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Muscle strength and the risk of falls in community-dwelling elderly in Central Java in urban and rural areas

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Abstract

Background: The elderly are individuals aged 60 and above, marking the final stage of the life cycle. The World Health Organization classifies the elderly into four groups: middle-aged elderly (45-59 years), elderly (60-74 years), older elderly (75-90 years), and very old elderly (above 90 years). Currently, there are 142 million people aged 60 and above in the 11 Southeast Asian WHO member countries. By 2050, this number is expected to triple, prompting the WHO to urge nations to prioritize aging on World Health Day. Decreased muscle strength for postural control is a risk factor for falls in the elderly, and a significant portion of falls may be attributed to this component. In Indonesia, the rate of fall-related injuries due to balance disorders is found to be 49.4% in individuals above 55 years, 67.1% in those above 65 years, and up to 35% in individuals between 70-75 years.
Purpose: To determine the influence of muscle strength on the risk of falls in the elderly in urban and rural areas.
Method: This study employed a cross-sectional study design, investigating the correlation between risk factors (independent) and outcomes (dependent) based on data collection through observations conducted at a single point in time. The research was conducted in Gonilan village as a representative urban area and Boyolali Regency, Central Java, as a representative rural area in August 2023. The study population included the elderly in Gonilan and Boyolali. Non-probability sampling with quota sampling was used, resulting in 204 participants meeting the survey criteria.
Results: Muscle strength in urban areas with low categories had an odds ratio (OR) of -0.282, Exp B of 1.048, ρ-value of 0.824 with a 95% confidence interval (CI) of 0.962. In contrast, urban areas with high categories had an OR of 0.037, Exp B of 0.754, ρ-value of 0.310 with a 95% CI of 1.130. This indicates that the ρ-value for all areas is greater than 0.05, meaning there is no influence of muscle strength on the risk of falls in urban and rural areas.
Conclusion: Based on the research findings, there is no influence of muscle strength on the risk of falls in the elderly in urban and rural areas. The risk of falls is influenced by various factors, including environmental conditions.

Keywords: Elderly; Fall; Muscle Strength; Risk Factor.

INTRODUCTION

Elderly individuals are those who have reached the age of 60 and above, referred to as the final stage of the life cycle (Lachman, Teshale, & Agrigoroaei, 2015). The World Health Organization classifies the elderly into four groups: middle-aged elderly in the age range of 45-59 years, elderly in the age range of 60-74 years, older elderly in the age range of 75-90 years, and very old elderly above 90 years (World Health Organization, 2022). Currently, there are 142 million people aged 60 and above in the 11 Southeast Asian WHO member countries. By 2050, this number is estimated to triple, prompting the WHO to urge countries to prioritize aging on World Health Day (World Health Organization, 2012).

The elderly are defined as individuals aged 60 years or older, regardless of gender, who are still

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engaged in activities and work or unable to support themselves and must rely on assistance from others (Shanas, Townsend, Wedderburn, Friis, Milhoj, & Stehouwer, 2017). The elderly are divided into four categories: middle-aged (*virility*) represents the stage of preparation for those aged 45–54 years, showing mental and physical maturity. Early elderly (*prasenium*) refers to those approaching the age range of 55–64 years. The elderly group (*senium*) includes residents aged 65 years and above, and the high-risk elderly are those aged above 70 years (Ministry of Health of the Republic of Indonesia, 2016).

Based on a survey, Indonesia is expected to experience the largest increase in the elderly population. Furthermore, the proportion of the elderly population in Indonesia is 9.92% or 26.82 million people in 2020. Central Java Province is among the top three provinces with the highest proportion of the elderly (12.59%) (Central Statistics Agency, 2020). On the other hand, the bodies of elderly individuals undergo structural and functional changes in organ tissues with age, which may affect body balance (Tieland, Trouwborst, & Clark, 2018).

