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The effect of exercise on patients with type 2 diabetes mellitus: A correlation and regression analysis of anthropometric variables

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Abstract

To determine the correlations between anthropometric variables and glycaemic indicators after a 3-month exercise programme in patients with Type 2 Diabetes Mellitus (T2DM), and to identify predictors of glycaemic response through regression analysis. A pre-post design was applied to 47 T2DM patients (male n=23, female n=24; mean age 59.7±8.8 years) from Khentii Province, Mongolia (2022–2024). A 3-month combined exercise programme — including walking, stretching, balance, and light resistance exercises — was delivered at primary care facilities. Fasting glucose, glycated haemoglobin (HbA1c), blood pressure, and anthropometric measures were assessed before and after the programme. Pearson correlation coefficients, paired t-tests, independent samples t-tests, and ordinary least-squares regression were performed using Python statsmodels and scipy libraries. Fasting glucose decreased significantly from 10.3 to 8.4 mmol/L (Δ=−1.86, p<0.001), HbA1c from 11.3 to 10.8% (Δ=−0.54, p=0.007), and systolic blood pressure from 135.5 to 130.3 mmHg (p<0.001). Pearson correlation analysis identified strong negative associations between body mass index (BMI) and HbA1c change (r=−0.651, p=0.005), body fat percentage and HbA1c change (r=−0.577, p=0.015), and a moderate positive association between age and baseline systolic blood pressure (r=0.381, p=0.009). OLS regression confirmed that baseline glucose alone explained 85.8% of glucose change variance (adj. R^2=0.847, β=−0.435, p<0.001), and each 1 kg/m^2 increase in BMI was associated with an additional 0.115% HbA1c reduction (β=−0.115, p=0.005). A 3-month exercise programme significantly improved glycaemic control and blood pressure in T2DM patients. Higher adiposity was the strongest predictor of HbA1c response, supporting BMI-stratified and individualised exercise prescriptions for T2DM management.

Keywords: Type 2 diabetes mellitus, Exercise intervention, Glycaemic control, Body mass index, Correlation analysis

Introduction

According to the World Health Organization, 537 million people worldwide were living with diabetes as of 2023, of whom 90–95% have type 2 diabetes mellitus (T2DM) (IDF, 2023). In Mongolia, the national prevalence of T2DM in adults aged 20–79 years reached 5% by 2022, with Khentii Province registering approximately 2,400 new diagnoses annually, representing 2.0–2.5% of the provincial population (Ministry of Health and Sports of Mongolia, 2022). These figures underscore the urgency of evidence-based non-pharmacological management strategies tailored to the Mongolian context.

Exercise is a cornerstone of T2DM management and is explicitly recommended by the American Diabetes Association (ADA, 2023) and the European Association for the Study of Diabetes (EASD). A landmark study by Pan et al. (1997) demonstrated that combined diet and exercise reduced the risk of T2DM conversion by 42% in individuals with impaired glucose tolerance, while Knowler et al. (2002) showed that lifestyle intervention — including exercise and dietary modification — outperformed metformin (58% vs 31% reduction in diabetes incidence). These findings established the foundational evidence base for exercise as a primary intervention.

However, the magnitude of the glycaemic response to exercise is known to vary substantially by age, sex, body composition, and baseline clinical status, necessitating a personalised approach (Colberg et al., 2016). Despite the growing international evidence base, research examining these relationships within Mongolian T2DM populations remains scarce, particularly studies that quantify the predictors of glycaemic response using regression methodology.

The present study aimed to: (1) evaluate pre- and post-intervention changes in clinical and anthropometric indicators following a 3-month

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exercise programme; (2) identify correlations between anthropometric variables and glycaemic outcomes using Pearson correlation analysis; and (3) determine independent predictors of glycaemic and blood pressure responses through OLS regression modelling.

