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Associations Between Muscle Strength, Glomerular Filtration Rate, And Fall Risk: Insights From The Morse Fall Scale

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Abstract*. Falls among older adults and individuals with chronic conditions pose a major public health concern, leading to injuries, reduced quality of life, and increased healthcare costs. Identifying modifiable risk factors is crucial for prevention. Muscle strength, particularly in the lower extremities, and renal function, measured by glomerular filtration rate (GFR), are potential predictors of fall risk. Sarcopenia and chronic kidney disease (CKD) exacerbate muscle weakness, impairing balance and mobility. While the Morse Fall Scale (MFS) assesses clinical and environmental risks, it lacks physiological measures like muscle strength and renal function. This study aims to bridge this gap by examining associations between muscle strength, GFR, and fall risk, enhancing fall risk assessments and contributing to a more comprehensive understanding of fall prevention. This cross-sectional study at Bina Bakti Nursing Home was done in 2024 examined muscle strength, GFR, and fall risk in 93 elderly (≥60 years). Participants provided consent; those with incomplete data were excluded. Partial correlation analysis showed strong right-left grip strength correlation (p < 0.001) but no significant associations with Morse Fall Scale scores (p = 0.058, p = 0.093), suggesting grip strength alone poorly predicts fall risk. This study confirms grip strength as a reliable muscle function measure but not a strong fall risk predictor. Age plays a dominant role, necessitating fall prevention strategies integrating balance, mobility, cognition, and environment. Renal function did not directly influence fall risk but may contribute indirectly through frailty, warranting further investigation.*

Keywords: *Fall Risk, Grip Strength, Morse Fall Scale, Renal Function*

1. INTRODUCTION

Falls among older adults and individuals with chronic health conditions represent a significant public health concern, often leading to severe injuries, reduced quality of life, and increased healthcare costs. (Vaishya & Vaish, 2020) According to the World Health Organization (WHO), approximately 28-35% of people aged 65 and older experience at least one fall each year, and this proportion increases to 32-42% for those aged 70 and above. (World Health Organization, 2007) Falls are the second leading cause of unintentional injury deaths worldwide, resulting in an estimated 646,000 fatalities annually. (Mekkodathil et al., 2020)

In Indonesia, the burden of falls among older adults is equally concerning, particularly as the country undergoes a demographic transition with a rapidly aging population. Data from

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the Indonesian Basic Health Research (Riset Kesehatan Dasar/RISKESDAS) indicates that falls are a common health issue among older adults, with a prevalence of 25% in individuals aged 55 and above. (Riset Kesehatan Dasar (Riskesdas), 2018) The risk of falls is exacerbated by factors such as muscle strength, and high rates of chronic conditions like diabetes, hypertension, osteoporosis, and chronic kidney disease. (Abu Bakar et al., 2021; Cheng et al., 2022; Rahimi et al., 2019; Taniguchi et al., 2019)

Identifying modifiable risk factors for falls is critical for developing effective prevention strategies. Among these factors, muscle strength and renal function, as measured by glomerular filtration rate (GFR), have emerged as potential predictors of fall risk. (Zaman et al., 2013) Muscle strength, particularly in the lower extremities, is a well-established determinant of physical stability and mobility (de Maio Nascimento et al., 2022). Age-related sarcopenia and chronic conditions such as chronic kidney disease (CKD) can exacerbate muscle weakness, increasing susceptibility to falls. (Rodrigues et al., 2022; Roshanravan et al., 2017) Reduced muscle strength compromises balance, coordination, and the ability to recover from postural disturbances, all of which are critical for preventing falls. While muscle strength is a key factor, it is only one piece of the puzzle. (de Maio Nascimento et al., 2022)

Building on this premise, this study aims to bridge the gap between physiological measures and clinical fall risk assessment tools. Specifically, we examine the associations between muscle strength, glomerular filtration rate, and fall risk as assessed by the Morse Fall Scale. By exploring these relationships, we seek to contribute to a better understanding of the multifactorial nature of fall risk.

