Title: Sensorimotor performance and reference values for fall risk assessment in community-dwelling adults - The Yishun Study

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ABSTRACT
Objective: What are the reference values of sensorimotor performance for fall risk in community-dwelling adults? How do our population norms compare to that of other populations? Are younger adults at risk of falls?
Methods: **In a cross-sectional study design,** sensorimotor functions and fall risk scores of community-dwelling adults were assessed and calculated to derive corresponding fall risk categories. Reference values were determined using the average scores by age-group. A total of 542 community-dwelling adults were recruited (21-90 years old) across 10-year (21-60 years) and 5-year age-groups (>60 years) to obtain a representative sample of community-dwelling adults in Singapore. We assessed five physiological domains: vision, proprioception, muscle strength, reaction time and postural balance, according to the Physiological Profile Assessment (PPA). Fall risk scores and the corresponding fall risk profiles were generated from an online calculator.
Results: Sensorimotor performance and PPA fall risk scores **were significantly worse for increasing age categories** (p<.01). Females had significantly slower reaction time (p<.001), lower muscle strength (p<.001) and higher fall risk (p=.008). Our representative sample of older adults (≥65 years) performed poorer in postural sway (z=-0.50) and reaction time (z=-0.55), but better in proprioception (z=0.29) and vision (z=0.23) compared to Caucasian norms. Among younger adults (21-59 years), 36.8% appeared to exhibit **higher** fall risk.
Conclusions: **Our study presents important reference data and compared sensorimotor functions and physiological fall risk across the age groups of community-dwelling adults in a South-East Asian population. Poor sensorimotor performance and fall risk** appear already pertinent in younger adults. **Further studies are warranted to improve our understanding of fall risk among younger adults**.
Impact Statement: In physical therapy practice, PPA reference values can aid clinicians in the development of targeted interventions tailored towards an individual's physiological risk profile, addressing specific physiological systems that require particular attention.

INTRODUCTION

Aging is associated with an increased fall risk and fall-related injuries. The prevalence of falls in community-dwelling older adults increases from 30% among those 65 years and older to 40% among octogenarians,[1] attributable to a decline in sensory inputs from the visual, proprioceptive and vestibular systems,[2,3] **low muscle mass, strength and function**,[2,4,5] and an impairment in balance and coordination.[1] Given the associations with debilitating consequences including loss of independence, decreased quality of life and injury-related mortality,[6,7] age-related fall risk and falls are a major public health concern.

The causes and risk factors for falls are complex and multifactorial[8]; thus, a comprehensive fall risk assessment requires multidomain evaluations. Various fall risk assessment tools, including the Timed Up-and-Go test (TUG),[9] Short Physical Performance Battery (SPPB)[10] and the Berg Balance Scale (BBS),[11] have been well-validated with acceptable levels of sensitivity and specificity,[12] and are considered clinically viable in their screening for fall risk. However, these assessment tools do not provide detailed information regarding the impairments of the respective physiological domains, and can be less useful in directing appropriate intervention strategies.[13] **A recent systematic review and meta-analyses on fall risk assessment concluded that the predictive validity of the tools currently used is not sufficient, and that the use of a large variety of fall risk assessment tools in the elderly does not identify elderly fallers with sufficient accuracy.[12] The Physiological Profile Assessment (PPA)[2] has not been included in the review and the TUG (pooled sensitivity of 0.76 and low inter-study heterogeneity) was the only physical performance test recommended.[12]**

In comparison, the PPA[2] is an **objective** 'impairment profiling' approach **to fall risk assessment** that **evaluates** the sensorimotor functions and quantifies the contributions of five physiological systems **that are required for successful motor performance** – vision, proprioception, muscle strength, reaction time and postural stability.[14] **With information on which specific physiological systems require particular attention, clinicians can develop targeted intervention and treatment strategies to address patients with higher fall risk. These physiological capacities have been tracked over the age spectrum and in individuals with different diseases (e.g. multiple sclerosis, Parkinson's disease).[14]** The PPA **compares favorably and is significantly correlated with other physical performance assessments such as the Ten-step Test (Spearman's correlation, r=0.25, p<.05), Static Balance Test (r=0.23, p<.05), Functional Reach Test (r=-0.23, p<.05), TUG (r=0.27, p<.05) and SPPB**

