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Effect of resistance training on blood glucose fluctuation and painful diabetic peripheral neuropathy in adults with type 2 diabetes mellitus

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Abstract

Background: Diabetes Mellitus (DM) Type 2 is a chronic metabolic disease that can cause serious complications, such as peripheral circulatory disorders and diabetic foot ulcers, if blood glucose levels are not controlled. Resistance Exercise is one form of physical activity intervention that has the potential to prevent these complications.
Purpose: To determine the effect of resistance training on blood glucose fluctuation and painful diabetic peripheral neuropathy in adults with type 2 diabetes mellitus.
Method: This study used a pre-experimental design with a two-group pretest-posttest design. A total of 60 participants were selected through simple random sampling, divided into two groups: intervention (n=30) and control (n=30). The intervention group was given Resistance Exercise for a certain period, while the control group was not given any treatment. Data were analyzed using the Paired t-Test .
Results: There were significant differences in the intervention group before and after intervention on blood glucose levels (p=0.000), peripheral blood circulation (p=0.000), and leg pain (p=0.000). Meanwhile, the control group did not show significant differences in peripheral blood circulation (p=0.161) and leg pain (p=0.083).
Conclusion: Resistance Exercise is effective in lowering blood glucose levels, improving peripheral blood circulation, and reducing leg pain in patients with Type 2 DM. This intervention is recommended as part of DM management at the primary care level.

Keywords: Blood Glucose; Diabetes Mellitus Type 2; Leg Pain; Peripheral Circulation; Resistance Exercise.

INTRODUCTION

Diabetes Mellitus Type 2 (DM Type 2) is a chronic metabolic disease characterized by increased blood glucose levels due to impaired insulin secretion and cell resistance to insulin. This disease is not only a global health challenge, but also a major cause of morbidity and mortality due to accompanying chronic complications, such as impaired peripheral blood circulation, neuropathy, and diabetic foot ulcers. These complications, if not treated early and properly, can lead to amputation of the lower extremities and even death (Dunstan, Daly, Owen, Jolley, De Courten, Shaw, & Zimmet, 2002).

Type 2 Diabetes Mellitus (DM) is a metabolic disease characterized by increased blood glucose levels due to impaired insulin secretion and low physical activity (Castaneda, Layne, Munoz-Orians, Gordon, Walsmith, Foldvari, & Nelson, 2002). Type 2 DM remains a major health problem with an incidence that continues to increase every year. According to the 2021 IDF survey, the number of people with Type 2 DM with chronic complications globally continues to increase, from 463 million people in 2019 to 470 million people in 2020, and soaring to 537 million people in 2021 (Hartanto,

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Widyaningrum, Budiono, Hendrawati, & Purwaningsih, 2025).

It is estimated that in the next 10 years, the number of Type 2 DM sufferers with chronic complications, such as diabetic foot ulcers, will increase by more than 50% and has the potential to become the seventh leading cause of death in the world by 2030 (Larasati & Haryanto, 2025). Every year, around 4.2 million people aged 20–79 years die from chronic complications caused by DM (Larasati & Suriadi, 2025). Indonesia is one of the countries with the largest number of Type 2 DM sufferers in the world. At the provincial level, South Sulawesi has the highest incidence of Type 2 DM in Indonesia with a prevalence of 1.83%, while Sidrap Regency recorded the highest figure in the province, reaching 9.27% (Sarifin, Zurur, & Febriyanda, 2025).

The prevalence of Type 2 DM in Sidenreng Rappang Regency continues to increase. In 2021, there were 1,320 sufferers; in 2022, there were 1,487 sufferers; and in 2023, there were 1,765; in 2024, there were 2038 people. This increase is triggered by an unhealthy lifestyle, such as overeating and lack of physical activity, which causes uncontrolled blood glucose (Sukarno, 2021). If left untreated, this condition is at risk of triggering chronic complications, such as diabetic foot ulcers and peripheral blood circulation disorders (Marbun, Ariyani, Sipayung, Ginting, Sinaga, & Sinaga, 2022).

Diabetic foot ulcers if not treated properly will lead to amputation and can even cause death (Anisah, Iksan, Listyorini, Herdalisa, & Bayuningsih, 2023). At the Sidenreng Rappang Regency Hospital, it was recorded that 48% of Type 2 DM sufferers experience diabetic foot ulcers every year, with 45% of them ending in amputation or death, mainly due to late treatment (Fitriani & Aderita, 2021). Therefore, appropriate physical activity intervention is needed to prevent chronic complications early on in Type 2 DM sufferers (Sakinah, Nurdin, Agus, & Aisyah, 2020). The cause is not getting early treatment (Arif, 2020). Therefore, appropriate physical activity therapy is needed to prevent the early emergence of chronic complications of Type 2 DM. One of the effective therapies in preventing complications of Type 2 Diabetes Mellitus (DM) is Resistance Exercise (Sumarni & Hartanto, 2023). Where the form of physical activity is carried out systematically by providing a load or resistance to the muscles, which can be applied to DM patients (Snowling, & Hopkins, 2006).