2. LITERATURE REVIEW

Muscle strength plays a crucial role in maintaining body balance and mobility, especially in elderly individuals. As people age, they experience a significant decline in muscle mass, a condition known as sarcopenia. This reduction in muscle strength directly impairs the ability to perform stable and responsive movements when changing body positions, such as walking or standing. Muscle weakness significantly increases the risk of falling, which can be assessed using the Morse Fall Scale (MFS). This tool evaluates fall risk through six key components, including physical conditions such as muscle weakness. Lower muscle strength results in a higher Morse Fall Scale score, indicating an increased fall risk. (Ham et al., 2005; Nishitani, 2023; Toyama et al., 2019)

Furthermore, decreased muscle strength affects neuromuscular coordination, which plays a crucial role in maintaining postural balance. Elderly individuals with reduced muscle strength become more vulnerable in situations requiring quick responses to prevent falls, such as tripping or sudden changes in walking surfaces. This condition makes them more susceptible to fall-related injuries. Therefore, assessing muscle strength through functional measurements and the MFS is essential for detecting individuals at high risk of falling. Poorly-managed muscle weakness increases fall frequency, making muscle-strengthening interventions critical in preventing this risk. (Cha, 2024; Karava et al., 2023; Rauscher et al., 2021)

The glomerular filtration rate (GFR) serves as a crucial indicator of kidney function. A declining GFR, which commonly occurs in the elderly, reflects a reduced ability of the kidneys to filter waste products and excess fluids from the body. When kidney function deteriorates, toxins that cannot be excreted accumulate, affecting multiple body systems, including the nervous and musculoskeletal systems. Toxin buildup in the peripheral nervous system impairs the body's ability to maintain balance, directly increasing the risk of falls. The Morse Fall Scale (MFS) can measure this relationship, as elderly individuals with declining kidney function tend to have higher scores, indicating a greater risk of falling. (Lattanzio et al., 2022; Lee, 2021; Zhang, 2023)

A decline in kidney function also disrupts mineral metabolism, particularly calcium and phosphate, which are essential for bone and muscle strength. These metabolic imbalances weaken muscles and bones, making older adults with reduced GFR more susceptible to balance impairments and muscle weakness, ultimately increasing their fall risk. Therefore, kidney function decline, as measured by the glomerular filtration rate, closely correlates with a higher risk of falling, especially in elderly individuals. Regular GFR evaluations, combined with fall risk assessments using the MFS, play a crucial role in prevention strategies to reduce fall incidence in high-risk populations. (Nishitani, 2023; Toyama et al., 2019; Y.-M. Yang & Choi, 2022)

3. METHODS

This study employed a cross-sectional design to examine the associations between muscle strength, glomerular filtration rate (GFR), and fall risk among elderly individuals. The study was conducted at Bina Bakti Nursing Home in 2024, with a total of 93 respondents consisting of elderly men and women aged 60 years and above. Inclusion criteria required participants to provide informed consent and meet the age requirement, while exclusion criteria excluded respondents with incomplete data.

Muscle strength, renal function, and fall risk were the primary variables assessed in this study. Muscle strength was measured using a hand dynamometer, which quantifies grip strength as an indicator of overall muscle function, measured in kg. Participants were instructed to perform the handgrip test following standardized protocols to ensure consistency and accuracy. Renal function was evaluated through serum creatinine levels in mg/dL, measured using an enzymatic reaction method. The estimated glomerular filtration rate (eGFR) was calculated using the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) equation:

eGFR=141× min (Scr/κ,1)α × max (Scr/κ,1)−1.209 × 0.993age×[1.018 (if female)]×[1.159 (if Black)] (Park & Jeong, 2018)

where:

Scr = serum creatinine (mg/dL),

κ = 0.7 for females and 0.9 for males,

α = -0.329 for females and -0.411 for males.

Min and max = minimum and maximum functions.

Fall risk was assessed using the Morse Fall Scale (MFS), a validated tool that evaluates six key risk factors: history of falling, secondary diagnoses, use of ambulatory aids, intravenous therapy, gait, and mental status. The total MFS score categorizes participants into low, moderate, or high fall risk. This tool was chosen for its reliability and widespread use in clinical settings to assess fall risk among elderly populations which is devided into low, moderate, and high risk.

