# Fall-Risk in Chinese Community-Dwelling Elders:

# A Physiological Profile Assessment Study

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**ABSTRACT**

**Aim:** The short-form Physiological Profile Assessment (PPA) is increasingly used in clinical practice for assessing fall risk in older people. However, a normative database is only available for Caucasian populations. The purpose of this study was to develop a normative database for the Hong Kong Chinese older people and examine the fall-risk profile of this population.

**Methods:** 622 participants aged 60 to 95 years were recruited. Participants underwent the PPA (containing tests of contrast sensitivity, proprioception, quadriceps strength, reaction time and sway), and composite fall risk scores were computed. Participants were then followed up for falls for one year.

**Results:** Quadriceps strength and lower limb proprioception scores were comparable to those reported for Caucasian populations. However, contrast sensitivity, simple reaction time and postural sway scores were relatively poor. The average composite fall-risk score was 1.7 ± 1.5, indicating a “moderate” fall-risk when compared to the Caucasian norms. Despite the relatively poor physical performances and moderately high fall-risk scores, the incidence of one plus falls in the 1-year follow-up period was only 16.4%, with only 2.6% reporting two plus falls. The area under curve for composite fall risk scores in discriminating fallers from non-fallers was 0.53 (95% CI 0.45–0.60).

**Conclusions:** Despite poorer performance in PPA tests, the incidence of prospective falls in a Hong Kong Chinese population was low. In consequence, the PPA could not discriminate well between fallers and non-fallers. This study provided

normality data for short-form PPA measures for older Chinese people as a reference for further studies.

## Introduction

Falls in older people are a serious health care problem in countries undergoing population ageing. Currently, the average annual fall rate in Chinese older people is 18%.[1] While this figure is lower than that found in Caucasian older people,[1] falls none-the-less lead to considerable adverse consequences for older people and high health care costs in Chinese populations. According to the statistics from the Hong Kong Hospital Authority, the total number of in-patient discharges and deaths due to falls among people aged 65 and above in the year of 2012 was 187 and 19,939 respectively.[2]

Assessment of fall risk in older people is complex due to the multifactorial nature of the underlying risk factors. Systematic reviews have shown that a multifactorial assessment of risk factors followed by targeted intervention is an effective strategy for preventing falls in this group.[3] For this approach to be successful, it is necessary to identify the population at risk, introduce standardized and reliable assessments and then put in place appropriate interventions.[4, 5]

The Physiological Profile Assessment (PPA) is a validated fall risk assessment tool that assesses vision, peripheral sensation, muscular strength, reaction time and balance.[6] It was deigned to be low-tech, portable and simple and quick to administer; be appropriate for older people to perform; and produce valid and reliable quantitative measures.[6] However, the current PPA normative database was derived from Caucasian population data and may not be appropriate for Chinese populations, which was indicated by the difference in PPA performance in Chinese and Caucasian population in a large scale study.[7] Difference in PPA performance

between Chinese and Caucasian population implied that the direct application of Caucasian normative data into Chinese population might not reflect the distribution of PPA performance accurately. The purpose of this study was to develop preliminary normative values for older Chinese people living in Hong Kong and to establish the fall-risk profile for this population. These findings could assist in identifying people who are at risk of falling and for evaluating the effectiveness of fall prevention program aimed at improving physical performance outcomes.

## Materials and Methods

### Participants

Six hundred and twenty older adults (524 female; 84.2%) aged 60 to 95 years (75.3 ± 7.1 years) who were relatively active and healthy members of social clubs, church groups and community centres were recruited. Exclusion criteria comprised: blindness, being chair bound, suffering from an unstable medical condition or having a cognitive impairment defined as a Mini-Mental State Examination score < 19.[8] Informed consent was obtained in accordance with a protocol approved by The Hong Kong Polytechnic University Human Research Ethics Committee. The study followed the tenets of the Declaration of Helsinki.

### Demographic information

Demographic information including age, gender, educational level and general health was collected using a structured questionnaire. Participants were asked to estimate the number of hours of regular exercise and rate their health status as poor, fair or good.