(*r*=-0.33, *p*<.001).[7,13] PPA also exhibits intra- and inter-rater reliability,[8] provides objective indications of fall risk and direction for tailored intervention,[13] and **shows good discriminatory ability for falls,[14]** capable of discriminating between multiple and non-multiple fallers with **75% sensitivity and specificity**.[2] In addition, the PPA battery, with the inclusion of postural sway and leaning balance assessed through coordinated stability and maximal balance range, has been shown to be useful in predicting mobility-related disability **(AUC=0.81, 95% CI 0.77-0.85)**.[15]

The PPA was developed and widely validated through a series of prospective cohort[16,17] and large-scale cross-sectional studies (n=1789),[18] however, its normative database is derived from Western populations,[16-19] and the reference data may not be appropriate for Asian populations who performed differently in physiological tests compared to Caucasians,[20] **and who are known to differ from Caucasians in regards to ethnicity, body size, lifestyles, and cultural backgrounds.[21]** In addition, there are few PPA studies in Asian populations **available to establish an Asian database and to validate the use of PPA among Asian populations.**[7,22] To our knowledge, no study has investigated the normative trends of physiological profiles and sensorimotor performance across the age groups of community-dwelling young, middle-aged and older adults.

The main objective of this study was to provide reference values of sensorimotor performance parameters for fall risk across the age groups (≥21 years) in a South-East Asian population of community-dwelling adults. **Furthermore, we explored if:** 1) **sensorimotor performance** norms of our population are different from Caucasian populations, and whether 2) younger adults are **also** at risk of falls.

METHOD

Design

In a cross-sectional study design, sensorimotor functions of vision, proprioception, muscle strength, reaction time and postural balance were measured according to the Physiological Profile Assessment (PPA) short version.[2] The PPA fall risk scores were calculated, and corresponding fall risk categories derived using the *NeuRA FallScreen® Falls Risk Calculator* (https://fbirc.neura.edu.au/fallscreen). Reference values were determined using the average scores according to age groups. **This study is part of a larger study involving the collection of normative data on physical and cognitive measures of community-dwelling adults in**

Singapore. Participants were required to attend the laboratory at the Geriatric Education and Research Institute (GERI) for a one-off data collection session lasting three hours on average.

Participants

Community-dwelling adults (≥21 years) were recruited from a large north-eastern residential town of Yishun in Singapore, residential population of 220,320 (50.6% **females**) with 12.2% older adults (≥65 years),[23] similar to the overall residential population in Singapore of 4,026,210 (51.1% **females**), with 14.4% older adults (≥65 years).[23] Random sampling was employed to obtain a representative sample of approximately 300 **male** and 300 **female** participants, filling quotas of 20-40 participants in each sex- and age-group (10-year age-groups between 21-60; 5-year age-groups after 60). Conventionally, the sample size of 30 or greater per age-group is sufficient for normative measures.[24] Between October 2017 and February 2019, using two-stage random sampling, 50% of all housing blocks were selected, and 20% of the units were approached for participant recruitment. Between March and November 2019, 50% of all housing blocks were randomly selected and all units approached. Up to three eligible participants were recruited from each unit. Non-response units were re-contacted a second time at a different time of day on a later date. Older adults (>75 years) were additionally recruited through community sources and from a list of registered participants in four senior activity centres. Exclusion criteria were: individuals with disabilities, injuries, fractures or surgeries affecting function, neuromuscular, neurological and cognitive impairments, or more than five poorly-controlled comorbidities. Those who are pregnant or planning for pregnancy were also excluded. Overall response rate was 39.0%. Ethics approval was obtained from the National Healthcare Group DSRB (2017/00212). All respondents signed informed consent before participating in the study.

