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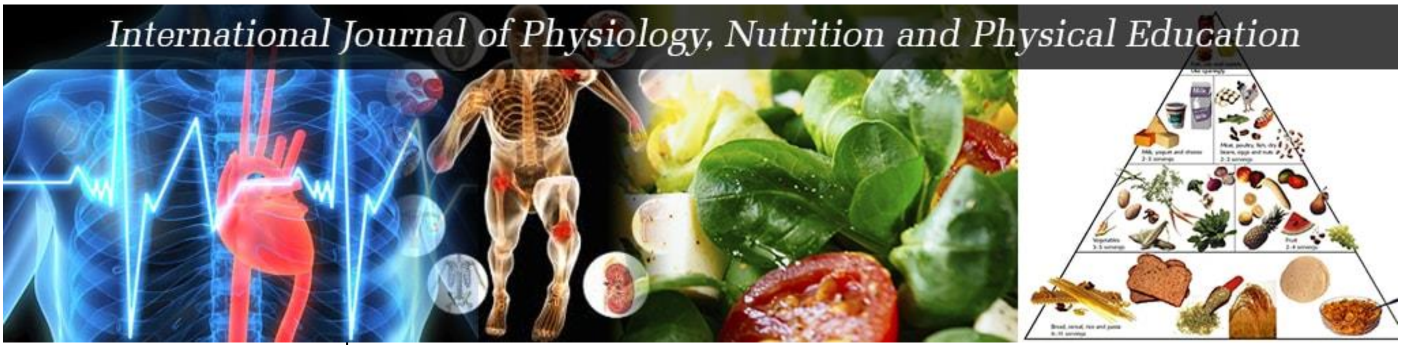

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Influence of handgrip strength on dynamic balance and functional mobility in older adults

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Abstract

Background: low muscle strength is common and important in geriatric syndromes including frailty and sarcopenia. Muscle strength is only one of the many components in risk of falls and it is currently unclear to what extend handgrip strength (HGS) is associated with dynamic balance and functional mobility. HGS is frequently used as a measurement of muscle strength, especially among older adults. However, there is conflicting evidence assessing the correlation between HGS and other feasible measures like dynamic balance and functional mobility.

Objective: To determine the relationship between HGS on dynamic balance and functional mobility in older adults.

Method: A cross sectional study was conducted among community living older adults. 33 older adults aged 65 and above were included in the study. Sociodemographic data were collected and test of HGS was carried out by using handheld dynamometer. Four square step test (FSST) was used to assess dynamic balance and time up and go test (TUGT) was used to asses functional mobility. The Pearson correlation test was used to find the correlation.

Results: The average HGS in the study group amounted to 20.33 kg, including 22.8 kg in men and 17.4 kg in women. Pearson correlation coefficient test found a negative correlation (r = -0.19) between HGS and FSST and was found to be statistically non-significant ($p>0.05$). similarly, negative correlation (r = -0.53) was found between HGS and TUGT and found to be statistically highly significant ($p<0.01$).

Conclusion: This study concluded that regardless of gender, higher HGS were associated with reduced dynamic balance and functional mobility. By means of simple tools, early diagnosis will facilitate the planning of appropriate intervention in older adults to present disability and mortality.

Keywords: Elderly, disability, handgrip strength, frailty

1. Introduction

Aging is a naturally-occurring process. As age increases, physical ability will gradually decrease. Reduction in physical ability and muscle mass is called sarcopenia. Sarcopenia is a major problem in the elderly due to its strong relationship with higher risk of falls, resulting in increased morbidity and mortality [1]. In the past two decades, sarcopenia has come to be recognized as an important geriatric syndrome, becoming a major focus of research covering from basic science to clinical management perspective [2].

As people age, gradual natural changes take place biologically, psychologically and physiologically which can have an unfavorable impact on people’s lives where health complications may increase and self-sufficiency might decrease [3]. Aging can also be associated with progressive loss of muscle mass with a simultaneous increase in fat mass [4]. A decrease in skeletal muscle mass takes place at the rate of 3–8% for a decade and begins after 30 years of age [5]. Its loss is also accompanied by a significant decrease in muscle strength amounting to more than 15% per decade [6].