Methods

Study design and participants

A quasi-experimental pre-post design was employed. Participants were 47 adults with confirmed T2DM diagnosis (ICD-10: E11) registered at three primary care centres and the internal medicine outpatient clinic of the Combined Hospital in Kherlenbayan-Ulaan soum, Khentii Province, Mongolia (2022–2024). The sample comprised 23 males and 24 females, with a mean age of 59.7±8.8 years (range 39–82). Inclusion criteria: confirmed T2DM, age ≥18 years, written informed consent. Exclusion criteria: comorbid chronic disease requiring specialised dietary management, pregnancy, inability to perform moderate physical activity.

Intervention programme

The 3-month (12-week) exercise programme was designed to achieve at least 30 minutes of moderate physical activity 3–5 times per week. Activities included brisk walking, stretching, balance exercises, and light resistance exercises adapted to the participants' physical capacity. Dietary counselling was provided in collaboration with a registered dietitian and delivered to all participants throughout the programme period.

Measurements

All measurements were obtained at baseline and at 12 weeks. Anthropometric assessment included: age, sex, height (cm), body weight (kg), body mass index (BMI, kg/m^2), fat mass (kg and %), waist-to-hip ratio, body water (%), excess weight (kg), energy expenditure (kcal/day), and a standardised 100-point health score. Clinical measurements included systolic and diastolic blood pressure (mmHg), heart rate (bpm), oxygen saturation (%), fasting peripheral blood glucose (mmol/L), and glycated haemoglobin (HbA1c, %).

Statistical analysis

All statistical analyses were performed using Python 3.10 (pandas 1.5, scipy 1.9, statsmodels 0.13). Descriptive statistics are reported as Mean ± Standard Deviation (M±SD) and range. Pre-post comparisons were assessed by paired-samples t-tests. Between-group comparisons (sex, age groups) used independent samples t-tests. Pearson product-moment correlation coefficients (r) were computed between anthropometric and clinical change variables. Ordinary least-squares (OLS) multiple regression models were constructed using predictors that achieved $p<0.05$ in correlation analysis. Statistical significance was set at $p<0.05$ (two-tailed); effect levels are reported as * $p<0.05$, ** $p<0.01$, *** $p<0.001$.

Ethics. The study was approved by the Ethics Committee of the "Type 2 Diabetes" research project. All participants provided written informed consent prior to enrolment. The study was conducted in accordance with the Declaration of Helsinki. Patient confidentiality was maintained throughout.

Results

Descriptive statistics

The mean BMI of 29.4±4.5 kg/m^2 places the sample in the overweight range according to WHO criteria. Female participants had significantly higher body fat than males (40.3±5.7% vs 33.7±6.5%, p=0.001). Baseline fasting glucose (10.3±4.9 mmol/L) and HbA1c (11.3±1.8%) indicated poor glycaemic control at enrolment. Full descriptive statistics are presented in Table 2.

Table 2. Descriptive statistics for anthropometric and clinical variables (n=47)

Variable	n	M	SD	Min	Max	Post-M±SD
Age (years)	46	59.7	8.8	39	82	–
Height (cm)	47	162.6	8.2	145	182	–

Body weight (kg)	47	78.0	14.2	53.2	119.6	–
BMI (kg/m^2)	47	29.4	4.5	21.5	42.3	–
Fat mass (kg)	46	29.6	9.8	11.1	59.3	–
Body fat (%)	47	37.1	6.9	18.1	49.5	–
Waist-to-hip ratio	47	0.94	0.15	0.00	0.99	–
Body water (%)	47	44.7	9.5	34.7	98.0	–
Excess weight (kg)	47	19.5	10.1	0.5	47.9	–
Energy expenditure (kcal/day)	47	1576	196	1164	2033	–
Health score (0–100)	47	68.7	13.7	29	91	–
Systolic BP – pre (mmHg)	47	135.4	15.7	102	160	130.3±12.0
Diastolic BP – pre (mmHg)	47	85.1	9.6	63	107	82.2±7.2
Heart rate – pre (bpm)	47	83.9	10.6	60	100	83.7±10.3
Fasting glucose – pre (mmol/L)	46	10.3	4.9	3.7	24.2	8.4±2.9
HbA1c % – pre	18	11.3	1.8	6.8	14.0	10.8±2.2

Note. M = mean; SD = standard deviation. Post-M±SD = mean ± SD after intervention. HbA1c measured in 17–22 participants

Source. Authors' data. Khentii Province, 2023–2024.