Outcome measures

Physiological Profile Assessment (PPA)

The PPA short version comprised assessments for five physiological domains[2]:

a. Vision (Melbourne Edge Contrast Sensitivity Test; MET) – Twenty circular patches with edges of reducing contrast are placed approximately 40 cm away from the participant. A four-alternative forced-choice method was used to determine the participant's lowest contrast sensitivity. The last correct answer was recorded.

b. Proprioception (Position Sense) – Participants were required to match their lower limbs on either side of a protractor-inscribed clear acrylic sheet with their eyes closed. The average degree of deviation (five trials) was recorded.

c. Muscle Strength (Knee Extensor Strength; KES) – Knee extensor strength (KES) was assessed **in kilograms (kg)** using a spring gauge strapped 10 cm above the ankle joint with hip and knee joints positioned at 90 degrees. The higher of two trials on the dominant side was recorded.

d. Reaction Time – This test comprises a hand-held electronic timer with a light as the stimulus and depression of a switch by the finger as the response. The average **time in milliseconds (ms)** of ten trials were recorded.

e. Postural Balance (Postural Sway) – A 40 cm-long rod with a vertically-mounted pen was attached to the participant's waist posteriorly. Standing on a foam rubber mat with eyes open, the participant attempts to stand as still as possible for 30 s. Total sway area (i.e., maximum mediolateral times anteroposterior displacement) was calculated **in squared millimetres (mm^2)** and recorded.

A fall risk score was generated online **based on their performance in the five physiological domains outlined above (a. to e.)** for each participant using the *NeuRA FallScreen® Falls Risk Calculator*, corresponding to one of six fall risk assessment profiles: 'Very Low' (PPA score: -2 to -1), 'Low' (-1 to 0), 'Mild' (0 to 1), 'Moderate' (1 to 2), 'Marked' (2 to 3) and 'Very Marked' (3 to 4). **These categorizations are derived from the weighted scores of the five physiological tests through discriminant function analysis of large-scale studies.[2,16-18] The PPA has been shown to be correlated with other physical performance assessments of fall risk, such as static balance, SPPB, sit-to-stand, dynamic balance (measured with the functional reach test) and TUG.[7]**

Additionally, leaning balance was assessed using the Maximal Balance Range (MBR) and Coordinated Stability (CS) tests,[25] **in which the same 40 cm-long rod was attached to the participant's waist anteriorly. In the MBR, participants were required to "lean forward from the ankles without moving the feet" as far forward and backward as possible, to the point just before losing balance, and the maximal anteroposterior distance traveled and indicated by the pen was measured.[25] The MBR test assesses the limits of a participant's anteroposterior dynamic stability, where a greater distance measured indicates better leaning balance. For the CS, participants were required to take the pen through a 1.5 cm-wide course by bending or rotating at the hips and knees without moving the feet. A total**

error score was calculated by "summing the number of occasions the pen failed to stay within the path,"[25] where a higher score indicates poorer dynamic balance and postural control. The CS test measures the participants' capacity for balance regulation through synchronized and controlled movements at the hips and upper body when leaning close to the limits of their equilibrium.[25]

Data analysis

SPSS version 22 (Chicago, Illinois, USA) was used for statistical analysis. Prevalence of PPA fall risk assessment categories were extrapolated to the general population weights by age groups. **Reference values** for PPA and each of the five sensorimotor component scores **were presented as mean (standard deviation)** for each age group. Standardized Z-scores, in relation to the population norms of a representative group of Caucasian Australians (≥65 years),[16-19] were derived from the online FallScreen Calculator. **Pearson correlations were employed to assess the associations of PPA score and its components with age, while sex** differences were compared using independent t-tests. **Participants were additionally stratified into young (<65 years) and old (≥65 years), with interaction and main effects of age and sex investigated using two-way ANOVA.** Statistical significance was set at $p<.05$.

RESULTS

A total of 542 participants (57.9% **females**) aged 21-90 years were recruited. Due to incomplete data from two participants, data from 540 participants were **analyzed**. Of these, 81.5% were Chinese, 8.7% Malays, 7.0% Indians, and 2.8% from other races. Mean age was 58.6 (18.7) years.