In the elderly, a decline in the strength of the lower extremity muscles can impact body balance. The front thigh and hamstring muscles are the ones that lose their strength most rapidly. According to previous research, Body Mass Index (BMI) can lead to a decrease in the strength of lower extremity muscles, which is crucial for maintaining balance while standing (Valentina, Kurniawati, & Maramis, 2019). Cognitive function in the elderly undergoes changes in the central nervous system (CNS) that affect balance, including the loss of neurons and dendrites, low metabolism, and cerebral perfusion neurotransmitter synthesis. Another study states that the number of cholinergic neurons decreases with age, leading to a decrease in acetylcholine neurotransmitter and a decline in brain function (Janeczek, Gefen, Samimi, Kim, Weintraub, Bigio, & Geula, 2018).

A history of falls can affect balance in the elderly due to failures in detecting shifts and the improper repositioning of body gravity (Ramadhani, Munawwarah, Maratis, & Ivanali, 2021). Falling is another term for the disturbed balance of an individual, especially in the elderly, due to weakened muscles disrupting the balance system, increasing the likelihood of falling. One of the main factors that increases the risk of death in the elderly is falling (Murtiyani, & Suidah, 2019).

As much as 7.63% of the Indonesian population resides in rural areas, characterized by life in West Java's Pasir Langu Primary Health Center located in Cisarua, West Bandung Regency, where the majority of the population works as farmers. A total of 3,194 elderly individuals actively participate in the integrated health posts at Pasir Langu Primary Health Center. Additionally, 7.49% of the elderly population in Indonesia resides in metropolitan areas. Previous research has analyzed the relationship between the strength and balance of lower limb muscles and the risk of falling. It found that improved balance can reduce the likelihood of falling, correlating with the strength of the front thigh muscles (Asti, Yanti, & Astuti, 2020).

The elderly are highly susceptible to the risk of falling, an unexpected event that causes a person to lie or sit on the floor or a lower surface without losing consciousness or sustaining injuries. One of the major geriatric tragedies is falling, especially among the elderly. The most common causes are issues with the sensory, cognitive, and central nervous systems that disturb balance, muscle strength, and muscle flexibility (Reimann, Ramadan, Fettrow, Hafer, Geyer, & Jeka, 2020).

The decline in muscle strength for postural control is one of the risk factors for falls in the elderly, and most falls may be caused by this component (Ranti, 2021). In Indonesia, the rate of fall-related injuries due to balance disorders is found to be 49.4% in individuals above 55 years, 67.1% in those above 65 years, and up to 35% in individuals between 70-75 years. Previous research indicates that 46% of elderly patients at the Medan Johor Primary Health Center's primary care unit are at high risk of falling, 36% at low risk, and 18% not in danger (Rohima, Rusdi, & Karota, 2020).

The Time Up and Go Test (TUG) is one of the measurement tools applied to assess the degree of the risk of falling. TUG is a direct clinical test used to evaluate mobility, balance, lower extremity function, and the risk of falling in various populations (Lusardi, Fritz, Middleton, Allison, Wingood, Phillips, & Chui, 2017; Sari, Motik, & Sudaryanto, 2023). Body balance is greatly influenced by muscle strength. Static balance and dynamic balance are two

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categories included in body balance. Dynamic balance refers to the body's ability to maintain proper posture during mobilization, while static balance refers to the body's ability to maintain the center of gravity while supporting the body in an upright position while standing or sitting. The quality of life in the elderly is influenced by their ability to maintain postural control during daily activities, supported by maintaining balance to reduce the risk of falling (Annisyah, Idramsyah, Bakara, & Ratnadhiyani, 2020).

The Sit-to-Stand test is often applied to evaluate the strength and balance of the lower extremities. The Five Times Sit-to-Stand Test (FTSTS) is a quick and inexpensive way to assess functional strength and balance in the lower extremities, applicable for conducting sit-to-stand tests. It is recommended for primary care doctors to implement FTSTS as a screening tool to assess the risk of falling in elderly patients. The test is conducted using a chair without armrests with a height of ± 43 cm. Patients perform five quick iterations with increasing complexity. The body functions better the faster the process. This test has very strong inter-level reliability (ICC ≥ 1.0) in healthy elderly individuals and inter-rater reliability (ICC ≥ 0.64) in the elderly community.

