CHAPTER 4

Results

4.1 Participant characteristics

Twenty-two older adults were recruited into the study. The demographic characteristics of the participants are shown in Table 1. All participants completed the protocol as prescribed, though three trials (0 body, 1 bag, 0 belt, 1 pocket, and 1 hand) from 3 participants could not be analyzed due to technical issues with the smartphone, leaving 217 trials for further evaluation.

Table 4.1 Demographic characteristics of the participants

Variables	Mean ± SD	Range (min-max)
Age (yr)	73.91±5.62	65-89
Weight (kg)	58.52±9.88	39-80
Height (cm)	157.16±8.44	143-171
BMI (kg/m^2)	23.69±3.59	17.93-33.74
Leg length (cm)	79.26±4.51	71.75-88.25

4.2 Concurrent validity of measurements

Results of validity analysis comparing gait parameters between the smartphone-based and GAITRite-based systems across smartphone location are presented in Table 4.2. For step length, the correlations between the two systems showed moderate to high correlations (r = 0.614 – 0.868) for all locations, except the hand location (r = 0.458). For step time, the body, bag, and hand conditions indicated high to very high correlations, ranging from 0.784 – 0.961. However, the pocket and belt conditions showed low to moderate correlations (r = 0.474 and 0.543, respectively). Gait velocity correlations were high to very high (r = 0.712 - 0.917) across all locations.

Step length biases ranged from 0.2-1.8 cm when the smartphone was placed on the body, bag, belt, or pocket. The hand condition demonstrated larger bias (11.5 cm). Step time bias ranged from 0.2-2.9 ms for all locations. Gait velocity bias ranged from 0.005-0.043 m/s when the smartphone was placed on either the body, bag, belt, or pocket. The hand condition demonstrated larger biases (0.206 m/s). Moreover, as shown in Figure 4.1-4.3, Bland-Altman analysis revealed that biases approached zero, particularly in the body, bag, and belt conditions. Across gait measures, smaller limits of agreement were demonstrated in the body and bag conditions, with larger differences found in the belt, hand, and pocket locations.

Table 4.2 The validity of the step length, step time, and gait velocity across smartphone locations

Variables	Location	GAITRite	Smartphone	Validity			
		Mean ± SD	Mean ± SD	r	Bias	LOA Lower	LOA Upper
Step length (m)	Body	0.56 ± 0.07	0.54 ± 0.08	0.868*	-0.013	-0.090	0.064
	Bag	0.55 ± 0.07	0.54 ± 0.09	0.800*	-0.011	-0.113	0.091
	Belt	0.55 ± 0.07	0.53 ± 0.08	0.614*	-0.018	-0.151	0.115
	Hand	0.56 ± 0.07	0.44 ± 0.08	0.458*	-0.115	-0.270	0.040
	Pocket	0.54 ± 0.07	0.53 ± 0.09	0.684†	-0.002	-0.130	0.126
Step time (sec)	Body	0.54 ± 0.06	0.54 ± 0.06	0.961†	-0.002	-0.033	0.029
	Bag	0.55 ± 0.06	0.54 ± 0.05	0.834*	-0.006	-0.068	0.057
	Belt	0.55 ± 0.06	0.52 ± 0.07	0.543*	-0.024	-0.143	0.096
	Hand	0.54 ± 0.06	0.53 ± 0.06	0.784*	-0.012	-0.088	0.065
	Pocket	0.56 ± 0.06	0.53 ± 0.06	0.474*	-0.029	-0.159	0.100
Gait velocity (m/s)	Body	1.04 ± 0.21	1.02 ± 0.21	0.917*	-0.022	-0.190	0.146
	Bag	1.03 ± 0.20	1.01 ± 0.21	0.900*	-0.014	-0.198	0.169
	Belt	1.03 ± 0.24	1.03 ± 0.16	0.821*	-0.005	-0.277	0.267
	Hand	1.05 ± 0.21	0.85 ± 0.18	0.712*	-0.206	-0.504	0.093
	Pocket	0.97 ± 0.20	1.01 ± 0.20	0.750*	0.043	-0.234	0.321

Abbreviations: SD, Standard deviation; r, Pearson's Correlation; Bias, Mean Difference (Smartphone – GAITRite); LOA, Limits of agreement.

*P < 0.001.

†P < 0.05.