Sensorimotor Functions and PPA Scores

Average sensorimotor performance scores and corresponding PPA scores are presented in **Table 1. A significant interaction effect of age and sex was found for KES ($p<.001$). A significant main effect of age in the absence of interaction effects was found for** MET, proprioception, reaction time, KES, postural sway, MBR, CS and overall PPA scores ($p<.01$; **Table 2**), **where the older adults had poorer performance than the younger adults. A significant main effect of sex was found for** reaction time ($p<.001$), KES ($p<.001$), CS ($p=.006$) and overall PPA score ($p=.008$), where females had slower reaction times, weaker KES, poorer CS and higher overall fall risk than men.

Prevalence of Fall Risk Categories

The overall population-adjusted percentages for fall risk assessment profile were 12.5% (Very Low), 39.5% (Low), 32.0% (Mild), 11.6% (Moderate), 3.2% (Marked) and 1.1% (Very Marked; **Table 3**). In older adults (≥65 years), the percentages were 2.0% (Very Low), 13.9% (Low), 31.7% (Mild), 32.3% (Moderate), 13.7% (Marked) and 6.4% (Very Marked; **Figure 1**), compared to 16.4% (Very Low), 46.9% (Low), 31.0% (Mild), 5.0% (Moderate), 0.8% (Marked) and 0.0% (Very Marked) in younger adults (21-59 years). The combined prevalence of those with marked and very marked fall risk **were** 0.8% (21-59 years), 14.2% (≥60 years), 20.1% (≥65 years) and 40.4% (≥75 years).

Standardized Z-Score Comparisons

In relation to the population norms derived from a representative group of Caucasian Australians (≥65 years),[16-19] our representative sample of older adults (≥65 years) performed poorer in postural sway (z=-0.50) and reaction time (z=-0.55), but better in proprioception (z=0.29) and MET (z=0.23; **Figure 2**). Among the younger adults (21-59 years), **higher** fall risk is mainly due to poor performance in reaction time and proprioception (**Figure 3**).

DISCUSSION

In this study, we present reference values for the sensorimotor functions: vision, proprioception, muscle strength, reaction time and postural balance; and derived PPA fall risk scores and the corresponding fall risk assessment profiles across the age groups of community-dwelling adults in Singapore. Our population-adjusted prevalence of PPA fall-risk assessment profile for older adults (≥60 years) were 1.9% (Very Low), 18.8% (Low), 34.9% (Mild), 30.2% (Moderate), 9.9% (Marked) and 4.3% (Very Marked), similar to those reported in Hong Kong[22] and Malaysia.[7]

Our analyses revealed significant **sex** differences in KES and reaction time, findings that paralleled those of other studies,[22,26-28] resulting in higher overall fall risk for females.[29-31] Sex-specific hormonal differences contribute to disparities in muscle strength, with higher testosterone levels in males exhibiting anabolic effects on muscle that lead to greater muscle mass and strength compared to females.[26] **Additionally, individuals with a shorter stature and lower body weight are known to have poorer muscle strength compared to their taller and heavier counterparts.[32] On average, males are significantly taller and heavier than females, which could have contributed to the sex differences found in KES.** Although widely reported that males have faster reaction times than females,[22,27,28,33] to date, it is still unclear why this is the case. A meta-analysis by Thomas and French concluded that the **sex** differences in reaction times are unlikely to have a biological basis, and are more likely to be a result of environmental factors.[33] Males in general have greater participation in competitive sports and games, as well as video games,[34] from a young age, and thus had more opportunities to practice the motor skills related to reaction time and processing speed.[34] More recent studies have suggested that although muscle contraction time is similar between males and females, males have comparatively stronger motor responses than females,[27,28] which could explain the finding that males have faster reaction times. Clearly, more studies are needed to elucidate our understanding of the apparent **sex** differences in reaction times that consequently result in greater physiological fall risk in females.