RESEARCH METHOD

This research applied a cross-sectional study design, a research design that sought to find correlations between risk factors (independent) and outcomes (dependent) based on data collection through observations conducted at a single point in time. The study was carried out in the village of Gonilan as a representative urban area and Boyolali Regency, Central Java, as a representative rural area in August 2023. The population in this study consisted of elderly individuals in Gonilan and Boyolali Village.

The sampling technique employed was non-probability sampling using quota sampling, resulting in a sample of 204 participants that met the survey criteria. Inclusion criteria included being above 60 years old, in good physical and mental health, capable of communication, both male and female, and willing to participate as a respondent. Exclusion criteria involved elderly individuals with physical and mental disorders, using mobility aids, suffering from knee osteoarthritis, experiencing pain in one or both limbs affecting walking patterns, having a history of injury, facing neuromuscular disorders such as stroke, Parkinson's, ataxia, coordination disorders, and having diabetes mellitus and heart disease.

The independent variable in this study is muscle strength, while the dependent variable is the risk of falling. Research instruments used included a questionnaire sheet, stopwatch, chair with a height of ±43 cm, a chair with armrests (backrest), and measuring tools. The researcher collected participants according to inclusion criteria who had provided informed consent. Explanation of the research purpose and objectives was given to participants before intervention. The first intervention involved the five-time sit-to-stand exercise using a standard chair with a straight backrest. Participants were instructed to sit on the chair, rest their back, fold their hands in front of the chest, and then perform sit-to-stand five times. The second intervention was the Time Up and Go test (TUG), which is a walking exercise with or without assistive devices. Participants walked 3 meters from the chair, turned around, walked back to the chair, and sat down, repeated five times. The researcher recorded the results of each participant's exercise and analyzed them after 7 sessions over a week of intervention.

In this study, there are assessment indicators for the variables used, including BMI categories: underweight if BMI <18.5, normal if in the range of 18.5-24.9, overweight if in the range of 25-29.9, and obesity if >30. Low muscle strength is indicated if the scale is <3, and high if the scale is >3. Successfully completing the TUG test in more than 12.6 seconds indicates a high risk of falling, and low risk if <12.6 seconds. Five times sit-to-stand is considered low if the score is ≥12 seconds and high if the score is >15 seconds.

The analysis used includes descriptive data analysis, presenting participant characteristics, and inferential analysis, including normality tests and impact tests (linear regression). Tests applied include the Spearman Rho correlation test for correlation, the Kolmogorov-Smirnov test for normality, and linear regression analysis as a statistical technique.

This research has obtained ethical clearance from the Health Research Ethics Committee (HREC) of Dr. Moewardi Regional General Hospital with number: 1.398/VII/HREC/2023.

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RESEARCH RESULTS

Table 1. Characteristic of Participants (N=204)

Variables	Urban (n=102)	Rural (n=102)
Age (Mean±SD)(Range)(Year)	(65.9± 3.826)(60-89)	(65.6± 4.632) (60-89)
Gender (n/%)		
Male	19/18.6	15/14.7
Female	83/81.4	87/85.3
Occupation (n/%)		
Housewife	65/63.7	51/50
Employee	20/19.6	15/14.7
Farmer	5/5	32/31.4
Civil Servant	12/11.7	4/3.9
BMI (n/%)		
Underweight	10/9.8	15/14.7
Normal	78/76.5	75/73.5
Overweight	12/11.8	11/10.9
Obesity	2/1.9	`1/0.9
Time Up and Go Test (n/%)		
Falling risk - low	34/33.3	28/27.4
Falling risk - high	68/66.4	74/72.6
Five Times Sit to Stand (n/%)		
Low	4/3.9	22/21.6
High	98/96.1	80/78.4