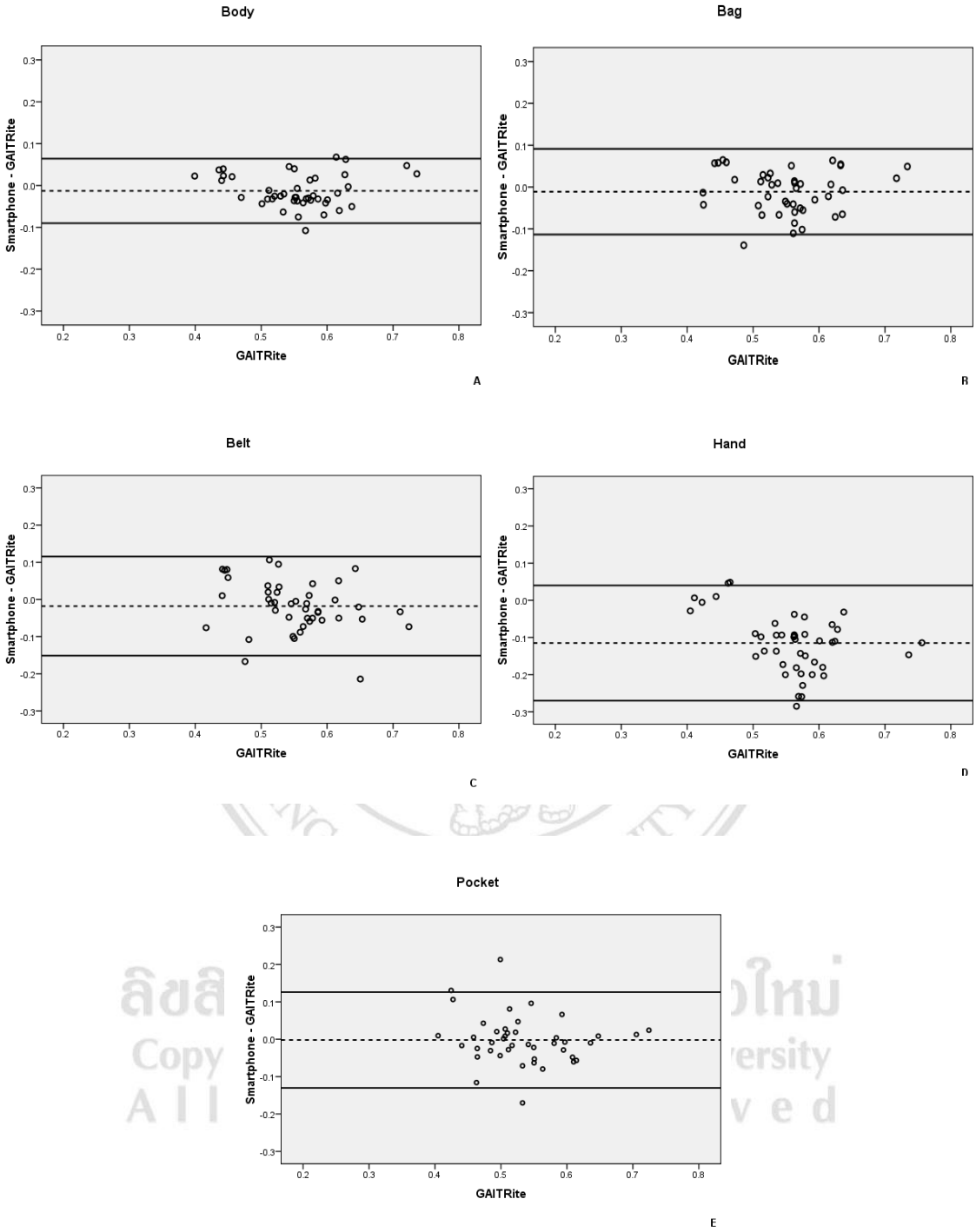

Figure 4.1 Bland-Altman plots for step length, when using the smartphone-based accelerometer compared to GAITRite. The dashed line is the average difference, with the solid lines providing the repeatability coefficient (± 1.96 SD).

