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The Effect of *Multimodal Exercise* on Fall Risk and Functional Ability in the Elderly with *Frailty Syndrome* with Type 2 Diabetes Mellitus

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Abstract

Elderly with Frailty Syndrome with Type 2 Diabetes Mellitus (T2DM) often experience loss of muscle mass and skeletal muscle function, causing a risk of falls and reduced functional abilities. To determine the effect of multimodal exercise on the risk of falls and functional ability in the elderly who experience frailty syndrome with T2DM. This research is quasi-experimental with a pretest-posttest design of 2 paired groups. A total of 50 older adults experiencing frailty syndrome with T2DM were divided into two groups of 25 people each. The T-Dependent Test and Wicoxon Test were used to determine changes before and after exercise administration, and the Mann-Whitney Test was used to determine the comparison between the intervention group and the control group. There was a reduced fall risk level and improved functional ability in the intervention group with Multimodal Exercise and in the control group (p=0.000). Multimodal Exercise had a difference in decreasing (Timed Up and Test) TUGT value higher than Elderly Gymnastics (p=0.001), and a higher increase in SPPB value was obtained in Multimodal Exercise than in the control group (p = 0.000). Multimodal Exercise intervention program was more effective in reducing fall risk and increasing functional ability.

Keywords : Elderly, Frailty Syndrome, Type 2 Diabetes Mellitus, Multimodal Exercise

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I. INTRODUCTION

Elderly or elderly is the final stage of the aging process, a life cycle that cannot be avoided and will be experienced by every individual (Thomas et al., 2019). The aging process is closely related to the decline in overall organ function that runs progressively with age (Aryana et al., 2018). Decreased physiological capacity in the form of symptoms or clinical signs and diseases which, if continued, will cause disability, disability, dependence, to death. Before reaching the stage of disability, often the elderly experience a syndrome known as frailty syndrome (weakness syndrome), which is a geriatric syndrome that is defined as a clinical condition in which there is an increase in susceptibility due to an aging process and deterioration in the physiological system, which causes a decrease in daily functional abilities(Rodriguez-mañas et al., 2019). According to The Cardiovascular Health Study, frailty syndrome reaches 7% of the elderly 65 and over and about 30% of the elderly over 80 years (Seto et al., 2015).

Frailty syndrome is often associated with the emergence of pathological conditions in the elderly due to decreased organ function, including skeletal muscle function, known as sarcopenia. Sarcopenia plays a role in the pathogenesis and etiology of frailty syndrome and is closely related to other chronic diseases, such as T2DM (Lima Filho et al., 2020). Some studies show that elderly people with diabetes mellitus are more likely to experience frailty syndrome than non-diabetic elderly (Jang, 2016).

The pathophysiology of DM is associated with frailty syndrome, where insulin resistance in T2DM, characterized by a decrease in the response of target organs to insulin, especially in skeletal muscle, can have an impact on lower extremity function, and further exacerbate the increase in intramyocellular fatty acid metabolites caused by reduced mitochondrial activity accompanied by decreased muscle function(Krentz et al., 2013). In addition, DM suffered in the long term can increase the loss of mass and function of skeletal muscles, causing the risk of falls, reduced functional abilities such as decreased mobility, changes in walking speed, and poor Activity of Daily Living (ADL) patterns (Muszalik et al., 2022).

Based on the high prevalence of frailty, it is best to implement preventive measures to slow the emergence and progression of frailty syndrome that has occurred and its effects. The therapeutic measures and intervention strategies that can be given are drugs, nutrition, and physical exercise(Sanz-Cánovas et al., 2022). Doing physical or physical exercise is an effective non-pharmacological treatment for the elderly. One exercise that is still rarely studied is a multicomponent exercise program known as the multimodal exercise (Liu et al., 2017).

The multimodal exercise program is an exercise that combines 2 or more types of exercise, generally consisting of aerobic exercise and anaerobic exercise endurance (Thomas et al., 2019), which is proven to increase physical capacity (Liu et al., 2017). So, researchers are interested in researching the effect of multimodal exercise on the risk of falls and functional ability in the elderly who experience frailty syndrome with T2DM.

II. METHOD

The research subjects comprised 50 elderly people at the Batara Hati Mulia Gowa Foundation who met the inclusion criteria and did not include the exclusion criteria. The inclusion criteria are aged 45 to >60 years, meet 3 out of 5 criteria for frailty syndrome phenotype and suffer from T2DM diagnosed by a doctor with laboratory results and long-suffering from T2DM for at least 3 years. Exclusion criteria are having complications of diabetic ulcer wounds or gangrene, taking drugs other than DM drugs, having a history of respiratory and nervous heart disease complications, and using assistive devices when walking.