Muscle weakness is a strong predictor of physical disability in older adults. Characterization of muscle strength is important because loss of strength is central to a number of major geriatric syndromes including sarcopenia [7], frailty [8], Mobility impairment [9] and falls [10]. Low muscle strength is also associated with poor future health. Among community-dwelling adults, it has been found to be predictive of increased future functional limitations and disability [11], increased fracture risk [12], development of chronic diseases [13], higher risk of cognitive decline and increased all-cause mortality [12], particularly for those aged over 60 years. The European Working Group on Sarcopenia in Older People (EWGSOP) has recognized sarcopenia as a syndrome and suggests this diagnosis when the patient presents low muscle mass, plus low muscle strength or low physical performance (measured by gait speed) [14]. In this way, some physical ability components can be measured in the elderly which includes; walking speed, stability, standing from a chair in 30 seconds, physiological profile assessment values, short physical performance battery values, functional mobility, and hand HGS [15].

Grip strength is associated with a variety of ageing outcomes and forms a key component of sarcopenia and frailty phenotypes [16]. There is considerable interest in its role as a marker of healthy ageing, as an outcome in intervention studies, and as a potential tool for clinical assessment [17]. The life course epidemiology framework recognizes that factors which promote healthy ageing may operate both by increasing the peak grip strength obtained in early adult life as well as by attenuating decline thereafter [18]. HGS is the only assessment technique recommended for the measurement of muscle strength and is a simple method for assessment of muscle function in clinical practice [19].

Muscle strength, measured by the maximum HGS test is widely used as a simple and robust marker of aging [20]. HGS in general is an indicator of muscle strength, and low HGS has been linked with premature mortality in middle-aged and elderly subjects [21]. Loss of grip strength is strongly associated with increasing chronological age [22]. It also appears to be a powerful predictor of disability, morbidity and mortality. Lower HGS is associated with incident as well as prevalent disability, suggesting that age-related loss of muscle mass and volitional muscle strength can be a cause as well as a consequence of physical disability, morbidity and mortality in the future [23-26].

Studies looking at the influence of grip strength on morbidity have focused on musculoskeletal disorders, for example higher muscle strength is related to increased bone mass and lower risk of fracture [27]. However, the most striking association is with future mortality. HGS in mid-life and later years predicts long-term survival [28].

A reduction in muscle strength in frail older adults may impair performance in manual tasks, and is associated with other important functional limitations in gait and balance, with significant consequences, such as increased risk for falls and loss of functional independence [29]. Throughout the world, about 35-40% of geriatric population group fall every year and due to which injuries caused from falling, results in serious health problems resulting in increase in healthcare costs [30-31].

The association between risk for falling, its functional mobility, balance and muscle mass strength is important because it can illustrate physical ability reduction in the elderly and in general [32]. One method for effective management of health care resources is preventive care that includes early detection and management of falls in older adults [33]. Early screening among older adults is recommended for preventive fall strategies [34].

The TUGT is used frequently to assess mobility in elderly patients because it can measure many aspects of functional mobility, such as strength, walking speed, stability, and cognitive ability at once [35]. However, a study done by Bijlsma AY *et al.* reported that the correlation between the two variables that is HGS and function mobility still varies [36]. Previous studies have found that 40% - 60% of fall-related injuries in the older adult occurred as a result of tripping while stepping over obstacles [37]. Likewise, multidirectional stepping speed decreased with age [38]. FSST is a balance outcome measure that involves stepping over four single-point canes placed on the floor in a cross-configuration. Over the last decade, the FSST has been increasingly utilized as a balance and fall risk screening tool for the community dwelling older adult population [39]. Accordingly, FSST may be more appropriate than other balance assessment tools for testing these risks. Also, balance testing on an unstable supporting surface increases the accuracy of fall history identification [40].

Falls among older adults is the major contributor to loss of independence, hospitalization from trauma, injury-related deaths and fractures, decrease in quality of life, and associated health care cost [41]. As aging process involves changes in functional autonomy there can be a direct consequence on dynamic balance [42]. A functional approach to clinically assess dynamic balance and functional mobility can be employed to determine whether or not HGS hindrance exists and if treatment is needed for the same [43].

While BMI, wholesome status and actual work are identified with way of life, research on HGS are predominantly directed in western societies where rich and sedentary life is followed [44]. Also, the relationship between HGS, ageing and mortality may be intervened by age related diseases and attenuated when these are uncommon [45].

Furthermore, ethnic differences of the study subjects can affect HGS due to differences in body size and shape, nutrition, physical activities, culture, and prevalence of fragility [8]. The same can be seen from the study of Dodds R *et al* who compared HGS in subjects from Ghana and Netherlands. He reported that differences in height, weight, and Body Mass Index (BMI) were associated with differences in HGS in both populations [46-47].