### The PPA Assessment

The short-form PPA consists of five sensorimotor performance parameters including (I) quadriceps muscle strength, (II) hand reaction time, (III) proprioception, (IV) postural sway and (V) visual contrast sensitivity. Visual contrast sensitivity was assessed using Melbourne Edge Test which presents 20 circular patches containing edges with reducing contrast. Correct identification of the orientation of the edge on the patches provides a measure of contrast sensitivity in decibel units, where 1 dB = 10 $\log_{10}$ contrast. Proprioception was measured using a lower-limb matching test,

where difference in matching the great toes in degrees was recorded using a vertical clear acrylic sheet inscribed with a protractor placed between the legs. Quadriceps muscle (isometric) strength in kilograms was examined in the dominant leg using spring gauge while participants were seated with the hip and the knee joints at 90° of flexion. Simple reaction time in milliseconds was assessed using a light as a stimulus and a finger-depression of switch as the response. Postural area (maximal anterior-posterior x mediolateral sway in mm) was assessed using a sway-meter that measured the displacement of the body at waist level while participants stood 30 seconds on a foam rubber mat with eyes open. The five PPA components were weighted to compute a composite PPA fall risk score expressed in standard (z-score) units, with high scores indicating poorer physical performance. In multivariate models, weighted contributions from these five variables provide a fall risk score that can predict community-dwelling older Caucasian people at risk of multiple falling with 75% accuracy over a 12-month period.[6] PPA test score ranges for poor fair, good and excellent performances based on Caucasian data are presented in Appendix 1.

**Falls definition and Follow up**

Falls were defined as “unintentionally coming to the ground or other lower level and other than a consequence of sustaining a violent blow, loss of consciousness, sudden onset of paralysis as in stroke or epileptic seizure”.[9] Participants were followed up for 12 months to report their prospective number of falls by monthly telephone calls.

### Statistical analysis

Descriptive data for the PPA component tests and composite risk scores including percentiles for 5 year age groups from 65 – 84 years and a final age group of 85 plus years were calculated. The proprioception, quadriceps strength, reaction time, and sway variables were positively skewed and were log transformed to allow allowing parametric analyses. Pearson correlations were used for assessing PPA performance scores and age, and group t-tests were used to compare the differences in these measures between men and women and between prospective fallers and non-fallers. Discrimination (the ability of the PPA composite scores to distinguish fallers from non-fallers) was quantified using the area under the receiver-operating characteristic curve (AUC). Data were analyzed with SPSS (version 18) for Windows (SPSS Inc., Chicago, IL).

## Results

### Demographic, health and lifestyle characteristics of the sample

The majority of participants had one or more systemic diseases including hypertension (52.7%), osteoarthritis (23.5%) and diabetes mellitus (19.5%). Only 22 participants (3.5%) required five or more prescribed medications. 359 participants (57.8%) rated their health as good, while 262 (42.2%) rated their health as poor to fair. Approximately one-fifth (23.7%) of the population reported regular use of walking aid and 528 participants (85%) reported undertaking regular exercise three times per week for more than 30 minutes.

### PPA normative values

Normative data of physical performances in the PPA, including percentiles for 5 year age groups from 65 – 84 years and a final age group of 85 plus years are presented in Table 1 Combined data are presented for the two genders for the contrast sensitivity, proprioception, reaction time and sway tests as performances between the genders were similar. Due to large and significant gender differences for quadriceps strength ($t= 4.9$, $df=620$, $p<0.001$), data for the two genders are reported separately. Performances in four PPA tests were weakly but significantly associated with age at $p <0.001$: contrast sensitivity $r= -0.3$, quadriceps strength $r= -0.2$, reaction time $r= 0.3$ and postural sway $r= 0.3$; proprioception was not associated with age $r= 0.03$. Composite fall risk scores were also significantly associated with age ($r= 0.4$, $p<0.001$). Figure 1 shows the fall-risk score increases by 0.9 for each 10-year increase in age.