This exercise aims to increase insulin sensitivity, strengthen muscles, and improve blood circulation, so it can help prevent complications of diabetic foot ulcers or tissue damage due to vascular disorders (Cauza, Hanusch-Enserer, Strasser, Ludvik, Metz-Schimmerl, Pacini, & Haber, 2005). In addition, Resistance Exercise also plays a role in improving blood circulation, increasing glucose metabolism, and optimizing insulin utilization (Sigal, Kenny, Boulé, Wells, Prud'homme, Fortier, & Jaffey, 2007). Active muscle movements during this exercise can increase contractions, so that cell permeability to glucose increases and blood glucose levels can be better controlled (Church, Blair, Cocreham, Johannsen, Johnson, Kramer, & Earnest, 2010). Regular application of Resistance Exercise is very important for people with Type 2 DM, because it can help improve quality of life, prevent complications, control blood glucose levels, and reduce the risk of cardiovascular disorders (Hadaegh, Khalili, Ghasemi, Tohidi, Sheikholeslami, & Azizi, 2009).

Interviews with nurses at the Lawawoi Health Center, Sidenreng Rappang Regency, revealed that the number of Type 2 DM patients in March 2025 reached 30 people. However, Resistance Exercise has not been implemented as part of therapy, and its effect on preventing chronic complications, especially reducing blood glucose and leg pain, is still minimally researched (Ooi, Mat Ludin, Loke, Fiatarone Singh, Wong, Vytialingam, & Lew, 2021). Further research is needed to develop Resistance Exercise as an effort to prevent chronic complications in Type 2 DM (Yamamoto, Nagai, Kawanabe, Hishida, Hiraki, Sone, & Tanaka, 2021).

RESEARCH METHOD

This quantitative study used a pre-experimental design, employing a two-group pretest-posttest design. In this approach, one group of subjects was measured before and after the intervention to assess the effects of the treatment, while the other group received no treatment. In this study, prior to the intervention, which included resistance exercise therapy, baseline measurements were taken of blood glucose levels, peripheral blood circulation, and leg pain scales in patients with type 2 diabetes mellitus. After the intervention, measurements were repeated

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to assess any changes. The study population included all patients with type 2 diabetes mellitus registered at the Lawawoi Community Health Center in Sidenreng Rappang Regency. Diabetic resistance exercise therapy was performed for 15 minutes twice a week for three months. A sample of 60 patients was divided into two groups, selected using simple random sampling, taking into account inclusion and exclusion criteria.

Data analysis used univariate analysis for each variable, with the results presented in the form of frequency distributions and percentages for each variable. While bivariate data is first tested using paired sample t test if the data is normally distributed, if the data is not normally distributed, the alternative test is the Wilcoxon test with a significance level of $p < 0.05$. Inclusion criteria: Patients who have been diagnosed with type 2 diabetes mellitus by a doctor, Age between 20-79 years, Suffering from type 2 diabetes mellitus for 1-3 years, Willing to be participants. Exclusion criteria: Patients with diabetic foot ulcers, Patients at risk of heart disease, Patients with respiratory disorders. This approach allows researchers to evaluate the effectiveness of Resistance Training in modifying the variables studied, with a control comparison group. With a sample size of 60 people, this study was divided into 2 groups, namely 30 intervention groups and 30 control groups. This study has obtained ethical approval with No. 008798 / EC / KEPK / I / 07/2025.

RESEARCH RESULTS

Table 1. Distribution by Gender in sufferers DM type 2

Variables	Group	
	Intervention (n=30)	Control (n=30)
Age (Mean±SD)(Range) (Year)	39.13±9.97	39.13±9.97
20-29	5/16.7	5/16.7
30-39	10/33.3	10/33.3
40-49	9/30.0	9/30.0
50-59	6/20.0	6/20.0
Gender (n/%)		
Man	11/36.7	11/36.7
Woman	19/63.3	19/63.3
Long Time Suffering from DM (n/%)		
1 year	15/50.0	15/50.0
2 years	9/30.0	9/30.0
3 years	6/20.0	6/20.0
Smoking Status (n/%)		
Yes	5/16.7	4/13.3
No	25/83.3	26/86.7

Source: Primary Data 2025

Based on table 1, it shows that out of 30 participants in the intervention group, 11 were male (36.7%) and 19 were female (63.3%). Meanwhile, out of 30 participants in the control group, 11 were male (36.7%) and 19 were female (63.3%). It shows that out of 30 participants in the intervention group, there were 5 people (16.7%) aged between 20-29 years, 10 people (33.3%) aged 30-39 years, 9 people (30.0%) aged 40-49 years and there were 6 people (20.0%) aged between 50-59. While out of 30 participants in the control group, there were 5 people

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(16.7%) aged between 20-29 years, 10 people (33.3%) aged 30-39 years, 9 people (30.0%) aged 40-49 years and there were 6 people (20.0%) aged between 50-59. It shows that of the 30 participants in the intervention group, 6 people (20%) had suffered from type 2 DM the longest, while the control group had 6 people (205).

