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THE EFFECTS OF MODERATE AND LOW-INTENSITY RESISTANCE EXERCISE ON HBA1C REDUCTION IN PATIENTS WITH TYPE 2 DIABETES MELLITUS

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ABSTRACT

Type 2 diabetes mellitus (T2DM) is a long-term metabolic disorder whose prevalence continues to rise worldwide. This study aims to examine the effectiveness of moderate-intensity resistance exercise compared with low-intensity resistance exercise and no exercise on glycemic control among patients with type 2 diabetes mellitus (T2DM). Methods: A quasi-experimental pre–posttest design with three parallel groups was used: a control group receiving standard care without exercise, a low-intensity resistance exercise group, and a moderate-intensity resistance exercise group (total N = 51 participants). The intervention consisted of a 12-week resistance exercise program (three sessions per week) using elastic loop bands with different resistance levels. Outcomes included anthropometric measures, blood pressure, glycemic parameters (HbA1c, fasting, and random blood glucose), and self-care behaviors assessed with the Summary of Diabetes Self-Care Activities (SDSCA) questionnaire. Eligible participants were adults aged 25–75 years with T2DM who were receiving oral and/or injectable therapy, without exercise contraindications, and able to provide consent. Individuals with severe diabetic complications, participation in other exercise programs, or medical conditions affecting HbA1c were excluded. Data were analyzed using paired t-tests and one-way ANOVA with Tukey post hoc tests. Results: The moderate-intensity group experienced a statistically significant reduction in mean HbA1c of 0.85% (p = 0.016). Changes in the control group (−0.23%) and low-intensity group (0.06%) were not statistically significant. Tukey post hoc analysis confirmed that HbA1c reduction in the moderate-intensity group was significantly greater than in the control group (mean difference, −1.03%; p = 0.004). However, the difference between moderate- and low-intensity groups was not significant (mean difference, −0.34%; p = 0.516). Conclusion: Moderate-intensity resistance exercise significantly improves glycemic control in patients with type 2 diabetes mellitus (T2DM). Adding structured moderate-intensity resistance training to non-pharmacological diabetes management can improve glycemic outcomes.

Kata Kunci:
Diabetes Mellitus;
HbA1C;
Intensitas sedang dan intensitas ringan;
Reistance exercise

ABSTRAK

Diabetes Mellitus (DM) tipe 2 adalah penyakit kronis dengan prevalensi global yang terus meningkat. Tujuan: mengetahui efektivitas resistance exercise intensitas sedang dibandingkan dengan intensitas ringan maupun tanpa latihan terhadap kontrol glikemik pada pasien DM tipe 2. Metode: desain studi quasi-eksperimental pre–post test dengan tiga kelompok (kontrol tanpa latihan, latihan intensitas ringan, latihan intensitas sedang), total N = 51 partisipan. Intervensi berupa resistance exercise terstruktur selama 12 minggu (3 sesi/minggu) menggunakan loop band karet dengan intensitas berbeda, dengan indikator antropometri, tekanan darah, dan glikemik (HbA1c, gula darah sewaktu, gula darah puasa) serta skala SDSCA (Summary of Diabetes Self-Care Activities). Kriteria inklusi: penderita DM tipe 2, menggunakan obat antidiabetes oral maupun injeksi, berusia 25–75 tahun, tidak memiliki kontraindikasi melakukan resistance exercise, dan bersedia menandatangani informed consent. Kriteria eksklusi: memiliki komplikasi diabetes berat, menjalankan program latihan fisik teratur lainnya, dan memiliki penyakit lain yang memengaruhi HbA1c. Analisis statistik meliputi uji paired t-test dan ANOVA, serta uji post hoc Tukey untuk perbandingan antar kelompok. Hasil: kelompok intensitas sedang mengalami penurunan rata-rata HbA1c sebesar 0,85% (p = 0,016), sedangkan kelompok kontrol dan ringan mengalami sedikit peningkatan yang tidak signifikan (−0,23% dan 0,06%). Uji post hoc Tukey menunjukkan penurunan HbA1c pada kelompok sedang signifikan lebih besar daripada kontrol (perbedaan mean −1,03%, p = 0,004) dan ringan (−0,34%, p = 0,516). Kesimpulan: resistance exercise intensitas sedang secara signifikan meningkatkan kontrol glikemik pasien DM tipe 2. Oleh karena itu, program latihan intensitas sedang dapat diintegrasikan dalam penatalaksanaan nonfarmakologis DM tipe 2 untuk memperbaiki kontrol gula darah.