Quadriceps strength and lower limb proprioception scores were comparable to scores reported for Caucasian populations. However, contrast sensitivity, simple reaction time and postural sway scores were relatively poor. Notably, 1.4% participants required >1000ms in the reaction time test and 47.7% of participants had scores categorized as “poor” using the Caucasian norms. The men were also significantly faster in the reaction time test than the women (292 ± 103 ms and 351 ± 155 ms respectively, $t= -4.25$, $df= 620$, $p= 0.001$). The average fall risk score of 1.7 ± 1.5 indicates a “moderate” fall-risk when compared with the Caucasian norms (Lord et al. 1994) and 35.3% of participants had fall risk scores > 2 indicating a “marked” fall risk. Figure 2 shows the proportion of participants in each fall risk category. Fall risk scores for women (1.8 ± 1.6) were significantly higher than those for men (1.3 ± 1.4) ($t= -3$, $df=616$, $p= 0.003$).

**Prospective falls**

464 participants (74.6%) completed the 12-month follow-up for falls. The reason for non-completion was mainly due to participants having moved or not being contactable. Among the follow-up participants, 16.4% had one or more falls and the number of reported falls ranged from 1 to 4: 1 fall (13.8%), 2 falls (1.7%), 3 falls (0.6%) and 4 falls (0.2%). Fallers performed worse in each PPA component test and had higher composite fall risk scores, but no differences were statistically significant (Table 2). The AUC for composite fall risk scores in discriminating between fallers and non-fallers was 0.53 (95% CI 0.45–0.60).

## Discussion

The main aims of this study were to develop a normative database for the Hong Kong Chinese older people and examine the fall-risk profile of this population. Table 3 shows the comparison of normative database for the Chinese population (obtained by this study) and the Caucasian population, [10], it was found that the Caucasian population performed better in all PPA parameters (except in sway performance because no direct comparison was established). Application of Caucasians normative data in Chinese population might under-estimate the physiological performance and thus the fall risk calculation would be inaccurate. We found that quadriceps strength and lower limb proprioception scores were comparable to those reported for Caucasian populations and that contrast sensitivity, simple reaction time and postural sway scores were relatively poor. The average composite fall-risk score was 1.7 indicating a “moderate” fall-risk when compared to the Caucasian norms. The complied normative database should assist future studies using the PPA in

evaluating balance performance in patient groups with balance disorders and evaluating effectiveness of interventions conducted in Chinese populations.

Despite the relatively poor physical performances and moderately high fall risk scores, the incidence of one plus falls in the 1-year follow-up period was only 16.4%; a figure in line with the average fall rate reported for other Chinese older populations (approximately 18%).[1] It has been previously suggested that the low fall rates in Chinese older people might be explained by a high concern about falls, vigilant/attentive behaviours and high levels of planned (as opposed to incidental) activities. In the current study sample, 85% reported that they frequently participated in “sports”, such as light gymnastics (i.e. stretching arms and legs, balance bodily movements), Tai Chi and Qi Gong regularly and 88% reported regularly exercising three or more times per week. The low fall rate may also be due to recent strategies in Hong Kong such as the “Primary Falls Prevention Programme for Older People” that are aimed at increasing awareness and knowledge of fall and fracture prevention among older adults. Launched in 2001, the above programme provides educational seminars for the elderly, a train-the-trainers programme and a staff training programme for volunteers and staff.[11]

The PPA was developed in studies conducted in Australia that involved primarily Caucasian older people, where the one plus and two plus fall rates per annum were approximately 35% and 20% respectively. The PPA in the Australian context was best at identifying people who suffered multiple (2+) falls over a year; a categorization of falls status considered appropriate because it has frequently been found that multiple falls within a year are more likely to indicate physiological

impairments and chronic conditions than does a single fall.[12-14] It is not overly surprising, therefore, that the PPA could not discriminate well between fallers and non-fallers in a sample where the annual incidence of one plus falls was 16.4%, and two plus falls only 2.6%.