Data analysis was performed using the Statistical Package for the Social Sciences (SPSS) version 25. Descriptive statistics were used to summarize the characteristics of the respondents, with continuous variables presented as mean values ± standard deviation. The normality of the data distribution was assessed using the Kolmogorov-Smirnov test, ensuring that the data met the assumptions required for parametric statistical tests. The relationships between handgrip strength, eGFR, and Morse Fall Scale scores were evaluated using the Pearson correlation coefficient test. The strength of the correlations was interpreted based on the following groupings: weak ($r<0.3$), moderate ($0.3< r <0.7$), and strong ($r>0.7$). Respondent characteristics, including age, gender, handgrip strength, creatinine, eGFR, and MFS scores, were summarized using descriptive statistics to provide an overview of the study population.

4. RESULT AND DISCUSSION

The study included a total of 93 respondents, with a majority being women (79.6%, n = 74), while men comprised 20.4% (n = 19) of the sample. The mean age of the participants was 74.19 years, reflecting a population of older adults. In terms of physical strength, the mean grip strength was measured for both hands. The right hand grip strength averaged 10.24 kg, while the left hand grip strength was slightly lower at 9.34 kg, indicating age-related declines in muscle function.

Renal function, assessed through serum creatinine levels and estimated glomerular filtration rate (eGFR), revealed a mean serum creatinine level of 1.04 mg/dL and a mean eGFR of 62.90 mL/min/1.73 m^2. These eGFR values suggest that, on average, the participants had mild to moderate reductions in kidney function, which is consistent with findings in older populations. Fall risk, evaluated using the MFS, showed a mean score of 33.66, placing the majority of respondents in the moderate fall risk category. This indicates that a significant proportion of the study population is at risk of falls and may benefit from targeted interventions to reduce this risk. (Table 1)

Additionally, this research applied the Kolmogorov-Smirnov test to evaluate the data distribution's normality. The findings demonstrated that all variable outcomes exhibited a normal distribution.

Table 1. Respondents' Characteristics

Variables	Results
Gender, mean (%)	
- Women	74 (79.6)
- Men	19 (20.4)
Age, mean (SD) years	74.19 (7.96)
Right hand Grip, mean (SD) kg	10.24 (6.42)
Left Hand Grip, mean (SD) kg	9.34 (6.56)
Creatinine, mean (SD) mg/dL	1.04 (0.31)
eGFR, mean (SD) ml/min/1.73m^2	62.90 (20.22)
Morse Fall Scale (MFS), mean (SD)	33.66 (25.94)

The Pearson correlation analysis revealed several significant relationships among the study variables. Morse Fall Scale (MFS) scores showed a statistically significant positive correlation with age (p = 0.035) and a significant negative correlation with right hand grip strength (r = -.230; p += 0.027) and left hand grip strength (r = -0.211; p = 0.043). These findings suggest that older age and lower grip strength are associated with a higher risk of falls. Age also demonstrated a significant negative correlation with eGFR (r = -0.238; p =

0.022), indicating that older participants tended to have lower kidney function. Similarly, creatinine levels showed a highly significant negative correlation with eGFR (r = -0.728; p < 0.001), consistent with the expected inverse relationship between these two variables.

Right hand grip strength and left hand grip strength were strongly and positively correlated with each other (r = 0.909; p < 0.001), confirming the consistency of grip strength measurements between both hands. Additionally, right hand grip strength showed a significant positive correlation with eGFR (r = 0.206; p = 0.048), suggesting that better kidney function may be associated with greater muscle strength. No significant correlations were observed between creatinine levels and grip strength measures (p > 0.05) or between eGFR and left hand grip strength (p = 0.178). Similarly, the relationship between MFS scores and creatinine levels did not reach statistical significance (p = 0.174). (Table 2)

Table 2. Pearson Correlation Between Hand Grip Strength and Renal Function to Morse Fall Scale (MFS)

