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Quadriceps muscle strength and postural balance as intrinsic risk factors of falls in institutionalized healthy older adults: A cross-sectional study in two selected elders' homes in Colombo, Sri Lanka

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Abstract

Background: Fall is a devastating consequence for elderly people that affects their quality of life. Many stumbles in the elderly are frequently associated with intrinsic risk factors such as muscle strength and balance impairments. The purpose of this study was to determine the relationship between quadriceps muscle strength and postural balance as intrinsic risk factors of falls among healthy elders in two selected elders' homes in Colombo district, Sri Lanka.

Methods: A cross-sectional study was conducted under a non-probability convenient sampling method with 60 elders (34 females & 26 males) who dwelt in the two selected elders' homes in Colombo district. Fall history was obtained through an interview-administered assessment sheet. A modified sphygmomanometer was used to measure left and right quadriceps muscle strength. The postural balance was assessed using a mini version of the balance evaluation system test (Mini-BEST).

Results: Mean age of the study sample was 76.67±6.23 years. The mean and standard deviation values of left quadriceps strength and right quadriceps strength were 138.63 ± 24.35mmHg, 149.90 ± 28.53mmHg respectively. The mean and standard deviation of postural balance was 20.88 ± 2.70. According to Pearson correlation coefficient, a strong positive linear relationship was revealed between right and left quadriceps muscle strength and postural balance.

Conclusions: The results of our study revealed a strong positive relationship between quadriceps muscle strength and postural balance among elderly people in two elders' homes. Therefore, it is recommended that maintaining good quadriceps strength and postural balance are more important to prevent falls in the elderly.

Keywords: Quadriceps muscle strength; Institutionalized elders; Postural balance; Falls

1. Introduction

According to the World Health Organization, the chronological age of 65 years is defined as 'elderly' or older person [1]. Usually, elderly people from 65 to 74 years old are referred to as "early elderly" and those over 75 years of age as "late elderly" [2]. By convention, being 65 years of age or older is defined as "Elderly". However, the onset of health issues in the elderly may occur in the early 50s or maybe only in the 40s.Ageing results from the impact of the accumulation of various molecular and cellular changes over time at the biological level. The process of ageing leads to gradual physical and mental deprivation, an increased risk of disease and eventually death. Apart from biological changes, ageing is also associated with other changes in life, such as retirement, moving to a more appropriate place and the death of friends and partners [3].

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With the developed health system most people may live beyond their sixties. According to WHO by 2050, a total of 2 billion elders are expected from the world's population, up from 900 million in 2015. The world population is ageing rapidly. Among the 7.3 billion people worldwide in 2015, an estimated 8.5 per cent, or 617.1 million, are aged 65 and older [4]. According to thematic report analyses in Sri Lanka the situation of population ageing using data from the Sri Lanka Population and Housing Census of 2012(SLPHC), conducted by the department of Census and Statistics provides in 2012 there were 2,524,570 people (12.4%) living above the age of 60 years. Population ageing in Sri Lanka is increasing more rapidly than in other south Asian countries and has been growing faster since 1980s. Between 1990 and 2015 the proportion of the population aged 60 years and above, has increased from 9.2% to 12.5 %. According to this report by 2050 the population of the elderly will reach 21.1% of the world population [5].

Falls are one of the most related problems in the elderly around the world. Many falls in older people are certainly multifactorial, resulting from the confluence of several intrinsic, environmental, pharmacologic, behavioral, activity-related factors and biological risk factors like muscle strength, and balance in older age [6]. Muscle strength is defined as "the significant measurable force that can be exerted by a muscle or muscle group to overcome resistance during a single maximum effort" [7]. Among lower extremity muscles, the quadriceps muscle acts as one of the most powerful lower limb muscles. Postural balance is defined as the ability of the body to maintain the center of body mass with the stability limit determined by the base of the support.

Even if falls don't cause an injury, frequently they trigger a loss of confidence in an older person and lead to an ongoing fear of falling. Eventually, this can lead to limitations in movements and reduced activity levels in older adults, which further increases the risk of falling. Falls are the main source of morbidity and disability in the elderly. More than one-third of people 65 years of age or older fall each year, and in half of the similar cases the falls are recurrent. Today, falls are the most common cause (85%) of injury-related hospital admissions among those aged 65 years or older. In the USA, 20 percent of community-dwelling elderly persons fall each year and this figure has doubled in institutionalized ambulatory populations [8].