We acknowledge the study has certain limitations. First the 25% loss to follow-up was relatively large, and it is likely that the loss was selective in nature with participants with adverse health events and possibly falls being over-represented in the group lost to follow-up. Second, we did not use the recommended method of falls surveillance (i.e. falls calendars with follow-up telephone calls),[15] but employed telephone calls to provide a culturally appropriate surveillance system. It is thus possible that this method may have been less accurate in recording falls and subsequently underestimated the population fall rate. Finally, as our cohort was relatively healthy and cognitively intact, we acknowledge that our findings may not generalize to older people who are frail or have cognitive impairments. This study provided preliminary normality data for the five short-form PPA measures for older Chinese people as a reference for further studies and clinical practice. Despite poorer performance in PPA tests, the incidence of prospective falls in a Hong Kong Chinese older population was low (16.4%). In consequence, the PPA could not discriminate well between fallers and non-fallers. Further large scale studies that encompass a broad range of physiological and behavioural factors may better measure fall risk in Chinese older people.

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**Disclosure statement**

No potential conflicts of interest were disclosed.

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**Figure Captions:**

**Figure 1.** Scatter diagram showing the association between Physiological Profile Assessment (PPA) composite fall risk scores and age.

**Figure 2.** Distribution of participants in each composite fall risk score category.

**Table 1.** Normative data for the Physiological Profile Assessment (PPA) component and composite fall risk scores for Hong Kong older people (Number of participants in each age group: 60-64: 47, 65-69: 91, 70-74: 143, 75-79: 163, 80-84: 113 and 85+: 65).

| | Age Range (years) | 10th percentile | 25th percentile | 50th percentile | 75th percentile | 90th percentile |
|---|---|---|---|---|---|---|
| **Melbourne Edge Test on contrast sensitivity (dB)** | **60-64** | 19 | 20 | 21 | 21 | 23 |
| | **65-69** | 17 | 19 | 21 | 21 | 23 |
| | **70-74** | 16 | 19 | 20 | 21 | 22 |
| | **75-79** | 16 | 19 | 19 | 21 | 22 |
| | **80-84** | 14 | 16 | 19 | 20 | 21 |
| | **85+** | 11 | 16 | 18 | 19 | 20 |
| | **All** | 15 | 18 | 19 | 21 | 22 |
| **Hand reaction time (millisecond)** | **60-64** | 218 | 234 | 262 | 338 | 417 |
| | **65-69** | 202 | 232 | 271 | 378 | 435 |
| | **70-74** | 210 | 246 | 281 | 345 | 428 |
| | **75-79** | 226 | 249 | 281 | 349 | 465 |
| | **80-84** | 252 | 274 | 330 | 438 | 585 |
| | **85+** | 252 | 313 | 373 | 534 | 733 |
| | **All** | 224 | 251 | 292 | 374 | 529 |
| **Quadriceps force (kg) (Men/Women)** | **60-64** | 16/18 | 26/21 | 36/31 | 50/41 | 60/47 |
| | **65-69** | 20/13 | 22/17 | 26/26 | 42/37 | 57/46 |
| | **70-74** | 14/11 | 20/15 | 28/23 | 49/34 | 70/41 |
| | **75-79** | 20/12 | 23/16 | 28/23 | 38/33 | 57/43 |
| | **80-84** | 20/10 | 21/17 | 30/22 | 32/29 | 47/37 |
| | **85+** | 16/9 | 23/14 | 31/17 | 42/25 | 48/33 |
| | **All** | 17/12 | 21/16 | 29/23 | 42/33 | 57/43 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Proprioception (degree)** | **60-64** | 0.4 | 1.0 | 1.6 | 2.2 | 3.2 |
| | **65-69** | 0.4 | 0.8 | 1.4 | 2.4 | 2.8 |
| | **70-74** | 0.6 | 1.2 | 1.6 | 2.4 | 3.8 |
| | **75-79** | 0.6 | 1.0 | 1.8 | 2.6 | 3.8 |
| | **80-84** | 0.6 | 1.0 | 1.6 | 2.4 | 3.2 |
| | **85+** | 0.3 | 0.8 | 1.6 | 2.4 | 3.1 |
| | **All** | 0.6 | 1 | 1.6 | 2.4 | 3.6 |
| **Sway performance on a foam surface with double legs and open eye (square millimeter)** | **60-64** | 228 | 351 | 589 | 1329 | 1786 |
| | **65-69** | 196 | 375 | 770 | 1784 | 2370 |
| | **70-74** | 218 | 462 | 874 | 1480 | 2342 |
| | **75-79** | 262 | 539 | 920 | 1439 | 2461 |
| | **80-84** | 337 | 674 | 1425 | 2156 | 3380 |
| | **85+** | 456 | 810 | 1482 | 2806 | 7600 |
| | **All** | 260 | 512 | 960 | 1743 | 2898 |
| **Fall-risk score** | **60-64** | -0.5 | 0.1 | 1 | 1.5 | 2.3 |
| | **65-69** | -0.6 | 0.1 | 0.9 | 2.6 | 3.0 |
| | **70-74** | 0.0 | 0.4 | 1.1 | 2.1 | 3.0 |
| | **75-79** | 0.2 | 0.7 | 1.3 | 2.2 | 3.3 |
| | **80-84** | 0.8 | 1.4 | 2.1 | 3.2 | 4.5 |
| | **85+** | 1.0 | 2.0 | 3.1 | 4.5 | 5.5 |
| | **All** | 0 | 0.6 | 1.4 | 2.6 | 3.9 |