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INTRODUCTION

Type 2 diabetes mellitus (T2DM) is a chronic metabolic disorder, and its global prevalence is rising rapidly (Care & Suppl, 2020). The International Diabetes Federation estimates that over 10% of adults worldwide have diabetes. In Southeast Asia, Indonesia holds the second-highest ranking in diabetes prevalence. According to the 2023 Survei Kesehatan Indonesia (SKI) by the Ministry of Health (Kemenkes), the incidence of type 2 diabetes mellitus (DM) nationwide reached 1.7%, with a notable provincial prevalence of 1.6% in the Riau Islands (Kepulauan Riau) (Kemenkes, 2023). More granular data reveal that in Natuna Regency, type 2 DM prevalence stood at 1.37%, while in North Bunguran Subdistrict (Bunguran Utara), the primary service area of Kelarik Primary Health Center, it was slightly lower at 1.35%. The geographical complexity of the archipelago and limited access to healthcare in remote areas increase the risk of complications.

T2DM accounts for most of these cases (Sun et al., 2022). T2DM is not curable but can be managed with comprehensive glycemic control. Persistent hyperglycemia raises the risk of complications, including cardiovascular disease, neuropathy, nephropathy, and retinopathy (Kemenkes, 2023). This highlights the need for optimal glycemic management. Self-care behaviors are central in T2DM management (Fereidooni et al., 2024). These include regular glucose monitoring, medication adherence, a healthy diet, and physical activity. Greater adherence to self-care is associated with improved outcomes (Fereidooni et al., 2024). Resistance exercise is a key non-pharmacological intervention for T2DM (Steven E. Kahn, 2024). Compared to other forms of exercise, resistance training is suitable for older adults and individuals with physical limitations (Ooi et al., 2021; Shoji et al., 2021; Chien et al., 2022). Past studies have found that resistance exercise improves muscle strength (Zhao et al., 2022) and insulin sensitivity (Fan et al., 2023). It also reduces HbA1c by about 0.78–1.2% (Kobayashi et al., 2023).

Recent studies rarely compare the effects of low-intensity (<50% 1RM) versus moderate-intensity (60–75% 1RM) resistance training in Indonesian patients with type 2 diabetes, especially regarding the minimum HbA1c reduction needed for clinical benefit and protocols suitable for primary health centers. Moderate intensity shows greater clinical effectiveness, reducing HbA1c by up to 0.85%, well beyond minimal therapeutic levels, while improving insulin sensitivity, whereas low intensity offers a safe starting option for frail elderly patients with minimal injury risk. This phased approach is more efficient and practical for community health centers (Puskesmas), supporting wider diabetes management in Indonesia.

METHOD

Type of Research

This study used a quasi-experimental pre–posttest design with three groups. One group received a moderate-intensity resistance exercise intervention, another received a low-intensity resistance exercise intervention, while the control group received no resistance exercise intervention. This design was selected to evaluate the effectiveness of resistance exercise interventions on HbA1c changes in patients with type 2 diabetes mellitus.

Place and Time of Research

This study was conducted at the Kelarik Primary Health Center in Bunguran Utara District, Natuna Regency, between September 2025 and January 2026.

Population and Sample

The population was patients with T2DM at the Kelarik Primary Health Center in Bunguran Utara District, Natuna Regency. Participants were assigned to three groups: control (standard education without exercise), low-intensity resistance exercise, and moderate-intensity resistance exercise, using convenience sampling. We calculated the sample size using Cohen's formula for two independent means ($\alpha = 0.05$, power = 80%, SD_low = 0.54, SD_moderate = 0.43), yielding a minimum of 15 participants per group (Lakens, 2022). To account for potential dropout, we recruited 17 participants per group, for a total of 51.

Data Collection

Inclusion criteria: diagnosed T2DM, age 25–75 years, on oral/injectable therapy, no contraindications to resistance exercise, and willing to provide consent. Exclusion criteria: severe diabetic complications, participation in other structured exercise programs, and conditions affecting HbA1c (such as anemia or thyroid disorders).