2. Materials and Methods

2.1 Study design and participants

This cross-sectional study was conducted in elderly population with age ≥ 65 years to find the influence of grip strength on dynamic balance and functional mobility. Community dwelling older adults residing in Southern Karnataka, were screened for inclusion and exclusion criteria and the subjects falling within the inclusion criteria were recruited for the study. Study protocol was approved by institutional Ethics Committee. The study population was selected by purposive sampling method.

2.2 Sample size and sampling

All study subjects were older adults aged 65 and above with normal cognitive status or a mild impairment and physically inactive adults—performing activities in a sitting position, such as reading and watching television for a minimum of 4 hours a day/6-7 days a week. The exclusion criteria included: Vestibular and neurological disorders, injuries of the lower limbs during the last 6 months, paresis or deformities in the upper limb and lower limb, severe systemic diseases and visual and hearing impairments.

A sample size of 33 was estimated based on the parameters of Wisniowska-Szurlej A *et al.* [31]

Sample size was calculated using the formula:

$$n = \frac{[Z_{1-\alpha/2} + Z_{1-\beta}]^2 [1 - r^2]}{r^2}$$

Where,
α is the Significance level (5%)
1-β is the power (80%)
r is the correlation coefficient (0.29)
The study was conducted in the course of 1 year (March 2020 to March 2021).

2.3 Interventions

Participants were recruited on basis of the inclusion and exclusion criteria and an initial examination including demographic data, hand dominance, MoCA was carried out prior to the study. The demographic form included information about participants gender, previous occupation, age, education level, weight and height. Each participant took part in the session and dynamic balance and functional mobility was assessed using FSST and TUGT test respectively. Hand held dynamometer for grip strength was measured in sitting position with elbow flexed to 90 degrees by side and wrist at neutral position. The subject was instructed to grasp the hand-held dynamometer as hard as possible without jerking motion. After three consecutive trials the best reading (kg) among three trials were recorded.

2.4 Outcome measures

2.4.1 Four Square Step Test

The FFST is used to assess dynamic stability and ability of the subject to step over low objects forward, sideways and backward[59]. It has been shown to have strong correlations with other measures of balance with good validity and reliability shown in as geriatric population. Time less than 10 seconds to complete the test indicates normal mobility among geriatric population.

2.4.2 Time Up and Go Test

TUG test determines fall risk and measure the progress of balance, sit to stand and walking [60]. It is a simple screening test that is sensitive and has specific measure of probability for falls among older adults. TUG is a commonly used screening tool to assist clinicians to identify patients at risk of falling. Time less than 12 seconds to complete the test indicates greater risk of falls.

2.4.3 Hand Held Dynamometer

To examine isometric grip strength, Jamar hand held dynamometer is recommended by the American Society for Surgery of the Hand (ASSH) and the American Society of Hand Therapist (ASHT). It is used as an effective strength measurement tool for the geriatric population.

3. Results and Discussions

The mean age of the subjects was 66.87±2.41. The mean score of height, weight and BMI were 1.59±0.05, 60.93±8.07 and 23.99±3.25 respectively. It was observed that 20 (60.6%) of the individuals are in the age group of 65 to 66 years which is maximum among the age group. Also, it was noted that 1 (3.0 %) of the individual was in the age group 70-74 years which is the minimum among age group. Using Karl Pearson's correlation coefficient, weak negative correlation was observed between HGS and FSST (r = -0.19) and was found to be statistically non-significant ($p>0.05$). (Table 2 & Fig 2) Also, using Karl Pearson's correlation coefficient, moderately negative correlation was observed between HGS and TUG (r = - 0.53) and was found to be statistically highly significant ($p<0.01$) as shown in (Table 3 and Fig 3).

Analysis of our data revealed that low HGS were associated with reduced dynamic balance and functional mobility in both men and women. HGS is a good indicator determining the risk of mortality and morbidity. In our study it was shown that the average strength of the HGS was 22.8 kg among men and 17.4 kg among women. Based on the consensus of the AWGS, the threshold for HGS was 26.0 kg for men and 18.0 kg for women [61]. Whereas, our study subjects had mean HGS below the threshold of AWGS. However, Evidence from WHO's Study on Global Ageing and Adult Health (SAGE) on age, socioeconomic patterns and regional variations in grip strength among older adults in India had similar mean HGS of 18.5 kgs in women but reduced mean HGS of 28.2 kgs among men [62]. The mean value of HGS in Singapore among 60 years and older adults were 28.3 kg in men and 17.2 kg among women [63]. Whereas, HGS was lower in China, among 50 years and older Chinese older adults having 34.3 kg as mean value of HGS in men and 21.9 kg in women [64]. Similarly, among 50 to 62 years of older adults in South Africa, the mean maximum HGS was 37.9 kg for men and 31.5 kg for women [65]. However, in a study among older adults in 11 European countries, the mean maximum HGS was 41.3 kg for men and 24.9 kg for women [66] whereas, among older Japanese-American men, mean maximum HGS was reported as 36.7 kg [11]. The result seems to confirm that developing world regions have lower HGS than developed world regions, which may be explained by differences in BMI value across the regions [46-67].

