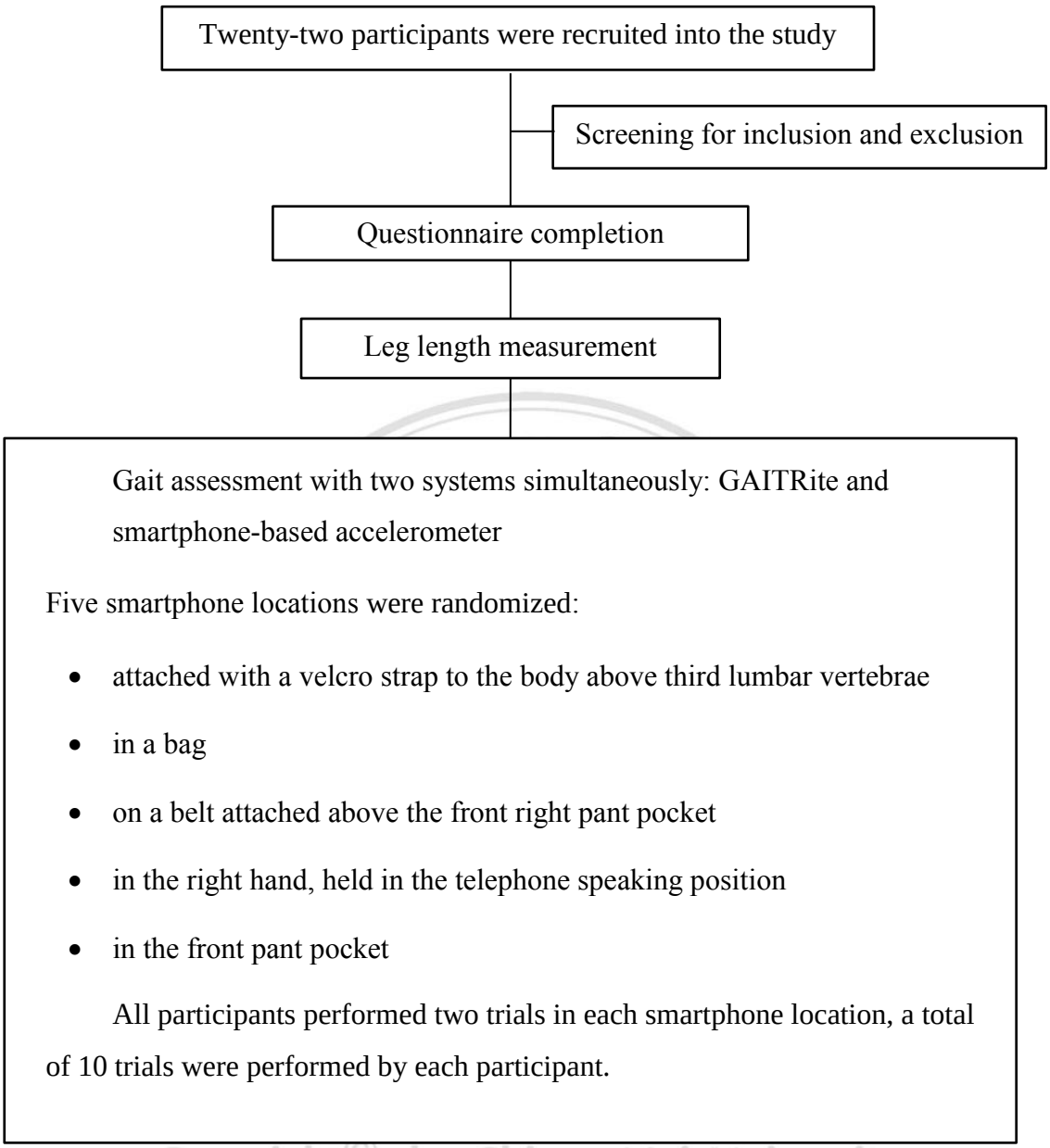

Figure 3.2 Flow chart of the study procedures

3.3 Data acquisition

Gait data obtained from the GAITRite system were used as a gold standard. The GAITRite dimensions measure 5 meters long and 0.6 meters wide. The spatial accuracy of the walkway was 1.27 cm and allows for a sampling frequency of up to 80 Hz. Spatiotemporal gait parameters such as gait velocity, step length, and step time were reported automatically through the GAITRite software.

A custom-built Android application (target SDK version 4.3 Jelly Bean; API level 18) was used to collect system time and tri-axial accelerometer data from the built-in hardware-sensor at the smartphone's maximum sampling frequency (100 Hz). All data obtained were downloaded following the completion of the data collection and analyzed using custom written programs in MATLAB (Mathworks Inc., Natick, MA, USA) on a laptop. Evaluations of gait velocity, step length, and step time were calculated based on algorithms previously described (27).

3.4 Outcome measures

3.4.1 Independent variables: The location of the smartphone

1) Body (attached with a Velcro strap to the body above L3)
2) Bag (in a bag)
3) Belt (on a belt attached above the front right pant pocket)
4) Hand (in the right hand, held in the telephone speaking position)
5) Pocket (in the front pant pocket)

3.4.2 Dependent variables: Spatiotemporal gait parameters

1) Gait velocity (m/s): velocity of the individual over the course of all recorded steps, which was obtained as the ratio of the total distance traveled and the ambulation time.
2) Step time (s): the time elapsed from the first contact of one foot to the first contact of the contralateral foot.
3) Step length (m): measured on the anterior-posterior axis of the walkway as the heel point of the current footfall to the heel point of the previous footfall on the opposite foot.

3.5 Equipment

- Questionnaire related to demographic information, health conditions. (Appendix A)
- GAITRite system automates (CIR system, USA), a carpet 5-m long with 16,128 pressure sensors, sampling rate 80 Hz. The walkway's active measurement area is 0.61 m wide and 4.27 m long. Sensors are arranged in a grid pattern (48 × 336) and placed 1.27 cm on center.
- Smartphone (Vivo X5, Android OS, v4.4.4 (KitKat))
- Measuring tape
- Bag (size 15 x 18 cm)
- Belt
- Phone sleeve
- Velcro strap
- Laptop with MATLAB (v2016a, Mathworks Inc., Natick, MA, USA)
- Digital video camera (Samsung, EC-PL151 Dual View Camera 5x)

3.6 Sample size calculation

The sample size was calculated based on the results of the vertical center of mass displacement parameter from Furrer's study (22) using G*Power 3.1.9.2. With a power of 0.8, effect size of 0.55 and a 0.05 alpha level, the estimated sample size was 22.

3.7 Statistical Analysis

Descriptive statistics were used to describe participant demographics. For the evaluation of the validity, the data obtained by the two different measurement devices (smartphone and GAITRite system) were compared using Pearson correlation coefficients (r). Correlation r-values of 0.90-1.00 were considered very high, 0.70-0.90 high, 0.50-0.70 moderate, 0.30-0.50 low and less than 0.30 negligible (34). Bland-Altman was used to demonstrate bias and 95% limits of agreement between the two equipments against their mean.

A two-way repeated measures analysis of variance (ANOVA) were used to examine differences between locations (body vs. bag vs. belt vs. hand vs. pocket) and equipment (GAITRite vs. smartphone) for gait outcome measures. Statistical significance was considered at an alpha level of $p < 0.05$. Post hoc analyses of significant interaction effects were conducted using pairwise comparisons with a Bonferroni correction. All data were analyzed in SPSS 20.0 (IBM Inc., Armonk, NY, USA).

3.8 Data collection location

Data collection took place at the Department of Physical Therapy, Faculty of Associated Medical Sciences, Chiang Mai University.