Based on Table 1, the total population in urban and rural areas consists of 204 samples, divided into two groups: 102 elderly individuals in urban areas and 102 elderly individuals in rural areas. The number of elderly females dominates in both urban and rural areas, with 83 (81.4%) and 87 (85.3%) participants, respectively. In urban areas, the dominant employment status among the elderly is housewives with 65 (63.7%), and employee with 20 (19.6%). In rural areas, the dominant employment status is housewives with 51 (50%) and farmers with 32 (31.4%). BMI in both urban and rural areas falls within the normal range, with 68 (66.4%) and 75 (73.5%) participants, respectively. Both urban and rural areas show a high risk of falling in the time-up-and-go test, with 68 (66.4%) and 74 (72.6%) participants, respectively. The muscle strength in the five times sit-to-stand test is high in both urban and rural areas, with 98 (96.1%) and 80 (78.4%) participants, respectively.

Table 2. Mann-Whitney Test for Data Normality

Risks of Falling	Muscle's Strength	
	Average (second)	p-value
Urban	93.71	0.033
Rural	111.29	0.194

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Based on Table 2, it can be observed that there is a difference in muscle strength between urban and rural areas. The muscle strength in urban areas has an average of 93.71 seconds with a ρ-value of 0.033, while in rural areas, the average is 111.29 seconds with a ρ-value of 0.194. This indicates that better muscle strength is present in urban areas.

Table 3. Test of the Influence of Muscle Strength on the Risk of Falling

Muscle's Strength	Risks of Falling			
	OR	Exp B	ρ-value	95%CI
Urban				
Low	-0.282	1.048	0.824	0.962
High	0.037	0.754	0.310	1.130
Rural				
Low	-0.124	0.884	0.915	0.926
High	0.037	1.038	0.523	1.164

Based on Table 3, muscle strength in the urban area with the low category has an odds ratio (OR) of -0.282, an Exp B of 1.048, a ρ-value of 0.824, and a 95% confidence interval (CI) of 0.962. Meanwhile, in the urban area with the high category, the OR is 0.037, Exp B is 0.754, ρ-value is 0.310, and 95% CI is 1.130. This indicates that the ρ-value for all areas is greater than 0.05, meaning there is no influence of muscle strength on the risk of falling in urban and rural areas.

DISCUSSION

Based on the characteristic of participants' data, it is evident that the elderly age range is between 60-89 years. The majority of the population is female, in line with previous research indicating that elderly women are perceived to have a better quality of life than men because women often receive support from family and relatives (Seangpraw, Ratanasiripong, & Ratanasiripong, 2019). On the other hand, elderly women are more susceptible to the risk of falling due to hormonal changes, experiencing menopause around the age of 45, compared to men who go through andropause until the age of 70 (Astria, & Ariani, 2016). The majority of elderly people are still married, this shows that their quality of life is higher when they live with their partner than when they are widowed or widowed (Rachmatika, Komalasari, Widodo, & Rahman, 2022).

The participants' occupational status is predominantly housewives, and previous research also states that the elderly with low income have a higher quality of life compared to those without income (Zin, Saw, Saw, Cho, Hlaing, Noe, & Hamajima, 2020). The results also indicate that muscle strength in the urban elderly is better than in rural areas, with an average of 93.71 seconds and a ρ-value of 0.033. Based on the influence test, the ρ-values for both urban and rural areas are above 0.05, indicating that muscle strength does not have an effect on the risk of falling in the elderly.

Urban areas, also known as urban, are regions with primary activities other than agriculture. Typically, urban areas serve as places for urban settlements, concentration and distribution of government services, social services, and economic activities. Generally, urban areas are densely populated. On the other hand, rural areas or rural regions are areas with primary agricultural activities, including the management of natural resources. Rural areas function as rural settlements, service centers, government services, social services, and economic activities, characterized by a more expansive residential area (Nugraha, 2020).

The World Health Organization classifies the elderly into four groups: middle-aged elderly (45-59 years), elderly in the range of 60-74 years, elderly in the range of 75-90 years, and very old elderly over 90 years (World Health Organization, 2022). The average age of the research subjects is 65 years, categorized as elderly. In the elderly phase, individuals undergo physical, cognitive, and psychosocial changes.