The intervention lasted 12 weeks, with three 40-minute sessions per week (including warm-up and cool-down). Low-intensity exercise used green bands (5–10 lbs; Borg CR-10 scale 3–4). Moderate-intensity exercise used yellow bands (10–15 lbs; Borg CR-10 scale 5–6). Exercises covered shoulder movements, triceps pushdown/push-up, leg raises, squats, biceps pull-outs, and overhead arm movements.

The first session was supervised, with vital signs and glucose measurements taken before and after exercise. Afterward, sessions were completed at home using videos. Participants submitted session photos and were monitored via WhatsApp by a healthcare team. If participants were unable to attend a scheduled exercise session, they could reschedule it within the same week. Training commenced with two sessions per week during the first week, increasing to three sessions weekly thereafter, totaling 35 sessions over three months. Participants were required to complete at least 51% of the total sessions (minimum of 18 sessions). Those completing less than 51% of sessions or changing medication dosage were considered dropouts. Data were collected using demographic forms, the Indonesian SDSCA (Sugiharto et al., 2019), and the Borg CR-10 scale (Zhao et al., 2022). HbA1c was measured with the Sinocare PCH 50 analyzer, certified by IFCC and NGSP. Measurements were taken at baseline and after 12 weeks.

Data Analysis and Processing

We used IBM SPSS Statistics version 22 to analyze the data. We assessed within-group changes with paired t-tests and between-group differences with a one-way ANOVA and Tukey HSD post hoc tests, using $\alpha = 0.05$ for significance. Ethics approval was granted by the Muhammadiyah Institute of Technology and Health, West Kalimantan (No.100/II.I.AU/KET.ETIK/IX/2025). All participants provided written consent. Confidentiality was maintained. There were no conflicts of interest.

RESULT

Baseline characteristics are presented in Table 1. Participants' ages ranged from 25 to 75 years. At baseline, the three groups were comparable with respect to age, duration of diabetes, BMI, blood pressure, waist circumference, fasting and random blood glucose, SDSCA scores, and HbA1c (all $p > 0.05$). Mean baseline HbA1c did not differ significantly among the control (8.74 ± 1.96%), low-intensity (8.53 ± 1.79%), and moderate-intensity groups (9.16 ± 2.05%) ($p = 0.564$), indicating adequate baseline homogeneity.

Table 1. Baseline Characteristics

Parameters	**Control (n:17)**	**Low (n: 17)**	**Moderate (n:17)**	**p**
Age, years (Mean±SD)	53.92±9.5	55.18±10.62	49.94±7.05	0.095
Sex, n (%)				
Male	9 (52.9)	2 (11.8)	1 (5.9)	0.002
Female	8 (47.1)	15 (88.2)	16 (94.1)	
Duration of Diabetes Mellitus (years)	4.00±2.47	5.47±2.85	2.88±1.54	0.009
Type of Diabetic Medication, n (%)				
Oral	17 (100.0)	14 (82.3)	16 (94.1)	0.150
Injection	0 (0.0)	3 (17.7)	1(5.9)	

Parameters	Control (n:17)	Low (n: 17)	Moderate (n:17)	p
Systolic Blood Pressure, mmHg (Mean±SD)	144.94±22.78	140.18±17.33	150.47±28.15	0.439
Diastolic Blood Pressure, mmHg (Mean±SD)	87.47±12.27	82.76±9.29	95.00±21.26	0.229
Body Weight, kg (Mean±SD)	65.13±13.52	55.85±8.69	63.71±10.84	0.042
Body Mass Index, kg/m² (Mean±SD)	25.98±5.82	23.27±3.41	26.53±4.56	0.109
Waist Circumference , cm (Mean±SD)	91.53±9.077	87.82±5.58	91.88±7.48	0.229
Random Blood Glucose, mg/dL (Mean±SD)	296.12±102.70	305.88±105.44	289.12±107.73	0.897
Fasting Plasma Glucose, mg/dL (Mean±SD)	192.18±75.48	185.88±88.45	192.65±67.21	0.960
SDSCA Score Dietary Management, (Mean±SD)	20.94±0.96	21.00±1.63	20.94±1.94	0.990
Physical Activity, (Mean±SD)	1.65±0.49	1.06±0.24	1.29±0.46	0.113
Foot Care, (Mean±SD)	9.47±0.52	9.47±0.51	9.35±0.49	0.578
Medication Adherence, (Mean±SD)	6.82±0.39	6.88±0.33	6.88±0.33	0.907
HbA1c , % (Mean±SD)	8.74±1.96	8.53±1.79	9.16±2.05	0.564