Pre-Post comparisons: Paired T-tests

After the 3-month programme, statistically significant improvements were observed in four of six clinical variables (Table 3). Fasting glucose declined from 10.3±4.9 to 8.4±2.9 mmol/L (Δ=−1.86, t=5.52, p<0.001), exceeding the pooled mean of −1.4 mmol/L reported by Umpierre et al. (2011). HbA1c fell from 11.3 to 10.8% (Δ=−0.54, p=0.007), approximating the −0.66% reported by Boulé et al. (2001). Systolic BP decreased from 135.5±15.7 to 130.3±12.0 mmHg (Δ=−5.2, p<0.001). Heart rate and oxygen saturation showed no significant change.

Table 3. Paired t-test results for clinical indicators before and after the 3-month exercise programme

Variable	n	Pre M±SD	Post M±SD	Δ	t	p
Systolic BP (mmHg)	47	135.5±15.7	130.3±12.0	−5.2±6.5	5.445	<0.001***
Diastolic BP (mmHg)	47	85.1±9.6	82.2±7.2	−2.9±5.6	3.516	0.001**
Heart rate (bpm)	47	83.9±10.6	83.7±10.3	−0.2±5.4	0.296	0.768
Saturation (%)	46	94.3±3.7	94.8±2.5	+0.5±3.2	−0.989	0.328
Fasting glucose (mmol/L)	46	10.3±4.9	8.4±2.9	−1.9±2.3	5.522	<0.001***
HbA1c (%)	17	11.3±1.8	10.8±2.2	−0.5±0.7	3.098	0.007**

Note. M±SD = mean ± standard deviation; Δ = mean change score; HbA1c measured in 17 participants. ** p<0.01; *** p<0.001

Source. Authors' data. Python scipy. stats. ttest_rel

Literature Review of Published Exercise Trials in T2DM: To contextualise the present findings, Table 1 summarises eleven key published studies on exercise interventions in T2DM. The evidence consistently shows that aerobic, resistance, and combined exercise modalities improve glycaemic control, with combined programmes showing the greatest HbA1c reductions (Sigal et al., 2007; Church et al., 2010). The only prior Mongolian study (Batzaya et al., 2023) reported HbA1c reductions of 1.14–1.21% over three months, closely aligning with the present findings.

Table 1. Summary of key published exercise intervention studies in type 2 diabetes mellitus

Author, Year	Design	Participants	Intervention	Variables	Key Result	Significance
Boulé et al., 2001	14 RCTs meta	n=504, mean 55 yr	Aerobic (20 wk)	HbA1c, VO_2max	HbA1c: −0.66%	First meta-analytic evidence that aerobic exercise reduces HbA1c in T2DM
Castaneda et al., 2002	RCT	n=62, 62–74 yr	Resistance (16 wk)	HbA1c, muscle density	HbA1c: −1.1%	Resistance training effective for older adults with T2DM
Dunstan et al., 2002	RCT	n=36, 60–80 yr	High-intensity resistance (6 mo)	HbA1c	HbA1c: −1.2% (control: +1.2%)	High intensity creates 2.4% between-group difference
Sigal et al., 2007	RCT	n=251, 18–55 yr	Aerobic / Resistance / Combined	HbA1c	Combined: −0.97%	Combined programme most effective
Church et al., 2010	RCT	n=262, mean 55 yr, both sexes	Aerobic + Resistance (9 mo)	HbA1c, body composition	Combined superior; sex differences in body composition	Confirms combined protocol superiority
Umpierre et al., 2011	Meta-analysis 47 RCTs	Mean 57 yr	Structured exercise	HbA1c	−0.67% (95%CI: −0.84 to −0.49)	Structured exercise more effective than advice alone
Look AHEAD, 2013	Cohort, 16 yr	n=5145, mean 59 yr	Aerobic + diet (intensive)	Weight, fitness, CV risk	Weight: −8.6%; fitness ↑	Long-term evidence for lifestyle change
Bacchi et al., 2012	RCT	n=40, 30–50 yr	Aerobic vs Resistance (4 mo)	Visceral fat, insulin sensitivity	Both modalities reduce visceral fat and improve insulin sensitivity	Both forms affect metabolism
Karstoft et al., 2013	RCT	n=20, mean 60 yr	HIIT vs Continuous aerobic (4 mo)	Glucose flux, body weight	HIIT: greater weight loss	HIIT emerging as effective new approach
Nicolucci et al., 2012	RCT	n=153, mean 58 yr	Supervised exercise	SF-36 quality of life, depression	SF-36: +6.5; depression ↓	Exercise improves quality of life
Batzaya et al., 2023	Pre-post	n=80, mean 55 yr, both sexes	Walking (3 mo, Khentii)	Glucose, HbA1c	Glucose: −0.3 to −0.6 mmol/L; HbA1c: −1.14 to −1.21%	First Mongolian clinical evidence in T2DM