Standardized Z-score comparisons of the sensorimotor functions **suggested** that on average, our representative sample of older adults (≥65 years) performed poorer in postural sway and reaction time, similar in KES, and better in proprioception and MET compared to the population norms of a representative group of Caucasian Australians (≥65 years). Siong et al. also reported significant population differences in the sensorimotor performance of older Hong Kong adults compared to the Caucasian population,[22] indicating that PPA fall risk scoring should be done from localized epidemiological studies rather than through comparisons with another population's normative database. In this respect, our study contributes important data to the reference values of sensorimotor performance in Asian, and specifically Singaporean, populations.

Our data suggests that sensorimotor performance may start to deteriorate from early adulthood, worsening exponentially with age, and could result in an exacerbated fall risk. Although very prominent (79.3%) in old age (≥60 years), **higher** fall risk due to a deterioration in sensorimotor functions, particularly reaction time and proprioception, is already pertinent (36.8%) in young and middle-age (21-59 years), indicating that falls and fall-related injuries arising from **poor physiological function** may not be exclusive to the older adults. **Further studies may be warranted to improve our understanding and expectations of balance and fall risk especially among younger adults, and in the long-term, better inform the design of intervention strategies for this population in clinical practice.**

This study has several limitations. **We did not have access to data of Caucasian populations, so comparisons were made using standardized Z-scores of established Australian norms that were generated from the Fallscreen online platform. These results need further confirmation with statistical comparison of population data that the present study has provided.** Our study presents cross-sectional data on the sensorimotor functions and corresponding physiological fall risk of Singaporeans. There could be cohort effects and may not be a true representation of the longitudinal changes experienced by aging individuals. Prospective follow-ups that track the actual falls incidence were not performed, thus, the PPA fall risk scores-predicted value of fall incidence were not validated for our population. **The distribution of data observed for certain variables (i.e., PPA score, proprioception and sway area) appear to have large standard deviations relative to the mean, indicating that these data have a wide spread; a larger sample size may be required to increase the reliability of the data. In a similar vein, we did not find significant interaction effects of age and sex for variables such as PPA score and reaction time, which could indicate the need for a larger sample size to increase statistical power.** Finally, the participants were also community-dwelling adults; therefore, our findings may not be **generalizable** to individuals who are hospitalized, institutionalized, or those with physical disability.

This study presents important reference data **and compared** the sensorimotor functions and physiological fall risk across the age groups of community-dwelling adults in a South-East Asian population. To address the fundamental physiological differences between Asian and Caucasian populations, it is important to develop norms that are applicable in the Asian context. Our findings indicate that **poor sensorimotor performance** and fall risk are already pertinent in younger adults. **Further studies are necessary to improve our understanding of fall risk among younger adults, in order to better inform the design and** role of early intervention strategies to preserve sensorimotor functions and attenuate the fall-related concerns that accompany old age. **In physical therapy practice, targeted interventions can also be tailored according to an individual's physiological risk profile, such as the use of exercises to improve lower limb proprioception (e.g. single leg squats, crossover walk etc.) and agility drills to improve reaction time in younger adults.**

DISCLOSURE STATEMENT

The authors declare no conflict of interest.

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AUTHOR CONTRIBUTIONS

BWJP: Conceptualization, Methodology, Formal Analysis, Investigation, Resources, Data Curation, Writing – Original Draft, Writing – Review & Editing, Project Administration. **SLW:** Conceptualization, Methodology, Writing – Review & Editing, Supervision, Project Administration, Funding Acquisition. **LKL:** Formal Analysis, Investigation, Resources, Data Curation, Project Administration. **KAJ:** Formal Analysis, Investigation, Resources, Data Curation. **WTS:** Formal Analysis, Investigation, Resources, Data Curation. **DHMN:** Formal Analysis, Investigation, Resources, Data Curation. **QLLT:** Formal Analysis, Investigation, Resources, Data Curation. **KKC:** Formal Analysis, Investigation, Resources, Data Curation. **MUJ:** Conceptualization, Methodology, Supervision. **TPN:** Conceptualization, Methodology, Supervision.