Table 2 Paired T-Test Results in Type 2 Diabetes Mellitus Patients

Variables	Intervention		Control	
	Mean ± SD	p-value	Mean ± SD	p-value
Random Blood Sugar				
Pretest	187.5±6.39		187.5±6.39	
Posttest	135.4±4.16		183.63±4.97	
Difference	52.10±4.95	0.000	3.86±1.96	0.000
Peripheral Blood Circulation				
Pretest	1.27±0.45		1.27±0.45	
Posttest	0.30±0.46		1.20±0.40	
Difference	0.96±0.18	0.000	0.67±0.25	0.161
Leg Pain				
Pretest	6.83±0.79		6.83±0.79	
Posttest	2.03±0.71		6.73±0.78	
Difference	4.80±0.88	0.000	0.10±0.30	0.083

Source: Primary data 2025

Based on table 2, the variable of blood sugar levels shows the mean value ± SD of the intervention group 187.5 ± 6.39 and the control group 187.5 ± 6.39 when the posttest is not much different, the p value of the intervention group is 0.000 (p <0.05) and the p value of the control group is 0.000 (p <0.05), meaning that the two groups are not homogeneous (there is a difference) in the quality of life in preventing complications during the pretest-posttest. In the peripheral blood circulation variable, the mean value ± SD of the intervention group is 1.27 ± 0.45 and the control group 1.27 ± 0.45 when the posttest is not much different, the p value of the intervention group is 0.000 (p <0.05) meaning that there is a difference in the intervention group while the p value of the control group is 0.161 (p> 0.05), meaning that there is no difference in blood circulation before and after. In addition, table 5 shows that the leg pain variable illustrates that the mean value ± SD of the intervention group was 6.83±0.79 and the control group was 6.83±0.79 when the posttest was not much different, the p value of the intervention group was 0.000 (p<0.05) meaning that there was a difference in the intervention group before and after the intervention, while the p value of the control group was 0.083 (p>0.05), meaning that there was no difference in blood leg pain before and after.

Table 3 Effect of Resistance Exercise Therapy on Patients with Type 2 Diabetes Mellitus

Variabel	Intervention Group		Control Group	
	t.test	p-value	t.test	p-value
Random blood Sugar	57.64	0.000	10.80	0.000
Blood circulationperipheral	29.00	0.000	1.44	0.16
Leg pain	29.65	0.000	1.79	0.083

Source: Primary data 2025

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Based on the results of the paired t test analysis, it shows that there is an effect of Resistance Exercise therapy on blood sugar levels in the intervention group with *a p* value of 0.000 (p <0.05) and a calculated t value (58.644)> t table $_{(29;\ 0.05)}$ is 2.045 so it can be concluded that H0 is rejected and Ha is accepted. In the control group, there is an effect on blood sugar levels with a *p* value of 0.000 (p>0.05) and a calculated t value (10.802)> t table $_{(29;\ 0.05)}$ is 2.045 so it can be concluded that H0 is rejected and Ha is accepted.

The results of the paired T test on the peripheral blood circulation variable showed that there was an effect of Resistance Exercise therapy on peripheral blood circulation in Type 2 DM patients in the intervention group with a *p* value of 0.000 (p <0.05) and a calculated t value (29,000) > t table $_{(29;\ 0.05)}$ is 2.045 so it can be concluded that H0 is rejected and Ha is accepted. While in the control group there was no effect with a *p* value of 0.161 (p> 0.05) and a calculated t value (1.439) < t table $_{(29;\ 0.05)}$ is 2.045 so it can be concluded that H_0 is accepted and Ha is rejected.

In addition, there is also an effect of Resistance Exercise therapy on leg pain in type 2 DM patients in the intervention group with a *p* value of 0.000 (p <0.05) and a calculated t value (29.651) > t table $_{(29;\ 0.05)}$ which is 2.045 so it can be concluded that H0 is rejected and Ha accepted. Meanwhile, in the control group there was no influence with a *p* value of 0.083 (p>0.05) and the calculated t value (1.795) < t table $_{(29;\ 0.05)}$ is 2.045 so it can be concluded that H0 is accepted and Ha is rejected.