The subjects were divided into 2 groups, each comprising 25 people. The first group was the intervention group providing a multimodal exercise program, and the second group was the control group, respondents who were given elderly gymnastics exercises. The intervention group was given exercise 3 times a week for 8 weeks, and the control group was given exercise 1 time a week for 8 weeks. Multimodal exercise combines exercise components consisting of muscle strength, balance, flexibility, and resistance training. Each multimodal exercise session is carried out in 3 stages: warm up with 8 movements, core exercises (aerobic and balancing exercise) with 10 movements and cool down with 5 movements. Elderly gymnastics is a stage of regular movement involving all muscles and joints and is easy to do. This exercise consists of movements involving movement of almost all body muscles, has recreational elements, and its implementation is flexible that can be done in open or closed spaces.

Before starting the exercise treatment for respondents, a pre-test examination was conducted in the first week to assess the fall risk level and functional ability. Then, a post-test was carried out after 24 treatments in the eighth week. Fall risk examination using the Timed Up and Go Test (TUGT) instrument, where participants are instructed to walk 3 meters according to the line on the floor at normal speed, then turn around and sit again; when starting to walk, the calculation of time begins, and the time ends after participants sit back in the chair. Functional ability examination with Short Physical Performance Battery (SPPB) is an instrument that can specifically evaluate functional ability, especially to measure physical performance status in the lower extremities. SPPB consists of 3 assessments: standing balance, walking speed, and chair stand tests. The timed results of each test are scaled according to the rules and interpreted from a score of 0 = poor performance to 12 = best performance.

Statistical analysis was performed with SPSS program version 26.0 (IBM Corporation, Armonk, NY, USA). Numerical data are presented as mean, standard deviation, and categorical data in frequency and percentage. The collected data will be tested for normality using the Shapiro-Wilk test, expressed as norm-distributed data if $P > 0.05$. Wilcoxon test to see the effect before and after giving multimodal exercise, and Paired t-test to see the effect before and after giving elderly gymnastics. Then the Mann-Whitney test aims to compare the difference between multimodal exercise and elderly gymnastics against changes in TUGT and SPPB scores after an 8-week exercise program between the two groups. The significant rate is set at $P \leq 0.05$.

This research has been approved by the Health Research Ethics Commission of the Faculty of Medicine, Hasanuddin University, Makassar, Indonesia, with ethical permit number 185/UN4.6.4.5.31/PP36/2023.

III. RESULTS

Table 1. Characteristics of Research Samples

Characteristic	Intervention Group		Control Group		Total
	n	(%)	n	(%)	
Age (years)					
60-68	12	48,0	10	40,0	22
69-76	11	44,0	12	48,0	23
77-84	2	8,0	3	12,0	5
Gender					
Man	11	44,0	9	36,0	20
Woman	14	56,0	16	64,0	30
Long Suffering from DM (years)					
3-6	19	76,0	22	88,0	41
7-10	6	24,0	3	12,0	9
Frailty Index					
Positive (+)	25	100,0	25	100,0	50
Negative (-)	0	0,0	0	0,0	0

Based on age category, it was obtained in the intervention group given *multimodal* exercise in the most age category, namely in 60-68 years, as much as 12 or 48%, while in the control group given elderly exercise, namely in 69-76 years as much as 12 or 48%.

Table 2. Intervention Group Normality Test

Normality Test	Shapiro-Wilk			Information
	Statistics	Df	P-value	
Pre Test TUGT	0,963	25	0,479	Usual
Post Test TUGT	0,889	25	0,011	Abnormal
Pre Test SPPB	0,927	25	0,076	Usual
Post Test SPPB	0,900	25	0,019	Abnormal

Furthermore, the normality test determines the difference test in research data analysis. The normality test results can be seen in Table 2 for the intervention group and Table 3 for the control group. The normality test uses the Shapiro-Wilk test because the study sample < 30 respondents. Based on Table **2** shows the results of the normal distribution due to P>0.05 and abnormally distributed due to P<0.05, so the *Wilcoxon* test is different because the assumptions of the *Paired t-test* are not met.

Table 3. Control Group Normality Test

Normality Test	Shapiro-Wilk			Information
	Statistics	Df	P-value	
Pre Test TUGT	0,921	25	0,053	Usual
Post Test TUGT	0,945	25	0,193	Usual
Pre Test SPPB	0,945	25	0,191	Usual
Post Test SPPB	0,930	25	0,087	Usual

Meanwhile, based on Table 3 shows the results that the data is normally distributed because P>0.05, so the *Paired t-test* can be tested.