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Table 1. Reference values for PPA and sensorimotor performance scores by age groups.

Age Group (y)	21-30	31-40	41-50	51-60	61-65	66-70	71-75	76-80	≥81	Overall
N	60	61	60	59	60	60	60	60	60	540
Age (y)	25.1 (2.8)	35.9 (2.9)	45.7 (2.8)	55.8 (2.9)	63.1 (1.4)	68.1 (1.5)	72.7 (1.6)	77.9 (1.4)	83.3 (2.2)	58.6 (18.7)
PPA Score*#										
Men	-0.50 (0.61)	-0.61 (0.54)	-0.25 (0.67)	-0.21 (0.76)	0.50 (0.79)	0.59 (0.91)	0.97 (1.00)	1.17 (0.91)	2.39 (1.52)	0.45 (1.25)
Females	-0.37 (0.54)	-0.09 (0.75)	0.01 (0.90)	0.31 (0.85)	0.81 (0.85)	0.79 (0.78)	0.91 (0.96)	1.58 (0.92)	2.08 (1.10)	0.67 (1.15)
MET Score#	23.1 (1.0)	22.3 (1.3)	21.7 (1.8)	21.1 (2.3)	20.4 (1.5)	20.8 (1.6)	20.5 (2.3)	20.0 (2.3)	18.9 (3.1)	21.0 (2.3)
Proprioception (◦)#	1.7 (1.2)	1.6 (1.0)	1.7 (1.4)	1.7 (1.4)	2.0 (1.6)	1.7 (1.4)	1.9 (1.4)	2.2 (1.9)	2.2 (1.5)	1.9 (1.5)
Reaction Time (ms)*#										
Men	215 (26.5)	214 (23.6)	224 (29.6)	217 (37.5)	232 (34.0)	226 (25.3)	247 (41.2)	245 (36.5)	301 (63.6)	235 (43.9)
Females	219 (18.4)	231 (31.8)	236 (38.6)	257 (52.9)	259 (45.8)	257 (38.2)	249 (36.5)	281 (35.5)	294 (72.1)	254 (48.9)
KES (kg)*#										
Men	45.9 (15.5)	43.6 (14.5)	38.4 (12.4)	39.1 (10.1)	30.6 (6.4)	28.8 (5.9)	23.8 (9.8)	21.7 (5.3)	18.6 (8.3)	32.2 (13.9)
Females	27.4 (7.8)	25.1 (6.4)	28.4 (7.3)	24.2 (6.6)	19.8 (4.2)	18.3 (5.9)	17.8 (4.1)	16.5 (6.5)	12.6 (6.5)	21.2 (8.1)
Sway Area (mm^2)#	558 (350)	535 (377)	663 (549)	637 (361)	987 (553)	1130 (796)	1393 (1134)	1613 (1139)	2000 (1548)	1035 (956)
MBR (mm)#	193 (25.5)	183 (19.9)	188 (32.7)	169 (36.5)	161 (27.5)	156 (29.4)	151 (25.0)	138 (37.0)	129 (29.5)	163 (36.1)
CS Score*#										
Men	1.2 (2.6)	0.2 (0.4)	0.4 (0.9)	0.6 (2.6)	2.3 (4.8)	3.0 (4.4)	5.0 (5.8)	7.2 (8.1)	13.5 (10.2)	3.7 (6.6)
Females	0.9 (1.8)	1.0 (1.9)	0.9 (1.4)	2.5 (3.2)	3.7 (4.1)	6.0 (5.9)	5.9 (6.9)	11.9 (10.0)	12.5 (10.0)	5.0 (7.3)
PPA Fall Risk										
Very Low (%)	11 (18.3)	12 (19.7)	8 (13.3)	5 (8.5)	1 (1.7)	2 (3.3)	0 (0)	0 (0)	1 (1.7)	40 (7.4)
Low (%)	33 (55.0)	31 (50.8)	27 (45.0)	23 (39.0)	14 (23.3)	10 (16.7)	11 (18.3)	3 (5.0)	2 (3.3)	154 (28.5)
Mild (%)	16 (26.7)	16 (26.2)	19 (31.7)	22 (37.3)	25 (41.7)	25 (41.7)	21 (35.0)	18 (30.0)	8 (13.3)	170 (31.5)
Moderate (%)	0 (0)	2 (3.3)	5 (8.3)	8 (13.6)	17 (28.3)	20 (33.3)	19 (31.7)	23 (38.3)	17 (28.3)	111 (20.6)
Marked (%)	0 (0)	0 (0)	1 (1.7)	1 (1.7)	3 (5.0)	2 (3.3)	6 (10.0)	13 (21.7)	19 (31.7)	45 (8.3)
Very Marked (%)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1.7)	3 (5.0)	3 (5.0)	13 (21.7)	20 (3.7)