As a result of our analyses, a statistically non-significant negative correlation between age and HGS was observed in the entire study group. Similar findings were obtained by Almeida *et al.* [68]. Similarly, Dodds *et al.* found that the average HGS had decreased by 0.1 kg each year after the age of 60 [46]. A longitudinal study among the Danish older population indicated that men were losing HGS faster than women [69]. Hughes *et al.* found that the 10-year decline in strength of each muscle group was greater in men than in women, however, men had greater isokinetic strength in all muscle groups compared to that of women [70]. HGS is influenced by sex, hand dominance and age based on a study by Bohannon *et al*. Our findings regarding the influence of sex on hand grip strength corresponded with those of Bohannon *et al*. who found that greater HGS in men than in women [71].

Furthermore, ethnic variations in the study subject's grip strength can be influenced by differences in body size, body shape, nutrition, physical activity, culture and the prevalence of fragility [13]. Similar result was seen in Dodds *et al.* study [46]. This study compared grip strength in subjects from Ghana and Netherlands and found that differences in height, weight and BMI were correlated with differences in grip strength in both populations. This demonstrated that differences in body size largely explained the differences in grip strength. The difference in grip strength in different world regions is noted between developed and developing countries and because of these differences, HGS is based on region and Asian countries set their own standard thresholds for grip strength[46]. There was clear evidence that average grip strength measurements were substantially lower in developing countries compared with developed world regions. The findings of their study were important because they highlighted on consensus definitions of sarcopenia and frailty, which might need different cut points for grip strength for different geographical regions.

Our research showed a correlation between dynamic balance and HGS. A study by Fujita *et al.* showed that greater balance disorders resulted in significantly lower grip strength [72]. Dynamic balance was inversely correlated with HGS. Thus, lower muscle strength was correlated with longer duration to complete the task, a finding which supports those from other studies [73-74]. Body balance is regarded as an essential component of many everyday tasks, ranging from maintaining a relaxed position to more complex activity such as walking during a conversation or changing direction while walking [75]. In order to maintain vertical balance, the center of body mass should remain within the limits of the quadrilateral support defined by the foot contour. Moving the center of pressure beyond the limits of foot support causes loss of balance, which is interfaced with the motor response [76]. Delay in muscle activation, decrease in muscle strength, and slower reaction time affect greater balance disorders [77]. Detection of existing balance disorders is important for preventing falls and planning improvement strategies.

The results of our study presented that the mobility TUGT regardless of sex, was negatively correlated with HGS. This suggests that people with weaker HGS required longer time to complete the test. Similar result was found in a study done by Porta M *et al*. This study showed correlations between TUGT and muscle strength and indicated that TUGT was significantly correlated with HGS [78-79].

The TUGT shows physiological changes that occur as people age [80]. Slow reductions in reaction time, nerve conduction velocity and sensory responses may result in balance difficulties, postural abnormalities and subsequently mobility and walking speed restrictions.

Our study found a different relationship between HGS and functional mobility than Singh DK *et al* [15] who did not find a significant correlation between HGS and TUGT. This difference can be due to the fact that our study subjects were from different ethnic group. Singh DK studies the correlation between various physical performance tests and physiological fall risk, including HGS and TUGT, and found no correlation with HGS, indicating no significant correlation with physiological fall risk. This result differed from the finding of Wang *et al*. [81],

Macedo *et al.* evaluated the relationship between HGS and functional mobility with physical activity [82]. They found moderate correlation between HGS and functional mobility. The same was also noted on Kannegieter *et al*. study [83]. This study correlated two variables with fragility in the older adults. In their study, HGS was significantly lower in elderly subjects and functional mobility was significantly higher in the fragile older adults. Therefore, HGS and TUGT were correlated because they were associated with fall risk, fragility and physical activities performed.

This study has several limitations. First, the sample size was small and the interpretation of the results was limited because of the cross-sectional nature of this study. As a result, we were unable to establish a causal link between low HGS, dynamic balance and functional mobility in older adults. Second, Dynapenia and depression share a common pathophysiological pathway. Since, our study had not considered depression assessment, the association between grip strength and depression could be biased by exclusion of that variable. Another drawback of this study could be sample limitation to those participants without cognitive decline.