Note. RCT = randomised controlled trial; HIIT = high-intensity interval training; T2DM = type 2 diabetes mellitus; BMI = body mass index; CV = cardiovascular; n/s = not significant

Source. Compiled by the authors from published literature

Pearson correlation analysis

The full Pearson correlation matrix is presented in Table 4. Six statistically significant associations were identified:

(1) BMI × ΔHbA1c: r=−0.651, p=0.005 — the strongest association; higher BMI predicts greater HbA1c reduction after exercise.

(2) Body fat % × ΔHbA1c: r=−0.577, p=0.015 —

higher adiposity predicts greater glycaemic response. (3) Fat mass (kg) × ΔHbA1c: r=−0.545, p=0.029 — absolute fat mass is similarly associated with HbA1c response.
(4) Excess weight × ΔHbA1c: r=−0.537, p=0.026 — moderate negative association.
(5) Age × baseline systolic BP: r=0.381, p=0.009 — older age predicts higher pre-intervention systolic pressure.
(6) Health score × ΔHbA1c: r=0.486, p=0.048 — better baseline health predicts greater HbA1c response.

Table 4. Pearson correlation matrix: anthropometric variables and clinical outcomes

Variable	Glucose pre	Glucose post	Systolic pre	Diastolic pre	HbA1c pre	ΔHbA1c
Age	0.007	0.024	0.381**	0.004	−0.323	−0.174
Sex (male=1)	0.184	0.181	−0.049	0.118	0.104	0.401
Body weight (kg)	−0.035	0.018	0.020	0.114	0.114	−0.362
Height (cm)	0.109	0.135	−0.165	0.102	0.217	0.090
Fat mass (kg)	−0.102	−0.060	0.148	0.155	−0.161	−0.545*
BMI (kg/m^2)	−0.121	−0.070	0.149	0.065	−0.009	−0.651**
Body fat (%)	−0.057	−0.025	0.211	0.144	0.098	−0.577*
Waist-to-hip ratio	−0.020	−0.040	−0.119	0.014	−0.200	0.035
Body water (%)	0.018	0.038	0.044	−0.028	0.143	0.068
Excess weight (kg)	−0.077	−0.030	0.123	0.095	0.067	−0.537*
Energy expenditure	0.032	0.065	−0.117	0.016	0.168	−0.107
Health score	0.140	0.093	−0.021	0.021	−0.170	0.486*

Note. r = Pearson correlation coefficient. ΔHbA1c = post minus pre HbA1c. Green shading = significant positive; yellow = significant negative. * p<0.05; ** p<0.01.
Source. Authors' data. Python scipy. stats. pearsonr.

Sex group comparisons: Independent samples t-tests comparing male and female participants revealed no significant sex differences in glycaemic outcomes (Table 5). The only significant difference was in body fat percentage (females 40.3±5.7% vs males 33.7±6.5%, p=0.001), consistent with published sex-related body composition norms (Church et al., 2010).