PPA: Physiological Profile Assessment; MET: Melbourne Edge Test; KES: Knee Extensor Strength; MBR: Maximal Balance Range; CS: Coordinated Stability.
Continuous variables are presented as mean (SD); categorical variables are presented as number (%)
* indicates a significant **sex difference using independent t-test** (p<.05)
 # indicates a significant association with age using Pearson correlations (p<.05)

Table 2. PPA and sensorimotor performance between the young (<65 years) and old (≥65).

Age Group (y)		**21-64**	**≥65**
N		289	251
Age (y)		44.3 (13.6)	75.0 (6.2)
PPA Score*#			
	Men	-0.24 (0.74)	1.23 (1.25)
	Females	0.09 (0.85)	1.35 (1.09)
MET Score#		21.8 (1.9)	20.1 (2.4)
Proprioception (◦)#		1.7 (1.3)	2.1 (1.6)
Reaction Time (ms)*#			
	Men	219 (29.9)	254 (49.8)
	Females	239 (41.2)	272 (51.3)
KES (kg)*#^			
	Men	39.9 (13.4)	23.6 (8.3)
	Females	25.4 (7.1)	16.5 (5.8)
Sway Area (mm^2)#		660 (446)	1494 (1188)
MBR (mm)#		180 (30.7)	144 (32.3)
CS Score*#			
	Men	1.0 (2.9)	6.7 (8.1)
	Females	1.6 (2.5)	9.1 (8.8)

PPA: Physiological Profile Assessment; MET: Melbourne Edge Test; KES: Knee Extensor Strength; MBR: Maximal Balance Range; CS: Coordinated Stability.
Continuous variables are presented as mean (SD); categorical variables are presented as number (%)
* indicates a significant **main effect of sex** (*p*<.05)
 # indicates a significant main effect of age (*p*<.05)
^ indicates a significant interaction effect of age and sex (*p*<.05)

Table 3. Prevalence estimates in study sample and adjusted to the Singapore general population age groups weights.

	Sample estimates					Population-adjusted estimates				
	Overall	21-59	≥60	≥65	≥75	Overall	21-59	≥60	≥65	≥75
PPA Fall Risk										
Very Low	7.4	15.4	1.3	1.2	0.7	12.5	16.4	1.9	2.0	0.7
Low	28.5	46.6	14.7	11.6	6.6	39.5	46.9	18.8	13.9	6.2
Mild	31.5	31.2	31.7	29.5	22.8	32.0	31.0	34.9	31.7	21.2
Moderate	20.6	6.0	31.7	33.1	33.1	11.6	5.0	30.2	32.3	31.5
Marked	8.3	0.9	14.1	16.7	24.3	3.2	0.8	9.9	13.7	26.2
Very Marked	3.7	0.0	6.5	8.0	12.5	1.1	0.0	4.3	6.4	14.2

PPA: Physiological Profile Assessment. Values are presented as percentages (%)