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Based on overall physical health conditions, there is a decline since entering the elderly phase of life. Functioning physical health enables the elderly to achieve quality aging. However, psychologically, those not prepared to face these changes may experience a lower quality of life (Utomo, 2010; McPhee, French, Jackson, Nazroo, Pendleton, & Degens, 2016).

The elderly phase involves a degenerative process that progresses with manifestations such as a decrease in muscle mass and strength. The process of declining muscle mass and strength involves the interaction of the peripheral and central nervous systems, hormonal factors, nutritional status, immunological factors, and insufficient physical activity. At the biomolecular level, this is caused by a decrease in the speed of muscle protein synthesis and/or an increase in the breakdown of muscle protein that is not proportional.

Generally, the neuropathy process has the most significant influence because this part is responsible for the degeneration of alpha motor nerves that supply muscle fiber innervation, leading to the loss of motor units. Other research indicates the impact of age on muscle strength, showing a loss of motor units with increasing age, as evidenced by surface electromyography results in elderly patients showing a decrease in the complexity of their graphs (Hida, Shimokata, Sakai, Ito, Matsui, Takemura, & Harada, 2016).

Based on previous research, the risk of injury due to falls depends on the vulnerability of each patient and the environmental hazards surrounding them. A good environment is less likely to pose a risk of falling, while a less favorable environment is more likely to lead to a risk of falling. This is particularly related to the geographical location, where urban areas, despite being densely populated, generally have well-organized surroundings with fewer slippery surfaces. On the other hand, rural areas are often associated with dirt roads that can be slippery.

The frequency of falls in an individual is related to the cumulative effects of various disturbances that occur due to aging (Ravindran, & Kutty, 2016). Falls are a common health issue in individuals aged 65 and above (Delle Fave, Bassi, Boccaletti, Roncaglione, Bernardelli, & Mari, 2018). In some countries, it has been found that 28-35% of individuals aged 65 and above, or individuals aged 70, experience falls, with around 32-42% each year, and 40% of these individuals reported repeated falling incidents (Boehm, Franklin, & King, 2014).

The risk of falls in the elderly is influenced by various factors. Risk factors for falling incidents are divided into intrinsic, extrinsic, or a combination of both. Intrinsic factors are internal factors, including age and the decline in sensory organ functions such as visual acuity and hearing. Extrinsic factors involve the environment and living conditions that can potentially affect falls in the elderly (Yoo, Kim, Yim, & Jeon, 2016).

Falls are the leading cause of non-fatal injuries but can result in death in older adults. Prevention or reduction of the risk of falling has become the main focus of various health issues. Over the past two decades, clinical-related research has provided doctors with various screening tools to measure the risk factors for falling incidents. Most processes have focused on a single intra-individual domain, such as body balance, muscle strength, and vision function. Additionally, there are extra-individual factors, such as home safety to prevent the risk of falling (Renfro, & Fehrer, 2011).

Approximately one-third of the elderly will experience a falling incident at least once a year. Secondary conditions arising from falling incidents can increase the risk of injuries, such as hip fractures and head injuries. Currently, fall risk reduction programs have significantly increased in public health. This is done to easily identify elderly individuals who need interventions to reduce or manage the risk of falling itself (Lusardi, Fritz, Middleton, Allison, Wingood, Phillips, & Chui, 2017).

One fairly effective way to reduce the incidence of falls is to practice a healthy lifestyle, whether in urban or rural areas. Avoiding stress and engaging in physical activities such as walking, strength training, or customized physical activities for each individual can contribute to a healthier lifestyle. Additionally, physical exercise has benefits in improving the functional capacity of the body's organs in weakened elderly individuals. Certainly, exercise programs tailored to this population have proven effective in fall prevention (Cadore, Rodriguez-Maias, Sinclair, & Izquierdo, 2013).

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CONCLUSION

Based on results of the research, there is no influence of muscle strength on the risk of falling in the elderly in urban and rural areas. The risk of falling is influenced by various factors, and one of them is the environmental conditions.

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