Table 5. Sex-based comparison of key variables (independent samples t-test)

Variable	Male (n=23) M±SD	Female (n=24) M±SD	p-value	Interpretation
Body weight (kg)	80.5±13.2	75.6±14.9	0.239	No significant difference
BMI (kg/m^2)	28.7±3.7	30.0±5.1	0.325	No significant difference
Body fat (%)	33.7±6.5	40.3±5.7	0.001**	Significantly higher in females
Fasting glucose – pre (mmol/L)	11.4±5.6	9.2±3.8	0.127	No significant difference
Fasting glucose – post (mmol/L)	9.0±3.1	7.8±2.5	0.153	No significant difference
Glucose change (Δ)	−2.4±2.8	−1.4±1.5	0.151	No significant difference
Systolic BP – pre (mmHg)	134.1±17.0	136.7±14.6	0.579	No significant difference
Health score	70.9±13.4	66.5±13.9	0.280	No significant difference

Note. M±SD = mean ± standard deviation. ** p<0.01
Source. Authors' data. Khentii Province, 2023–2024

Age group comparisons

Participants were stratified into four age groups (Table 6). The ≥70-year group showed the highest baseline fasting glucose (13.9 mmol/L) and the largest glucose reduction (Δ=−3.2 mmol/L); however, n=7 for this group, and results should be interpreted cautiously. Health scores were higher in younger age groups (72–73) and lower in those aged ≥60 years (65), consistent with age-related functional decline.

Table 6. Mean clinical and anthropometric values by age group

Age Group	n	Weight (kg)	BMI	Glucose pre	Glucose post	Glucose Δ	Health Score
<50 years	5	76.9	28.4	10.4	8.7	−1.8	72.0
50–59 years	17	75.1	28.1	11.0	8.6	−2.3	72.8
60–69 years	17	81.0	30.3	8.6	7.6	−1.1	64.7
≥70 years	7	81.0	31.1	13.9	10.7	−3.2	64.6

Note. Mean values are presented. Glucose Δ = post minus pre (negative = decrease). Small subgroup sizes require cautious interpretation

Source. Authors' data. Khentii Province, 2023–2024

OLS regression analysis

Five OLS regression models were constructed to quantify the independent contribution of anthropometric predictors to clinical outcomes (Table 7). Results are interpreted as the unit change in the dependent variable per one-unit increase in the predictor, holding other variables constant.

Table 7. Summary of OLS regression models (n=17–46)

Model / Predictor	n	R^2	adj.R^2	F / p(F)	p	β [95% CI]
Model A: Systolic BP ~ Age					46	R^2=0.145, adj.R^2=0.126, F=7.49**
Age (years)					0.009**	0.676 [0.178, 1.174]
Model B: ΔHbA1c ~ BMI					17	R^2=0.423, adj.R^2=0.385, F=11.01**
BMI (kg/m^2)					0.005**	−0.115 [−0.190, −0.041]
Model C: ΔGlucose ~ Baseline glucose + BMI + Age					45	R^2=0.858, adj.R^2=0.847, F=82.46***
Baseline glucose (mmol/L)					<0.001***	−0.435 [−0.492, −0.378]
BMI					0.383	0.027 [−0.035, 0.090]
Age					0.840	0.003 [−0.030, 0.037]
Model D: ΔSystolic BP ~ Baseline systolic + Age + Sex					46	R^2=0.519, adj.R^2=0.485, F=15.13***
Baseline systolic BP (mmHg)					<0.001***	−0.308 [−0.406, −0.211]
Age					0.232	0.105 [−0.070, 0.281]
Sex (male=1)					0.143	2.095 [−0.741, 4.931]
Model E: ΔHbA1c ~ Body fat %					17	R^2=0.333, adj.R^2=0.288, F=7.49*
Body fat (%)					0.015*	−0.086 [−0.153, −0.019]

Note. β = unstandardised regression coefficient; SE = standard error; CI = confidence interval; adj. R^2 = adjusted coefficient of determination. Significance: * p<0.05; ** p<0.01; *** p<0.001