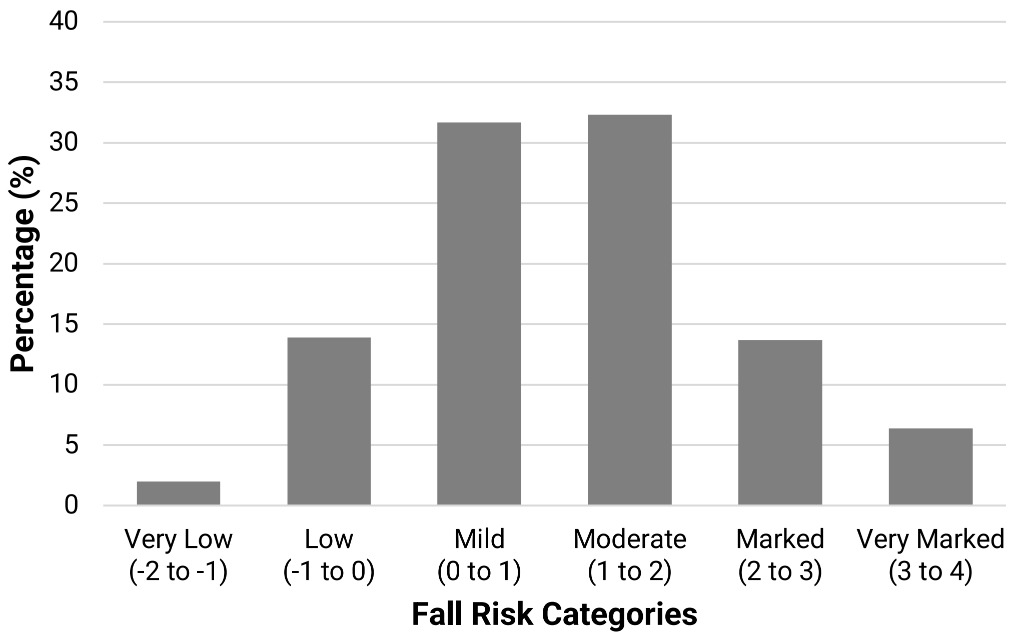

Figure 1. Population-adjusted percentages for fall risk in older adults, 65 years and older.

Figure 2. Z-scores of older adults (≥65 years) in relation to population norms of Caucasian Australians (≥65 years).

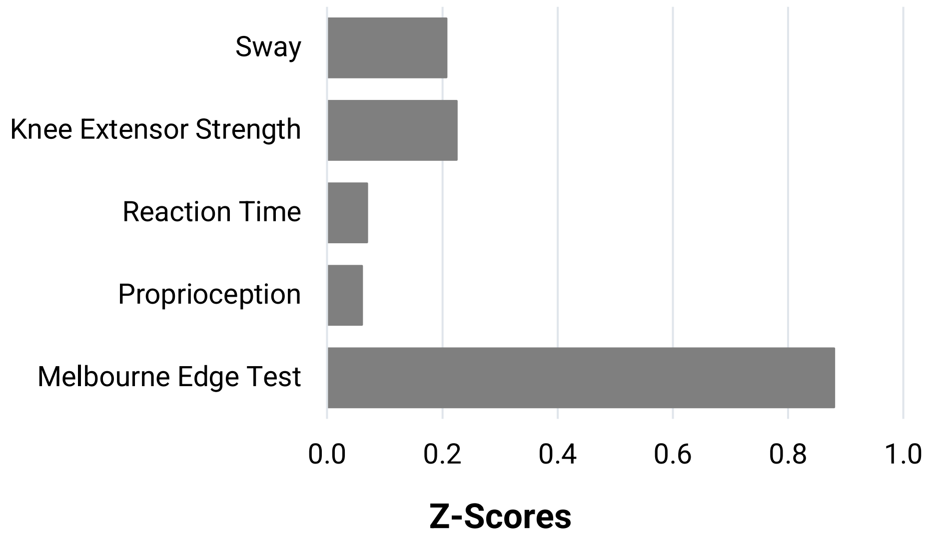

Figure 3. Z-scores of younger adults (21-59 years) with **higher** fall risk in relation to population norms of Caucasian Australians (≥65 years).