Many falls can be prevented through multifactorial interventions. Exercise programs, rehabilitation and medical management are the most effective single interventions. Balance and lower-limb strength exercises are well known to effectively reduce falls in the elderly. A firm interpretation of both fall risk factors as well as effective strategies is required to reduce risk and prevent these injuries [9,10,11,12]. In this background, our study aim was to understand the relationship of quadriceps muscle strength and postural balance to falls of institutionalized elderly in selected elder's homes in Sri Lanka.

2. Material and Methods

2.1. Recruitment of participants

A cross-sectional study was conducted under a non-probability convenient sampling method with 60 elders (34 females & 26 males) who dwelt in the Salina Alwis elders' home and Sahana Udaya elders' home. Elders aged 65 years or above and all male and female elderly people in Salina Alwis elders' home and Sahana Udaya elders' home were included to the study. The research sample was selected according to all the inclusion and exclusion criteria (Figure: 1)

Ethical clearance was obtained from the Ethical Review Committee of General Sir John Kotelawala Defence University (RP/S/2020/05) and permission to conduct the study was obtained from the relevant elders' homes.

2.2. Data collection tools

For the measuring of quadriceps muscle strength, a modified sphygmomanometer was used. Before the data collection, the modified sphygmomanometer was calibrated using standard free weights to verify whether the equipment provided consistent measurements throughout the study and a pre-test was carried out.

Postural balance was measured using mini BESTest. Mini BESTest includes 14 items, including 4 sections (anticipatory postural adjustment, reactive postural control, sensory orientation and dynamic gait) scored from 0-2, so the maximum score is 28[13, 14].

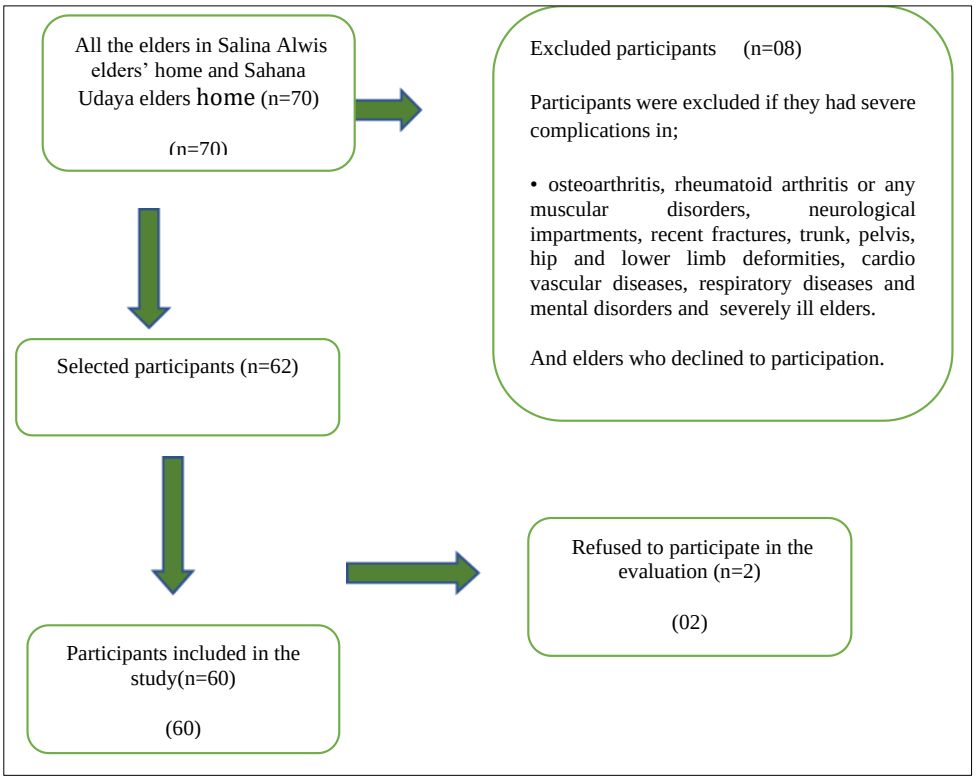

Figure 1 Flow chart of participant recruitment

3. Method of data collection

The data collection procedure was conducted under the three stations, by 2 investigators. Prior to the data collection, the 2 investigators were trained on the methodology and the validated instruments were tested for reliability prior to the data collection. A single investigator collected the data in particular measurements to maintain the reliability of the data.