Source. Authors' data. Python statsmodels.api OLS

Model A confirmed that age independently predicts pre-exercise systolic BP (R^2=0.145, β=0.676, p=0.009): each additional year of age is associated with approximately 0.68 mmHg higher systolic pressure. Model B showed that each 1 kg/m² increase in BMI predicts an additional 0.115% HbA1c reduction after exercise (R^2=0.423, β=−0.115, p=0.005); a patient with BMI=35 kg/m² is expected to achieve ~1.15% greater HbA1c reduction than one at BMI=25 kg/m². Model C demonstrated that baseline glucose alone explained 85.8% of glucose change variance (adj. R^2=0.847, β=−0.435, p<0.001), with each 1 mmol/L higher baseline predicting an additional 0.435 mmol/L reduction after the programme. Model D confirmed that baseline systolic BP was the sole significant predictor of systolic change (β=−0.308, p<0.001), explaining 51.9% of variance; the higher the initial BP, the greater the post-exercise reduction. Model E showed that each 1% increase in body fat predicts an additional 0.086% HbA1c reduction (R^2=0.333, β=−0.086, p=0.015), reinforcing the association between adiposity and glycaemic responsiveness.

Discussion

The central finding of this study is that the degree of adiposity — as indexed by BMI (r=−0.651), body fat percentage (r=−0.577), and excess weight (r=−0.537)

— is the strongest predictor of HbA1c response to exercise in Mongolian T2DM patients. The regression model (Model B) quantifies this relationship clinically: every 10 kg/m² increase in BMI above the reference level predicts approximately 1.15% additional HbA1c reduction after the programme. This finding aligns with the AMPK-GLUT4 insulin-independent glucose transport mechanism described by Goodyear and Kahn (1998), whereby exercise activates AMPK more strongly in insulin-resistant adipose tissue, enhancing glucose uptake proportionally to initial adiposity.

The observed glucose reduction of Δ=−1.86 mmol/L exceeds the pooled mean of −1.4 mmol/L reported across 47 RCTs by Umpierre et al. (2011), and the HbA1c reduction of −0.54% closely matches the −0.66% reported by Boulé et al. (2001). Model C demonstrates that baseline glycaemic status is itself the most powerful predictor of change (adj. R^2=0.847), reflecting the combined influence of regression to the mean and physiological treatment response — patients with the most severely elevated baseline glucose derive the greatest absolute benefit. These findings are consistent with Look AHEAD Research Group (2013) and support the case for exercise programme prioritisation in patients with poor initial glycaemic control.

The age-systolic blood pressure correlation (r=0.381, p=0.009) and Model D findings underscore the need for cardiovascular monitoring in older patients undertaking exercise programmes, consistent with Myers et al. (2002) and Marwick et al. (2009). Model D further shows that the absolute magnitude of systolic BP reduction increases proportionally with baseline severity — each 1 mmHg higher baseline predicts an additional 0.31 mmHg post-exercise reduction, implying the greatest benefit for patients with hypertension.

No significant sex differences in glycaemic outcomes were observed, consistent with Church et al. (2010). However, the significantly higher body fat percentage in females (p=0.001) suggests that female patients may benefit differentially from exercise programmes that specifically target adipose tissue, such as resistance training protocols shown effective by Bacchi et al. (2012). The absence of significant age-group differences in glucose response, while unexpected, may reflect regression to the mean in the ≥70-year subgroup where baseline glucose was highest.

Several limitations must be acknowledged. First, the pre-post design without a concurrent control group precludes causal attribution. Second, HbA1c was measured in only 36–47% of participants (n=17–22), limiting the statistical power of HbA1c-related findings. Third, the overall sample (n=47) is modest for subgroup analyses. Fourth, exercise adherence and dietary compliance were assessed through self-report without objective monitoring. Future studies should employ randomised controlled designs with complete HbA1c assessment and multi-province sampling to strengthen the domestic evidence base.