Table 2. Physiological parameters after the 12-week intervention

Parameters	Control (n:17)	Low (n: 17)	Moderate (n:17)	p
Systolic Blood Pressure, mmHg (Mean±SD)	138.71±25.79	137.18±14.13	147.06±23.43	0.368
Diastolic Blood Pressure, mmHg (Mean±SD)	83.06±11.80	82.76±6.86	88.76±11.28	0.167
Body Weight, kg (Mean±SD)	65.13±13.52	55.88±8.05	63.47±11.27	0.289
Body Mass Index, kg/m² (Mean±SD)	25.98±5.82	23.30±3.15	26.34±4.45	0.109
Waist Circumference, cm (Mean±SD)	91.53±9.077	88.00±5.56	91.76±7.54	0.272

Parameters	**Control (n:17)**	**Low (n: 17)**	**Moderate (n:17)**	**p**
Random Blood Glucose, mg/dL (Mean±SD)	296.12±102.70	295.59±104.17	255.65±103.96	0.393
Fasting Plasma Glucose, mg/dL (Mean±SD)	192.18±75.48	302.65±109.68	268.47±101.86	0.989
SDSCA Score Dietary Management, (Mean±SD)	20.94±0.96	22.88±1.86	23.71±0.98	0.592
Physical Activity, (Mean±SD)	1.65±0.49	22.88±1.86	23.06±1.75	0.000
Foot Care, (Mean±SD)	9.47±0.52	3.00±0.00	3.00±0.00	0.800
Medication Adherence, (Mean±SD)	6.82±0.39	9.53±0.51	9.35±0.49	0.689
HbA1c, % (Mean±SD)	8.98 (2.17)	8.48 (1.81)	8.32 (1.60)	0.564

Physiological parameters after the 12-week intervention are summarized in Table 2. Across all groups, no significant changes were observed in body weight, body mass index, blood pressure, waist circumference, or most metabolic parameters ($p > 0.05$). Notably, the SDSCA physical activity score increased significantly in both exercise groups compared with the control group ($p < 0.001$), reflecting greater exercise adherence. Exercise adherence reached 79.08% in the low-intensity group and 72.38% in the moderate-intensity group. In contrast, SDSCA domains related to diet and glucose management did not show significant short-term changes.

Table 3. Changes in HbA1c levels before and after the intervention

Groups	**N**	**Pre-Test Mean (SD)**	**Post-Test Mean (SD)**	**Mean Change (Δ)**	**Sig**
Control	17	8.75 (1.96)	8.98 (2.17)	-0.23	0.066
Low	17	8.54 (1.80)	8.48 (1.81)	0.06	0.326
Moderate	17	9.17 (2.06)	8.32 (1.60)	0.85	0.016

Changes in HbA1c levels before and after the intervention are shown in Table 3. The moderate-intensity resistance exercise group demonstrated a significant mean reduction in HbA1c of 0.85% (from 9.17% to 8.32%; $p = 0.016$). Conversely, the control group showed a non-significant increase of 0.23% ($p = 0.066$), while the low-intensity group showed a minimal, non-significant change of 0.06% ($p = 0.326$). One-way ANOVA revealed a significant between-group difference in HbA1c change, driven primarily by the moderate-intensity group.

Table 4. Comparison of HbA1c Reduction Between Control, Low-Intensity, and Moderate-Intensity Groups

Comparison	Mean change	Std. Error	p-value
Control versus Low-Intensity	−0.34	0.30	0.516
Control versus Moderate-Intensity	−1.03*	0.30	0.004
Low-Intensity versus Moderate-Intensity	−0.69	0.30	0.067

Building on the group differences, post hoc Tukey analysis (Table 4) indicated that the reduction in HbA1c in the moderate-intensity group was significantly greater than that in the control group (mean difference −1.03%, p = 0.004). Although the reduction was larger than in the low-intensity group, this difference did not reach statistical significance (mean difference −0.69%, p = 0.067). No significant difference was found between the control and low-intensity groups.