3.1 Tables and figures

Table 1: Distribution of age, height, weight and BMI

	Age	Height	Weight	BMI
Mean	66.87	1.57	60.93	23.99
Std. Deviation	2.41	0.05	8.07	3.25

Table 2: Correlation of HGS with FSST

		FSST
Hand Grip Strength	Pearson Correlation	-0.195
	Sig. (2-tailed)	.278
	N	33

Table 3: Correlation of HGS with TUGT

		TUGT
Hand Grip Strength	Pearson Correlation	-0.530
	Sig. (2-tailed)	.002
	N	33

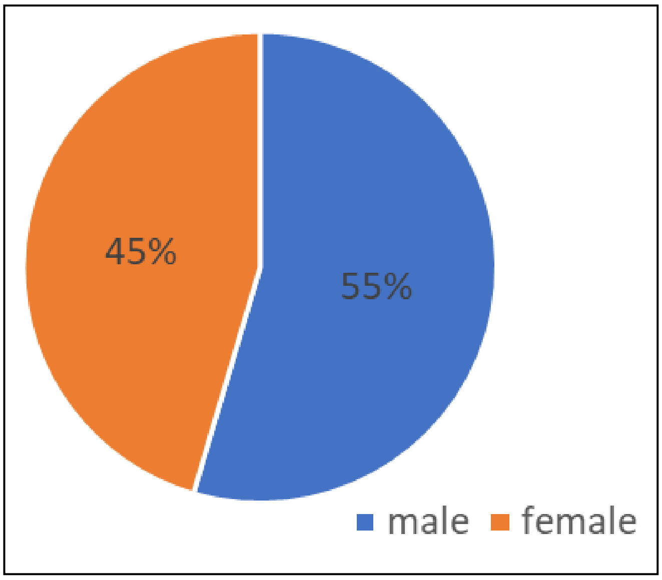

Fig 1: gender distribution

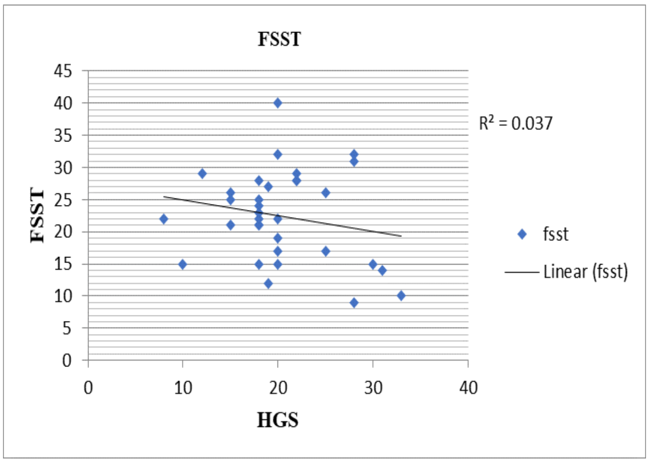

Fig 2: correlation of HGS with FSST

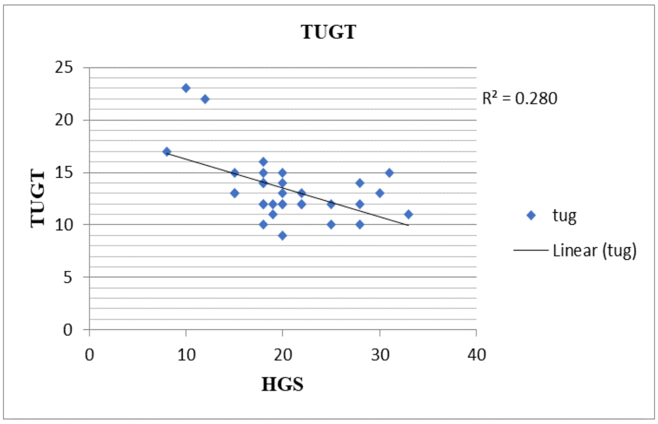

Fig 3: correlation of HGS with TUGT

4. Conclusion

In summary, our findings indicated that HGS, regardless of gender is associated with dynamic balance and functional mobility in elderly population. The older adults with reduced HGS showed a negative correlation between dynamic balance and functional mobility. Which concluded that HGS mediated the relationship between dynamic balance and functional mobility in older adults. Our results indicated that reduced grip strength as a significant predictor of fear of fall among older adults. Therefore, when assessing the risk of fall in older adults, policy makers, physicians and health care workers should consider grip strength as primary evaluation making as it is easier to implement effective treatments in long term care facilities.

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