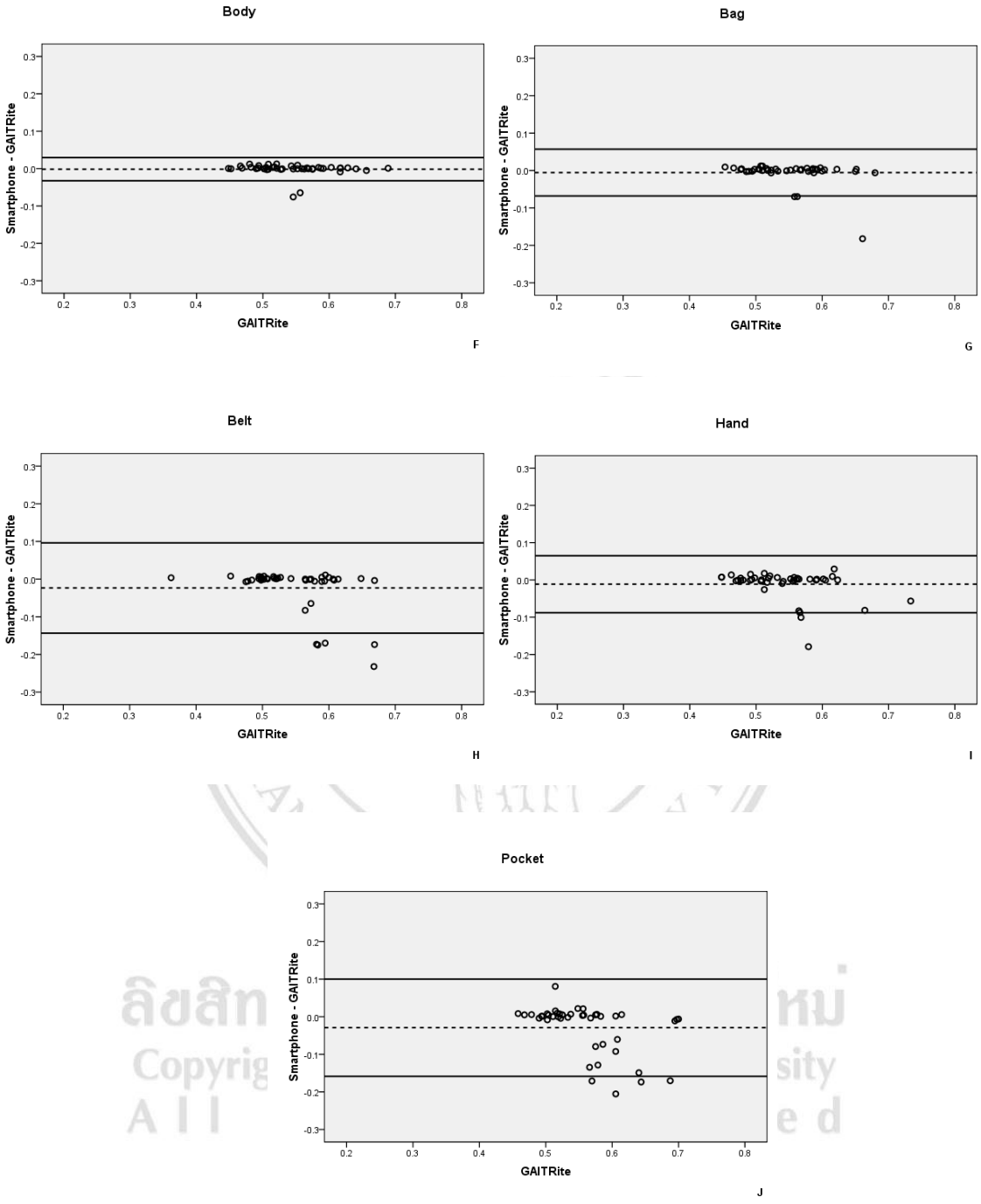

Figure 4.2 Bland-Altman plots for step time, when using the smartphone-based accelerometer compared to GAITRite. The dashed line is the average difference, with the solid lines providing the repeatability coefficient (± 1.96 SD).