**Table 2.** Physiological Profile Assessment (PPA) component and composite fall risk scores for the non-fallers and fallers for those completing the 1-year follow-up (High scores in the proprioception, reaction time, sway and composite fall risk tests and low scores in the contrast sensitivity and quadriceps strength tests indicate poor performances).

| | **Non-fallers in 1-year follow-up (n= 388)** | **Fallers in 1-year follow-up (n= 76)** |
|---|---|---|
| **Contrast sensitivity (dB)** | 19.3 ± 2.9 | 18.8 ± 2.9 |
| **Proprioception (degrees)** | 1.9 ± 1.7 | 2.1 ± 1.7 |
| **Quadriceps force (kg)** | 25.1 ± 12.6 | 24.2 ± 12.7 |
| **Hand reaction time (ms)** | 335 ± 140 | 338 ± 137 |
| **Sway area ($mm^2$)** | 1399 ± 1392 | 1940 ± 61 |
| **Fall risk score** | 1.64 ± 1.45 | 1.86 ± 1.67 |

**Table 3.** Normative data for the Physiological Profile Assessment (PPA) component for Hong Kong older people and the Caucasian population [10]. Only the data in 25th and 90th percentile was compared. No direct comparison could be made in the sway area between two populations as the sway path was the measured parameters rather than the sway area in Caucasian population.

| | | Hong Kong Chinese | Caucasian population | Hong Kong Chinese | Caucasian population |
|---|---|---|---|---|---|
| | **Age Range (years)** | **25th percentile** | | **90th percentile** | |
| **Melbourne Edge Test on contrast sensitivity (dB)** | **60-64** | 20 | 22 | 23 | 24 |
| | **65-69** | 19 | 21 | 23 | 24 |
| | **70-74** | 19 | 20 | 22 | 24 |
| | **75-79** | 19 | 19 | 22 | 23 |
| | **80-84** | 16 | 18 | 21 | 23 |
| | **85+** | 16 | 15 | 20 | 21 |
| **Hand reaction time (millisecond)** | **60-64** | 234 | 192 | 417 | 249 |
| | **65-69** | 232 | 194 | 435 | 258 |
| | **70-74** | 246 | 197 | 428 | 267 |
| | **75-79** | 249 | 203 | 465 | 284 |
| | **80-84** | 274 | 208 | 585 | 305 |
| | **85+** | 313 | 222 | 733 | 336 |
| **Quadriceps force (kg) (Women)** | **60-64** | 21 | 30 | 47 | 50 |
| | **65-69** | 17 | 28 | 46 | 46 |
| | **70-74** | 15 | 25 | 41 | 46 |
| | **75-79** | 16 | 22 | 43 | 45 |
| | **80-84** | 17 | 17 | 37 | 43 |
| | **85+** | 14 | 16 | 33 | 40 |
| **Proprioception** | **60-64** | 1 | 0.2 | 3.2 | 1.8 |