DISCUSSION

Effect of Exercise Intensity on Glycemic Control

This study found that moderate-intensity resistance exercise was associated with a statistically significant HbA1c reduction compared to the non-exercise control group (p = 0.016), while the low-intensity exercise group showed no significant change (p > 0.05). Notably, the difference between moderate- and low-intensity groups was not statistically significant. These findings are consistent with prior evidence indicating that resistance training is an effective non-pharmacological strategy for lowering HbA1c in individuals with type 2 diabetes. Previous studies have reported reductions in HbA1c ranging from 0.39% to over 1.0% following structured resistance training programs (Jansson et al., 2022; Kobayashi et al., 2023; Li et al., 2024).

Systematic reviews have suggested that moderate-intensity resistance exercise may provide superior metabolic benefits compared with low-intensity protocols, although not all studies report statistically significant differences between intensities (Oude et al., 2025). In the present study, the moderate-intensity group achieved a greater reduction in HbA1c than the control group, whereas the low-intensity group showed only minimal changes. Discrepancies with studies reporting no difference between exercise intensities may be attributable to variations in exercise modality, movement patterns, session structure, and adherence levels (Kanaley et al., 2022).

Physiological Mechanisms of Resistance Exercise

Moderate-intensity resistance exercise enhances insulin sensitivity through several mechanisms. Skeletal muscle contractions stimulate insulin-independent translocation of GLUT-4 transporters to the cell membrane, thereby facilitating glucose uptake even in the presence of insulin resistance (Abedinzadeh et al., 2025). Additionally, moderate-intensity exercise improves lipid metabolism, reduces intramyocellular fat accumulation, and suppresses low-grade chronic inflammation by decreasing pro-inflammatory cytokines such as TNF-α and IL-6, all of which contribute to improved glycemic regulation (Chen et al., 2020; Yan et al., 2025).

Interpretation of the Limited Effect in the Low-Intensity Group

The absence of a significant reduction in HbA1c in the low-intensity group may reflect an insufficient metabolic stimulus to induce optimal physiological adaptation. Furthermore, it is important to recognize that HbA1c responses are influenced by intervention duration, exercise adherence, dietary intake, and concurrent pharmacological therapy, particularly when exercise intensity is relatively low (Morihara et al., 2025). Clinically, HbA1c reductions ≥0.5% are considered meaningful, reducing microvascular complications by 25% and cardiovascular risk by 15–20% (Care & Suppl, 2022).

The observed improvement in SDSCA physical activity scores among the intervention groups indicates enhanced exercise adherence and engagement. However, the 12-week duration and exercise intensities employed were insufficient to produce significant changes in anthropometric (weight, BMI, waist circumference) or hemodynamic (blood pressure) parameters. These findings indicate that sustained adherence to physical activity (as measured by SDSCA) lays the foundation for future cardiometabolic improvements, though longer interventions (>16 weeks) and dietary co-intervention may be required for comprehensive outcomes (Su et al., 2023).

CONCLUSION AND SUGGESTION

Moderate-intensity resistance exercise was associated with statistically significant HbA1c reductions compared to non-exercise controls ($p = 0.016$), whereas low-intensity exercise yielded no significant glycemic improvements. These findings reinforce resistance training as a valuable adjunctive approach for glycemic management in type 2 diabetes, consistent with documented HbA1c reductions. Nurses and healthcare teams can promote sustainable exercise adoption through age-appropriate protocols and interdisciplinary collaboration, enhancing self-management within primary healthcare frameworks such as community diabetes programs.

Furthermore, the study supports the integration of moderate-intensity resistance exercise into primary healthcare programs for chronic disease management, such as community-based diabetes programs. Structured resistance exercise, delivered with appropriate supervision and safety considerations, may represent a practical strategy for improving glycemic control within resource-limited primary care environments.

This study has several limitations. Convenience sampling and non-random group allocation introduced potential selection bias, compounded by small sample sizes ($n = 17$/group) that limit generalizability. The 12-week duration was insufficient for detecting sustained cardiometabolic adaptations, while the lack of professional supervision may have affected exercise technique consistency. Uncontrolled confounders, including dietary intake, extraneous physical activity, stress, and medication adherence, further complicate outcome attribution. Future research should employ randomized controlled trials with larger samples ($n \geq 50$/group), extended durations ($\geq$ 24 weeks), supervised dietary co-interventions, professional training supervision, and objective monitoring (continuous glucose monitoring) to establish optimal resistance exercise protocols for primary care diabetes management.

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