3.1. Station 1

Written informed consent was obtained from each participant through a consent form followed by an explanation of the study procedure. All the participants were provided with an information sheet, consent form and an interviewer-administered basic assessment sheet including, a history of medical conditions and history of falls of the participants, according to their preferred language in Sinhala, English and Tamil. Each participant was given an identity number and all personal details were recorded under the identity number to protect the anonymity and confidentiality of the subjects throughout the research.

By the presence of an episode of a fall in the last six months, the subjects were divided into two groups (non-fall group and fall group). The history of falls was ascertained from the interview administrated general information sheet.

3.2. Station 2

3.2.1. Evaluation of quadriceps muscle strength

For the assessment of the quadriceps strength, appropriate positioning and procedures were followed [15]. Before initiating the assessment, a demonstration was done for the measurement of quadriceps muscle strength and the participants were asked to perform submaximal isometric contractions in order to familiarize the equipment and procedure.

During the testing procedure, the participants were instructed to perform a maximal isometric contraction for 5 seconds with verbal encouragement from the investigator like "one, two, three force" to initiate the movements and to hold the contraction. The peak value at any point during the period of 5 seconds was recorded at each trial. Three trials were obtained for the quadriceps muscles in both legs. A rest interval of 15 seconds was allowed between 3 trials to prevent

fatigue. Before each measurement, the investigator ensured the pre-inflation of the equipment to 20mmHg. The participants were instructed not to perform compensatory movements during the strength assessment.

3.3. Station 3

3.3.1. Evaluation of postural balance

Before the testing, the second examiner demonstrated the mini BESTest for a clear understanding of the testing procedure. All 14 items were explained.

3.4. Data analysis

The SPSS (Statistical Package for Social Sciences) computer software version 25 was used for the data analysis in the study. Descriptive statistics were used in analyzing the demographic and physical characteristics of the study sample. The minimum, maximum, standard deviation (SD), mean, median, and skewness of the data were obtained. The Pearson correlation was used to assess the relationship between quadriceps muscle strength and postural balance to falls in the elderly, and an independent Sample T-Test was used to assess the association of quadriceps muscle strength and postural balance with the fall group and non-fall group.

4. Results

A total of 60 elders who matched the inclusion and exclusion criteria were recruited for further analysis. The gender distribution of our study sample, female and male were 56.7% (n= 34) and 43.3% (n=26) respectively. The demographic and clinical characteristics of the study sample were analyzed using descriptive statistics. The mean age of the study sample was 76.67 years (SD = 6.23) with the minimum age being 65 and the maximum age being 88. The range of left-side quadriceps muscle strength of the participants were between 90 mmHg and 180 mmHg with the mean and SD being 137. 63 ± 24.35 mmHg. The range of right-side quadriceps muscle strength of the participants were between 80 mmHg and 200 mmHg with the mean and SD being 149.90 ± 28.53 mmHg. The range of postural balance of the participants was between 16 –26 and the mean value of the postural balance was 20.88 (SD = 2.70). Further, falls and non-falls prevalence among elders in Salina Alwis elders' home and Sahana Udaya elders' home were 38.3% and 61.7% respectively.

In the study, Pearson correlation test results were significant at p=< 0.05. A significant, strong positive correlation was observed between the quadriceps muscle strength and postural balance of participants with a correlation coefficient of 0.815 (Table 1).

Table 1 Relationship between Quadriceps muscle strength and postural balance

	Quadriceps muscle strength		
	N	Sig. (2-tailed)	Pearson Correlation
postural balance	60	0.000	0.815
N= Number of participants			

According to the independent sample t-test results, a significant difference was observed between quadriceps muscle strength, postural balance and fall state (fall and non-fall) (Table 2).

Table 2 Relationship between Quadriceps muscle strength, postural balance and fall state

	Fall state	**N**	**Mean**	**Sig.(2 tailed)**
Quadricep muscle strength	Fall	23	116.00	0.028
	Non-fall	37	161.13	
Postural balance	Fall	23	18.17	0.031
	Non-fall	37	22.57	

5. Discussion

Population aging in Sri Lanka has been growing faster since the 1980s. According to UNFPA thematic report 2012, the highest no of an aging population can be seen in the western province, of Sri Lanka. Usually, in Sri Lanka, elderly people are looked after by their family members, but in a middle-income country with socio-economic and other changes, elderly people do not receive proper care and attention as before. As a result, elderly people who reside in aged care facilities increase day by day. In these elderly institutions, older people are continuously observed by caregivers; but according to a previous study fall rates are higher for nursing home residents and those in institutions [10].