Conclusion

A 3-month structured exercise programme significantly improved fasting glucose (Δ=−1.86 mmol/L, p<0.001), HbA1c (Δ=−0.54%, p=0.007), and systolic blood pressure (Δ=−5.2 mmHg, p<0.001) in 47 T2DM patients from Khentii Province, Mongolia. Correlation and regression analyses demonstrated that higher BMI and body fat percentage are the strongest predictors of glycaemic response to exercise, providing a physiologically coherent rationale for BMI-stratified exercise prescriptions. These findings contribute to a growing evidence base for exercise as a primary non-pharmacological intervention in Mongolian T2DM management and support the integration of individualised exercise counselling into primary care protocols for overweight and obese T2DM patients. Randomised controlled trials with larger samples and complete biomarker assessment are warranted.

Ethical approval. The study was approved by the Ethics Committee of the "Type 2 Diabetes" project. All participants provided written informed consent. The study was conducted in accordance with the World Medical Association Declaration of Helsinki.

Conflict of interest. The authors declare no conflict of interest.

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References

American Diabetes Association. (2023). Standards of medical care in diabetes – 2023. Diabetes Care, 46(Suppl 1), S1–S291. https://doi.org/10.2337/dc23-Sint

Bacchi, E., Negri, C., Zanolin, M. E., Milanese, C., Faccioli, N., Trombetta, M., ... & Moghetti, P. (2012). Metabolic effects of aerobic training and resistance training in type 2 diabetic subjects: A randomized controlled trial. Diabetes Care, 35(4), 676–682. https://doi.org/10.2337/dc11-1655

Batzaya, P., Enkh-Uyanga, O., Mendbayar, L., & Munkhzul, H. (2023). Effects of exercise on patients with type 2 diabetes mellitus in Khentii Province. Mongolian Physician, 3(1), 45–51.

Boulé, N. G., Haddad, E., Kenny, G. P., Wells, G. A., & Sigal, R. J. (2001). Effects of exercise on glycemic control and body mass in type 2 diabetes mellitus: A meta-analysis of controlled clinical trials. JAMA, 286(10), 1218–1227. https://doi.org/10.1001/jama.286.10.1218

Castaneda, C., Layne, J. E., Munoz-Orians, L., Gordon, P. L., Walsmith, J., Foldvari, M., ... & Nelson, M. E. (2002). A randomized controlled trial of resistance exercise training to improve glycemic control in older adults with type 2 diabetes. Diabetes Care, 25(12), 2335–2341. https://doi.org/10.2337/diacare.25.12.2335

Church, T. S., Blair, S. N., Cocreham, S., Johannsen, N., Johnson, W., Kramer, K., ... & Earnest, C. P. (2010). Effects of aerobic and resistance training on hemoglobin A1c levels in patients with type 2 diabetes. JAMA, 304(20), 2253–2262. https://doi.org/10.1001/jama.2010.1710

Colberg, S. R., Sigal, R. J., Yardley, J. E., Riddell, M. C., Dunstan, D. W., Dempsey, P. C., ... & Tate, D. F. (2016). Physical activity/exercise and diabetes: A position statement of the American Diabetes Association. Diabetes Care, 39(11), 2065–2079. https://doi.org/10.2337/dc16-1728

Dunstan, D. W., Daly, R. M., Owen, N., Jolley, D., De Courten, M., Shaw, J., & Zimmet, P. (2002). High-intensity resistance training improves glycemic control in older patients with type 2 diabetes. Diabetes Care, 25(10), 1729–1736. https://doi.org/10.2337/diacare.25.10.1729

Goodyear, L. J., & Kahn, B. B. (1998). Exercise, glucose transport, and insulin sensitivity. Annual Review of Medicine, 49, 235–261. https://doi.org/10.1146/annurev.med.49.1.235

Hamasaki, H. (2016). Daily physical activity and type 2 diabetes: A review. World Journal of Diabetes, 7(12), 243–251. https://doi.org/10.4239/wjd.v7.i12.243

International Diabetes Federation. (2023). IDF Diabetes Atlas (11th ed.). IDF. https://www.diabetesatlas.org

Karstoft, K., Winding, K., Knudsen, S. H., Nielsen, J. S., Thomsen, C., Pedersen, B. K., & Solomon, T. P. J. (2013). The effects of free-living interval-walking training on glycemic control, body composition, and physical fitness in type 2 diabetic patients. Diabetes Care, 36(2), 228–236. https://doi.org/10.2337/dc12-0658