DISCUSSION

This study focuses on three main variables that are closely related to chronic complications in patients with Type 2 Diabetes Mellitus, namely blood sugar levels, peripheral blood circulation, and the level of foot pain (Yamamoto et al., 2021). Blood sugar levels are the main indicator in controlling diabetes and greatly affect the risk of microvascular complications (Soares, Machado-Lima, Brech, Greve, Dos Santos, Inojossa, & Alonso, 2023). Peripheral blood circulation reflects the ability of the vascular system to distribute blood to body tissues, which if disturbed can cause ischemia and diabetic foot ulcers (Takenami, Iwamoto, Shiraishi, Kato, Watanabe, Yamada, & Ishii, 2019). Meanwhile, foot pain is a common symptom of diabetic peripheral neuropathy, which is often an early sign of nerve disorders due to chronic hyperglycemia. These three variables are interrelated and can be used as a benchmark for the effectiveness of physical intervention or rehabilitative therapy in preventing the progression of Type 2 DM complications (Wan & Su, 2024). Therefore, in this study, these three variables were analyzed in depth to assess the impact of *Resistance Exercise therapy* as a structured and systematic physical exercise intervention (Arazi, Gholizadeh, Sohbatzadeh, & Eghbali, 2020).

The results showed that there was a significant difference between the pretest and posttest values in the intervention group for three main variables, namely blood sugar levels, peripheral blood circulation, and leg pain. In the intervention group, blood sugar levels decreased significantly after the intervention, with a p value = 0.000 (p <0.05), indicating the effectiveness of the intervention in controlling blood glucose. The same thing also happened to the variables of peripheral blood circulation and leg pain, where the intervention group showed a significant increase (p = 0.000). Meanwhile, the control group did not show significant changes in the variables of blood circulation and leg pain, as seen from the p value > 0.05. This indicates that the improvement in the intervention group was due to certain intervention actions or programs that were not given to the control group. These results are in line with previous research by (Rondhianto, Hakam, & Al Alawi, 2025) which stated that family-based education and interventions can improve blood sugar control and improve symptoms of peripheral neuropathy. Likewise, a study by (Hartanto et al., 2025) showed that education-based nursing interventions can improve peripheral perfusion and reduce leg pain in patients with type 2 diabetes mellitus. However, there are several studies that did not find significant changes in pain variables, possibly due to different intervention approaches, frequencies, or duration of implementation (Abo El Ata, Shaheen, Abdelgilil Khalil, & Yousef Saleh, 2021).

The results of this study are supported by the Self-Care Deficit Nursing Theory (Dorothea Orem) which emphasizes the importance of empowering individuals or families in managing chronic diseases. Interventions that improve family skills in patient care

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have been shown to improve clinical outcomes, including decreased blood sugar levels and improved peripheral circulation. In addition, according to the Pathophysiology of Diabetes Mellitus theory , good blood glucose control will reduce microvascular complications including neuropathic pain and circulatory disorders. (Zheng, Ley, & Hu, 2018).

The researchers assumed that the success of the intervention in the treatment group was due to a combination of structured education, consistent monitoring, and active family support. The active participation of families in care is believed to strengthen the effectiveness of the intervention. In addition, the control group did not receive the intervention and therefore did not show improvement, strengthening the assumption that the change variable was greatly influenced by the implementation of the intervention program. The researchers also assumed that the educational methods used were practical and easy to understand by patients and families, thus increasing the success of its implementation.

CONCLUSION

The results showed that the intervention provided had a significant impact on the three variables studied. In the blood sugar level variable, there was a significant difference before and after the intervention in the intervention group ($p < 0.05$), although the average value at posttest did not differ between groups. Similar things were also found in the peripheral blood circulation and leg pain variables, where the intervention group showed significant changes ($p < 0.05$), while the control group did not show significant differences ($p > 0.05$). These findings indicate that the intervention implemented was effective in lowering blood sugar levels, improving peripheral blood circulation, and reducing the level of leg pain in participants. Therefore, the intervention is recommended as part of efforts to improve the quality of life and prevent complications in patients with similar conditions.

SUGGESTION

Resistance Exercise is used as part of non-pharmacological therapy routinely performed by Type 2 Diabetes Mellitus patients, especially to help lower blood sugar levels, improve peripheral blood circulation, and reduce leg pain. Health workers, especially in primary care such as Community Health Centers, are expected to integrate this exercise into ongoing patient education and coaching programs. In addition, local governments and health institutions need to support the implementation of physical exercise as an effort to prevent chronic complications of DM. Further research is also recommended with a stronger design and wider variables to examine the long-term impact of *Resistance Exercise* on the quality of life of Type 2 DM patients.

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