The gender distribution of our study sample, female and male was 56.7% and 43.3% respectively. According to the previous literature, similar gender distribution in elderly people, [10,11,12) for both genders were manifested in our study. The age range of our study sample was between 65-88 years with the mean age being 76.67 years. This age range and the mean age are consistent with many of the research carried out among elderly people (15, 16, 17).

Under physical characteristics, quadriceps muscle strength in right and left lower limbs were measured by MST. The left quadriceps muscle strength ranged from 90 mmHg – 180 mmHg with mean quadriceps strength of 137.63 ± 24.35 mmHg. The right quadriceps strength ranged from 80mmHg – 200mmHg with mean quadriceps strength of 149.90 ± 28.53 mmHg. In literature, several studies were carried out by using the modified sphygmomanometer test. A similar study conducted by Brito, et al, [21] revealed an average quadriceps strength of 253.57 ± 32.47. This huge difference may be due to racial variance between Asian and European older adults. In contrast to our study Helewa et al, [22] and Souza et al, [23] showed means of 213.6 ± 41.4 and 239.08 ± 42.21 mmHg average quadriceps strength respectively. The reason that our study findings may not be similar to the previous literature could be elderly people in other studies may be more physically fit than our study sample. The different study populations such as rheumatoid arthritis patients, hemiplegic patients etc. also were used [22, 23].

The mean value of the postural balance of our study sample was 20.88 ± 2.70. This mean value was similar to the study by Hoski, et al, [24] with the mean being 25.9 ± 4.0. In contrast to our study findings Viveiro, et al, [25] revealed a mean of 12.5 ± 6.8. But the study population was the same in both studies, who were older adults, living in nursing homes. This difference may be due to the sampling size variance between the two studies. A study with the different balance disorders participants, conducted by Godi, et al, [26] showed a mean of 12.8 ± 6.9. Comparatively low results presented in previous studies may be due to the study population used by the researchers.

The main aim of our study was to identify the relationship between quadriceps muscle strength and postural balance in elderly people. The results of our study show that the right and left quadriceps muscle strength was positively correlated with postural balance in elderly people. In the literature, there were not enough studies carried out to determine the relationship between quadriceps muscle strength and postural balance in elderly people. But Ito et al, [27] supported this fact by showing the positive correlation between knee extension strength sit-up, one-leg standing time with eyes open, and 6 minutes walking distance, r= 0.385, r= 0.196, and r= 0.468 respectively. Costa et al, [28] evaluated the correlation between static balance and quadriceps muscle strength in post-menopausal women (r= 0.315). Carter et al, [29] found a correlation between the strength of knee extensors and dynamic balance in osteoporotic elderly women aged 65- 75 years (r= 0.51). These contrasted study findings may be due to the difference in study populations used by the researchers.

The findings revealed a strong positive relationship between quadriceps muscle strength and postural balance among the elderly people in two elders' homes. As intrinsic risk factors for falls in the elderly, this strong positive relationship of quadriceps muscle strength and postural balance directly affects the falls of elders.

6. Conclusion

In conclusion, the results of our study revealed a high prevalence of falls among elders in Salina Alwis elders' home and Sahana Udaya elder's home. A strong positive relationship was obtained between quadriceps muscle strength and postural balance among the elderly people in two elders' homes. Furthermore, the study revealed significant differences in mean values for quadriceps strength among falls and non-falls groups of elders. A comparatively high mean value for quadriceps muscle strength was obtained among the non-falls group. A significant difference in mean values for postural balance among the falls and non falls elderly group was obtained and the falls group of elderly showed a low mean value compared to non-falls elderly. Therefore, it is recommended that maintaining good quadriceps strength and postural balance is more important to prevent falls in the elderly.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare that no conflict of interest

Statement of ethical approval

The study was approved by the Ethical Review Committee, Faculty of Medicine of General Sir John Kotelawala Defence University.

Statement of informed consent

Written informed consent was obtained from all subjects involved in the study.

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