| | | | | | |
|---|---|---|---|---|---|
| **(degree)** | **65-69** | 0.8 | 0.3 | 2.8 | 2.1 |
| | **70-74** | 1.2 | 0.4 | 3.8 | 2.4 |
| | **75-79** | 1 | 0.4 | 3.8 | 2.8 |
| | **80-84** | 1 | 0.6 | 3.2 | 3.2 |
| | **85+** | 0.8 | 0.8 | 3.1 | 3.8 |
| **Sway performance on a foam surface with double legs and open eye (square millimeter)** | **60-64** | 351 | - | 1786 | - |
| | **65-69** | 375 | - | 2370 | - |
| | **70-74** | 462 | - | 2342 | - |
| | **75-79** | 539 | - | 2461 | - |
| | **80-84** | 674 | - | 3380 | - |
| | **85+** | 810 | - | 7600 | - |

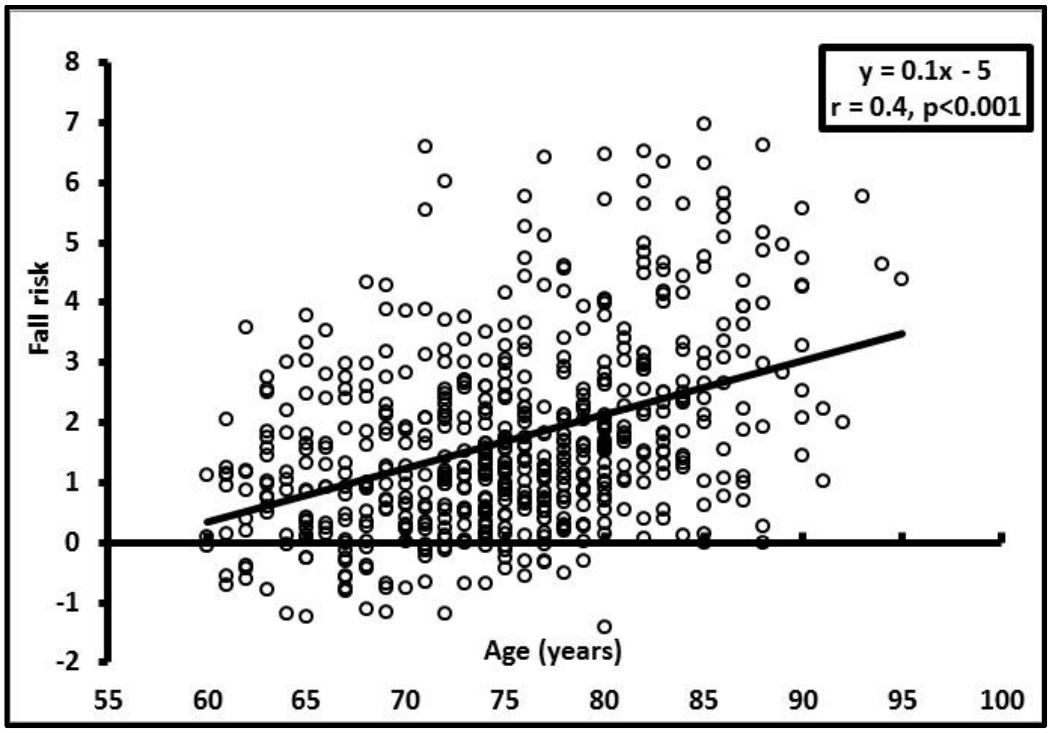


**Figure 1.** Scatter diagram showing the association between Physiological Profile Assessment (PPA) composite fall risk scores and age