Table 4. Effect Test Before and After Giving Multimodal Exercise Against TUGT and SPPB Values in the Intervention Group

Group	TUGT			SPPB		
	Median±(min-max)	Difference	P-value	Median±(min-max)	Difference	P-value
Intervention Group						
Pre Test	19±(15-23)	-6,48	0,001*	6±(3-9)	3,4	0,001*
Post Test	12±(10-14)			9±(6-11)		

Ket: Wilcoxon Test

The effect of exercise on TUGT and SPPB scores is presented in Tables 4 and 5, and comparisons of *multimodal exercise* and elderly gymnastics are presented in Table 6. Based on Table 4 of the *Wilcoxon* test results, where the TUGT pre and post-test and SPPB pre and post-test in the intervention group obtained a p-value of 0.000 because P<0.05 it can be concluded that there is a very significant effect of exercise, as well as for the control group in Table 5 using the *Paired t-test* obtained p-value of 0.000 because P<0.05 it can be concluded that there is also a very significant effect of giving exercise.

Table 5. Test of Effects Before and After Giving Elderly Gymnastics Training Against TUGT and SPPB Values in the Control Group

Group	TUGT			SPPB		
	Mean±SD	Difference	P-value	Mean±SD	Difference	P-value
Control Group						
Pre Test	17.68±2.23	-4,88	0,001*	5.84±1.57	2,32	0,001*
Post Test	12.8±1.68			8.16±1.62		

Ket: Paired t-test

Table 6. Comparative Test of the Effect of Exercise Administration between Intervention Group and Control Group

Group	TUGT			SPPB		
	Median±(min-max)	Difference	P-value	Median±(min-max)	Difference	P-value
Intervention Group	6±(4-9)	1	0,001	-3±((-4)-(-2))	-1	0,000
Control Group	5±(3-8)			-2±((-4)-(-1))		

Ket: Mann-Whitney Test

Based on Table 6, between the intervention group given multimodal exercise treatment and the control group given elderly exercise treatment with the TUGT difference value is 1 obtained P = 0.001, which means there is a very significant difference with the highest median value in the group given *multimodal exercise* treatment, i.e., 6. Then, the SPPB value has a difference of -1 between the intervention group and the control group with P = 0.000, which means there is a very significant difference, with the highest median value in the group given *multimodal exercise* treatment being -3.

IV. DISCUSSION

Based on data from the Central Bureau of Statistics, the classification of older adults is divided into several parts, namely 65-74 years (youngest old), 75-84 years (middle old), and >85 (oldest old) (Lee et al., 2018). According to the World Health Organization (WHO), the elderly are someone who enters the age of 60 years and over, besides being at risk of experiencing changes in health problems, one of which is the risk of decreased body function (Marlita et al., 2018).

Decreased function in older people may be influenced by chronic inflammatory factors and *intermediary systems* either directly or indirectly. There was an increase in molecules from interleukin-6 (IL-6), C-reactive protein, tumor necrosis factor-α, and neopterin, affecting chronic inflammation and immune system activation (Rizka et al., 2018). Increased inflammatory mediators in the body can impact hemoglobin levels, triggering anemia, *insulin-like growth factor* (IGF-1), albumin, micronutrients, and vitamins. Multisystem dysregulation caused by the inflammatory molecular response causes various symptoms in the musculoskeletal, cardiovascular, and endocrine systems and causes nutritional dysregulation (Uyainah et al., 2015) Problems in the neurological, endocrine, and immune systems can damage the physiological balance of muscles(Lima Filho et al., 2020).

In the gender category, it is known that women constitute the majority sample in the treatment group of 56% and the control group of 64%. This data is supported by world data based on the United Nations (UN), which states that women live an average of 4.5 years longer than men(He et al., 2016) Several physiological factors cause women to live longer than men, namely *sex hormones*. Because men do not have as much estrogen as women, the risk of developing diseases increases(Ginter & Simko, 2013) Especially when entering old age, where levels of *sex hormone dehydroepiandrosterone sulfate* and insulin-like *growth factor-1 (IGF-1*) are known to be lower (Pytel et al., 2022) As well as related to the X chromosome, where micro RNA on the X chromosome plays an important role in regulating the immune system. Women have two X chromosomes, so if there is a genetic mutation on one X chromosome, women have reserves to compensate. Men do not have this benefit, allowing women to live longer than men (Maryani & Kristiana, 2018). The difference in life expectancy between women and men can also be caused by the influence of different lifestyles(Ginter & Simko, 2013).

And the factor of long-suffering from DM was found in the treatment group the most in the period of 3-6 years, which was 76%, and in the control group, the most also in the period of 3-6 years was 88%. If someone is indicated to suffer from DM for a long time, they can be at risk of complications. The occurrence of microvascular and macrovascular complications will increase significantly after more than 5 years of disease duration(19). This is because as age increases, the effectiveness of insulin will decrease, and the body's ability to manage glucose decreases(Prasetyo & Wahyuni, 2021), where some studies reveal that more than half of all prevalence of DM sufferers, both type 1 and type 2 Diabetes Mellitus types, will experience complications including cardiovascular disease, retinopathy, kidney failure, and peripheral vascular disease(du Plessis et al., 2022).