Parameter		**MFS**	**Age**	**Creatinine Level**	**e-Glomerular Filtration Rate**	**Right Hand Grip Strength**	**Left Hand Grip Strength**
Morse Fall Scale (MFS)	Pearson Correlation	1	.219*	.142	-.188	-.230*	-.211*
	Sig. (2-tailed)		.035	.174	.072	.027	.043
Age	Pearson Correlation	.219*	1	.169	-.238*	-.179	-.191
	Sig. (2-tailed)	.035		.106	.022	.087	.066
Creatinine Level	Pearson Correlation	.142	.169	1	-.728**	-.112	-.051
	Sig. (2-tailed)	.174	.106		.000	.287	.625
e-Glomerular Filtration Rate	Pearson Correlation	-.188	-.238*	-.728**	1	.206*	.141
	Sig. (2-tailed)	.072	.022	.000		.048	.178
Right Hand Grip Strength	Pearson Correlation	-.230*	-.179	-.112	.206*	1	.909**
	Sig. (2-tailed)	.027	.087	.287	.048		.000
Left Hand Grip Strength	Pearson Correlation	-.211*	-.191	-.051	.141	.909**	1
	Sig. (2-tailed)	.043	.066	.625	.178	.000	

The partial correlation analysis, controlling for age, examined the relationships between hand grip strength (right and left) and MFS scores. The results showed that right hand grip strength and left hand grip strength were strongly correlated with each other (r = 0.906; p < 0.001), even after adjusting for age. This indicates a high degree of consistency between the grip strength measurements of both hands. However, the relationship between right hand grip strength and MFS scores did not reach statistical significance (p = 0.058), suggesting that lower grip strength may not independently predict fall risk when age is controlled. Similarly, the correlation between left hand grip strength and MFS scores was also not statistically significant (p = 0.093), further supporting the idea that grip strength alone may not be a strong predictor of fall risk in this context. (Table 3)

Table 3. Pearson correlation between Hand Grip Strength and Renal

Control Variables			**Right Hand Grip Strength**	**Left Hand Grip Strength**	**Morse Fall Scale (MFS)**
Age	Right Hand Grip Strength	Correlation	1.000	.906	-.199
		Significance (2-tailed)	.	.000	.058
	Left Hand Grip Strength	Correlation	.906	1.000	-.176
		Significance (2-tailed)	.000	.	.093
	Morse Fall Scale (MFS)	Correlation	-.199	-.176	1.000
		Significance (2-tailed)	.058	.093	.

The strong correlation between right and left hand grip strength, even after controlling for age, underscores the consistency of muscle strength measurements across both hands. This aligns with existing literature suggesting that grip strength is a reliable indicator of overall muscle function and physical capacity in older adults. However, the lack of a significant relationship between grip strength and MFS scores when age was controlled suggests that muscle strength alone may not be a sufficient predictor of fall risk. This finding challenges the assumption that interventions targeting muscle strength alone will significantly reduce fall risk in elderly populations. Instead, it highlights the need for a more holistic approach that considers multiple risk factors, such as balance, mobility, and environmental hazards.

The relationship between age and fall risk, as measured by the Morse Fall Scale (MFS), is consistent with a robust body of evidence demonstrating that advancing age is one of the most significant risk factors for falls. As individuals age, they undergo a series of physiological changes that collectively increase their vulnerability to falls. These changes include sarcopenia (age-related loss of muscle mass and strength), declines in neuromuscular function, and reductions in balance and coordination. (Appeadu & Bordoni, 2023; Iamtrakul et al., 2021) These age-related declines are often compounded by the presence of chronic health conditions, sensory impairments, and polypharmacy, all of which further elevate fall risk. (Lipsitz et al., 2018)

The observed correlation between age and fall risk aligns with the frailty syndrome, a well-established concept in gerontology. Frailty is characterized by decreased physiological reserve and increased vulnerability to stressors, including falls. (Z. C. Yang et al., 2023) Muscle strength, particularly grip strength, is a key component of frailty assessments and is often used as a proxy for overall physical function. (Spiegowski et al., 2022) However, the partial correlation analysis in this study revealed that the relationship between grip strength and fall risk diminishes when age is controlled. This suggests that age may act as a mediating variable, influencing both muscle strength and fall risk independently. In other words, while muscle strength is an important factor, its predictive power for fall risk may be overshadowed by the broader effects of aging on physical and cognitive function. (Trevisan et al., 2021)