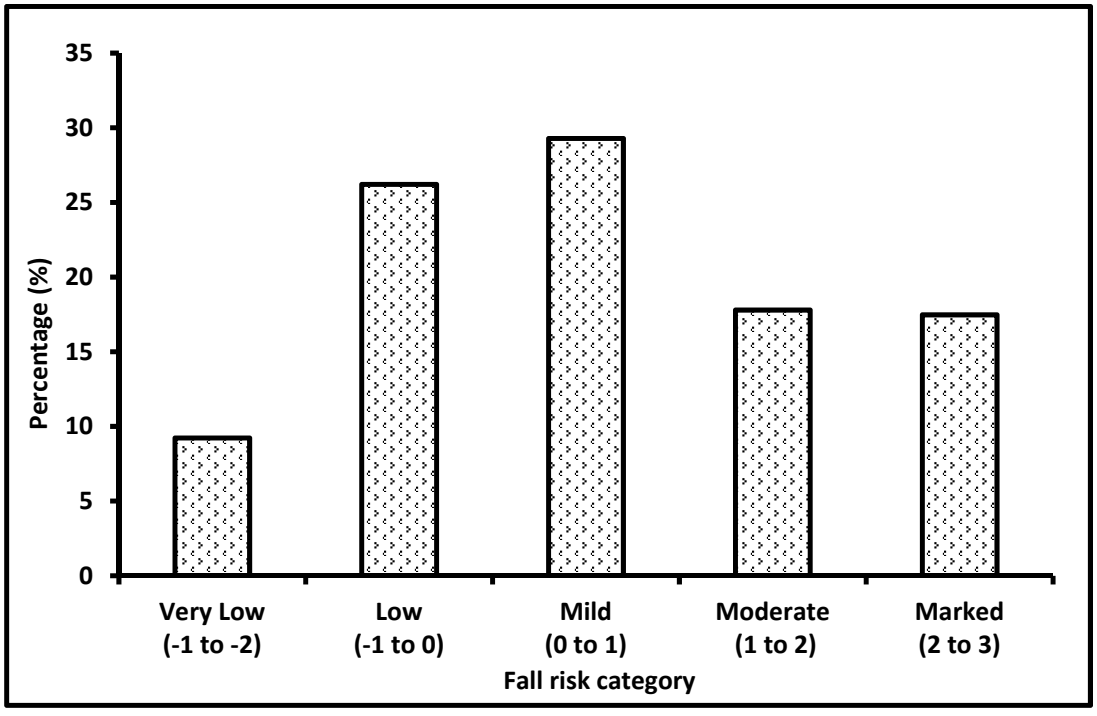


**Figure 2.** Distribution of participants in each composite fall risk score category

**Appendix 1.** Categorization of performance based on Caucasian norms for the Short-form Physiological Profile Assessment (PPA) [6]

| **Assessment** | | **Categorization of performance based on Caucasian norms [6]** | | |
|---|---|---|---|---|
| **1** | Quadriceps strength (kg) | | Female | Male |
| | | Excellent | >35 | >45 |
| | | Good | 20-35 | 30-45 |
| | | Fair | 15-20 | 15-30 |
| | | Poor | <15 | <15 |
| **2** | Hand reaction time (ms) | Excellent: <200 | | |
| | | Good: 200-250 | | |
| | | Fair: 250-300 | | |
| | | Poor: >300 | | |
| **3** | Proprioception (degrees error) | Good: <2 | | |
| | | Fair: 2-4 | | |
| | | Poor: >4 | | |
| **4** | Postural sway (mm) | Excellent: <400 | | |
| | | Good: 400-800 | | |
| | | Fair: 800-1300 | | |

| | | |
|---|---|---|
| | | Poor: >1300 |
| **5** | Contrast sensitivity (dB) | Excellent: 24 |
| | | Good: 20-23 |
| | | Fair: 16-19 |
| | | Poor: 1-15 |