In this study, the intervention group given *multimodal exercise* treatment and the control group with the provision of elderly gymnastics for 8 weeks of the study period showed changes in the form of

reduced risk of falls and increased functional ability in the elderly who experienced *frailty syndrome* with T2DM. The multimodal exercise program is an exercise that combines 2 or more types of exercise, generally consisting of *aerobic* exercise and anaerobic *exercise* (Thomas et al., 2019).

Aerobic exercise is useful in increasing heart-lung power and muscle ability and improving blood circulation. During exercise, a neuromuscular adaptation process can increase the number of blood capillaries in the muscles so that oxygen diffusion in the muscles becomes easier (Hedayatpour & Falla, 2015). This causes the ability to supply more oxygen per unit of muscle mass so that someone who is given *aerobic* exercise can perform activities optimally compared to people who are not given exercise(Formiga et al., 2020).

Anaerobic Exercise consists of a type of strength and balance exercise, a systematic procedure in the form of repetitive muscle work at a certain time. Balance exercise can improve postural balance by involving proprioceptive ness (Syah & Susy Purnawati, 2016). The movements during exercise can activate the movements realized and then received by the sensory nerves; the incoming input will be sent to the brain precisely in the cerebral cortex to convert sensory information into motor information. Motor neurons are then formed so that action potentials occur in the muscles. This action potential can cause the sarcoplasmic reticulum to release large amounts of calcium ions until there is an attraction on the actin and myosin filaments which causes muscle contraction (Nisa & Maratis, 2019). Muscle contractions can increase muscle fibers, called hypertrophy (da Silveira Langoni et al., 2019).

During hypertrophy, muscle contractile protein synthesis progresses more rapidly, increasing the number of actin and myosin filaments in the myofibrils, which often increases progressively by 50%. Some of these myofibrils will break down in hypertrophied muscles to form new myofibrils; along with an increase in the size of the myofibrils, the enzyme system responsible for providing energy will also increase. This mainly occurs in the increase in ATP-PC and enzymes used for the glycolysis process, allows rapid energy supply during strong and short muscle contractions, and causes changes in muscle biochemistry(Budiwibowo & Setiowati, 2015).

This is in line with Naderi et al. (2019) entitled "*Effect of Low and Moderate Acute Resistance Exercise on Executive Function In Community-Living Older Adults,"* which suggests that giving *physical exercise* to the elderly can increase muscle strength, muscle endurance, and balance caused by neuromuscular adaptation in the elderly to prevent the risk of falling (Naderi et al., 2019). Also, a previous study conducted by Liu et al. (2017) found 15 relevant articles on multimodal exercise, where *multimodal exercise* proved effective in increasing lower extremity muscle strength, and dynamic balance, improving the functional ability of the elderly and effective in reducing the risk of falls in the elderly (Liu et al., 2017). Added to the research of Leocadio et al. (2019) entitled "*Effectiveness of a Multimodal Intervention in Functionally Impaired Older People* with Type 2 Diabetes Mellitus" stated that the provision of structured multimodal interventions proved effective in improving significant function in the elderly aged >70 years with Type 2 Diabetes Mellitus conditions (Rodriguez-mañas et al., 2019).

In comparative research from the two groups, it can be concluded that there is a significant difference in TUGT and SPPB values. The intervention group given multimodal exercise treatment had a more significant increase in TUGT and SPPB values compared to the control group with elderly gymnastics treatment due to the different mechanisms of the two exercise treatments given, where the *multimodal exercise* program can stimulate muscle contractions so that there is an increase in muscle fibers or called hypertrophy, this can certainly increase muscle strength in the elderly (da Silveira Langoni et al., 2019). Exercise given to the elderly by increasing muscle strength, muscle endurance, and balance due to neuromuscular adaptation in older people can prevent falls and improve functional ability (Naderi et al., 2019).

V. CONCLUSION

This study shows that multimodal exercise and elderly gymnastics are equally effective for reducing the risk of falls and improving functional ability in the elderly who experience frailty syndrome with T2DM. However, a structured multimodal exercise program for 8 weeks obtained more effective results than an elderly exercise in reducing the risk of falls and improving functional ability. Further research is needed to be related to the application of multimodal exercise in patients with other degenerative diseases, and it is necessary to conduct research with a longer period with more samples in each treatment and a more even number of research samples both related to sex, age group and duration of suffering from the disease.

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