The findings related to renal function, particularly the inverse relationship between eGFR and age, reflect the natural decline in kidney function that accompanies aging. While renal function did not show a direct association with fall risk in this study, its relationship with age and muscle strength suggests that it may indirectly influence fall risk through its impact on overall health and physical function. (Cheng et al., 2022) This aligns with theories positing that chronic conditions, such as reduced kidney function, contribute to frailty and functional decline in older adults. (Nixon et al., 2017; Pedone et al., 2011) As individuals age, their kidneys undergo structural and functional changes, including a reduction in the number of nephrons, decreased renal blood flow, and diminished glomerular filtration capacity. (Denic et al., 2016) These changes are part of the natural aging process and are often accelerated by the presence of comorbidities such as hypertension, diabetes, and cardiovascular disease. The observed decline in eGFR with advancing age is consistent with the concept of renal senescence, which describes the gradual deterioration of kidney function over time. (MacRae et al., 2021)

While renal function, as measured by eGFR, did not show a direct association with fall risk in this study, its relationship with age and muscle strength suggests that it may indirectly influence fall risk through its impact on overall health and physical function. Reduced kidney function is often associated with a range of systemic effects, including electrolyte imbalances, anemia, uremic toxins accumulation, and metabolic acidosis. (Rapa et al., 2019) These physiological changes can contribute to muscle wasting, weakness, and fatigue, all of which are known risk factors for falls. (Duryea & Schell, 2023; Yu-Yahiro, 1994; Zemaitis et al., 2024)

The indirect influence of renal function on fall risk is also supported by the multifactorial nature of falls in older adults. Falls are rarely caused by a single factor but rather result from the interplay of multiple risk factors, including impaired mobility, balance deficits, cognitive impairment, and polypharmacy. (Appeadu & Bordoni, 2023) Reduced kidney function may exacerbate these risk factors by contributing to neuropathy, cardiovascular instability, and medication toxicity. (Arnold et al., 2016; Yamamoto & Kon, 2009) For example, CKD patients often experience peripheral neuropathy, which can impair proprioception and balance, increasing the likelihood of falls. Similarly, the accumulation of medications or their metabolites due to impaired renal clearance can lead to dizziness, orthostatic hypotension, and cognitive impairment, further elevating fall risk. (Drew et al., 2019; Franceschini et al., 2010; Jungers et al., 1986)

The lack of a significant correlation between creatinine levels and fall risk in this study underscores the multifactorial nature of falls in older adults. Falls are rarely the result of a single physiological or clinical factor but rather arise from the complex interplay of biological, behavioral, and environmental influences. While creatinine levels are a useful marker of renal function, they do not capture the broader spectrum of factors that contribute to fall risk, such as muscle strength, balance, gait stability, cognitive function, and medication use. (Baxmann et al., 2008; Levey et al., 1988)

5. CONCLUSION

This study confirms that handgrip strength is a reliable indicator of muscle function, but is inadequate as a sole predictor of fall risk. No significant correlation was found between handgrip strength and Morse Fall Scale (MFS) scores after controlling for age, indicating that age plays a dominant role in fall risk. Therefore, fall prevention strategies should be multifactorial, including balance, mobility, cognitive function, and environmental safety training, not just strength training. Age is strongly correlated with fall risk due to physiological decline such as sarcopenia, neuromuscular disorders, and sensory deficits. Although kidney function does not directly affect fall risk, its association with frailty suggests a potential indirect effect that needs further investigation. Assessment of kidney function is also recommended as part of a comprehensive geriatric evaluation. Limitations of this study include its cross-sectional design that cannot establish a causal relationship, and it did not account for cognitive impairment, medication use, and environmental factors. Future studies should be longitudinal and include a broader assessment of muscle function, such as leg strength and postural control, and test the effectiveness of an integrated intervention that includes strength, balance, and cognitive training in preventing falls in older adults.

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