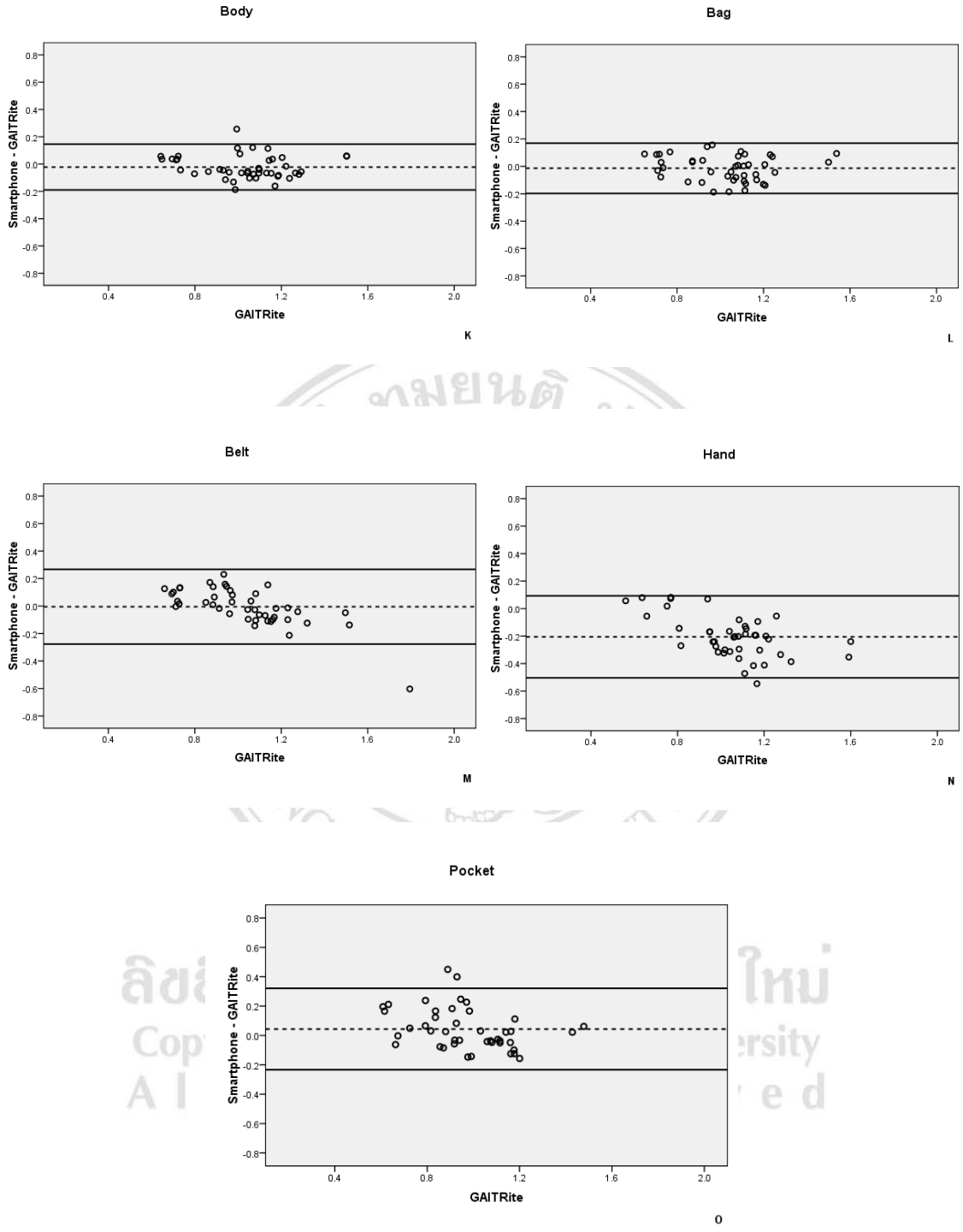

Figure 4.3 Bland-Altman plots for gait velocity, when using the smartphone-based accelerometer compared to GAITRite. The dashed line is the average difference, with the solid lines providing the repeatability coefficient (± 1.96 SD).

4.3 Gait parameters derived from the smartphone-based accelerometer and GAITRite across smartphone locations

The results of the repeated-measures ANOVA showed that the equipment × location interaction was significant for step length, step time, and gait velocity (P<0.001, 0.049, and <0.001, respectively; Table 4.3). Follow-up analyses revealed that the gait parameters (i.e. step length and gait velocity) derived from the smartphone-based accelerometer were equivalent to those derived from GAITRite across all locations, except the hand (P<0.001 for step length, and gait velocity). For step time, no significant difference was found between data derived from the two systems.

In addition, the results from GAITRite revealed that when carrying a smartphone in the pocket, older adults walk with shorter step length compared to the bag and hand location (P=0.001 and 0.001, respectively), longer step time compared to the body and hand location (P=0.001 and <0.001, respectively), and slower gait velocity compared to the body, bag, and hand location (P<0.001, <0.001, and <0.001, respectively). Meanwhile, gait parameters derived from smartphone-based accelerometer demonstrated that when carrying a smartphone in the hand, older adults walk with shorter step length compared to other locations (P<0.001), and slower gait velocity compared to other locations (P<0.001). However, the step time derived from smartphone-based accelerometer was equivalent across all locations.

Table 4.3 Gait parameters derived from two equipment across smartphone locations (Values presented as mean ± standard deviation)

Gait variables	GAITRite (Mean ± SD)					Smartphone (Mean ± SD)					*P**
	Body	Bag	Belt	Hand	Pocket	Body	Bag	Belt	Hand	Pocket	
Step length (m)	0.56 ± 0.08	0.55 ± 0.07	0.55 ± 0.07	0.56 ± 0.08	0.53 ± 0.07	0.55 ± 0.08	0.54 ± 0.09	0.53 ± 0.09	0.44 ± 0.08	0.52 ± 0.08	<0.001*
Step time (s)	0.55 ± 0.06	0.55 ± 0.06	0.55 ± 0.07	0.54 ± 0.06	0.56 ± 0.06	0.54 ± 0.06	0.54 ± 0.05	0.52 ± 0.06	0.53 ± 0.06	0.53 ± 0.06	0.049*
Gait velocity (m/s)	1.04 ± 0.22	1.03 ± 0.21	1.03 ± 0.24	1.06 ± 0.23	0.97 ± 0.20	1.02 ± 0.22	1.01 ± 0.22	1.02 ± 0.17	0.84 ± 0.18	1.00 ± 0.20	<0.001*

NOTE. 2-way repeated-measures ANOVA showed significant difference at $p \leq 0.05$

*Equipment x location interaction effect as calculated by using 2-way repeated-measures ANOVA