Knowler, W. C., Barrett-Connor, E., Fowler, S. E., Hamman, R. F., Lachin, J. M., Walker, E. A., & Nathan, D. M. (2002). Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. New England Journal of Medicine, 346(6), 393–403. https://doi.org/10.1056/NEJMoa012512

Little, J. P., Gillen, J. B., Percival, M. E., Safdar, A., Tarnopolsky, M. A., Punthakee, Z., … & Gibala, M. J. (2011). Low-volume high-intensity interval training reduces hyperglycemia and increases muscle mitochondrial capacity in patients with type 2 diabetes. Journal of Applied Physiology, 111(6), 1554–1560. https://doi.org/10.1152/japplphysiol.00921.2011

Look AHEAD Research Group. (2013). Cardiovascular effects of intensive lifestyle intervention in type 2 diabetes. New England Journal of Medicine, 369(2), 145–154. https://doi.org/10.1056/NEJMoa1212914

Malin, S. K., Gerber, R., Chipkin, S. R., & Braun, B. (2013). Independent and combined effects of exercise training and metformin on insulin sensitivity in individuals with prediabetes. Diabetes Care, 35(1), 131–136. https://doi.org/10.2337/dc11-0925

Marwick, T. H., Hordern, M. D., Miller, T., Chyun, D. A., Bertoni, A. G., Blumenthal, R. S., … & Rocchini, A. (2009). Exercise training for type 2 diabetes mellitus: Impact on cardiovascular risk. Circulation, 119(25), 3244–3262. https://doi.org/10.1161/CIRCULATIONAHA.109.192521

Ministry of Health and Sports of Mongolia. (2022). Health statistical report 2022. Ulaanbaatar: MHSM.

Myers, J., Prakash, M., Froelicher, V., Do, D., Partington, S., & Atwood, J. E. (2002). Exercise capacity and mortality among men referred for exercise testing. New England Journal of Medicine, 346(11), 793–801. https://doi.org/10.1056/NEJMoa011858

Nicolucci, A., Balducci, S., Cardelli, P., Cavallo, S., Fallucca, S., Bazuro, A., … & Pugliese, G. (2012). Relationship of exercise volume to improvements of quality of life with supervised exercise training in patients with type 2 diabetes. Diabetologia, 55(3), 579–588. https://doi.org/10.1007/s00125-011-2425-9

Pan, X. R., Li, G. W., Hu, Y. H., Wang, J. X., Yang, W. Y., An, Z. X., … & Howard, B. V. (1997). Effects of diet and exercise in preventing NIDDM in people with impaired glucose tolerance: The Da Qing IGT and Diabetes Study. Diabetes Care, 20(4), 537–544. https://doi.org/10.2337/diacare.20.4.537

Park, S. W., Goodpaster, B. H., Lee, J. S., Kuller, L. H., Boudreau, R., De Rekeneire, N., … & Newman, A. B. (2009). Excessive loss of skeletal muscle mass in older adults with type 2 diabetes. Diabetes Care, 32(11), 1993–1997. https://doi.org/10.2337/dc09-0264

Sigal, R. J., Kenny, G. P., Boulé, N. G., Wells, G. A., Prud'homme, D., Fortier, M., … & Jaffey, J. (2007). Effects of aerobic training, resistance training, or both on glycemic control in type 2 diabetes. Annals of Internal Medicine, 147(6), 357–369. https://doi.org/10.7326/0003-4819-147-6-200709180-00005

Snowling, N. J., & Hopkins, W. G. (2006). Effects of different modes of exercise training on glucose control and risk factors for complications in type 2 diabetic patients. Diabetes Care, 29(11), 2518–2527. https://doi.org/10.2337/dc06-1317

Umpierre, D., Ribeiro, P. A. B., Kramer, C. K., Leitão, C. B., Zucatti, A. T. N., Azevedo, M. J., … & Schaan, B. D. (2011). Physical activity advice only or structured exercise training and association with HbA1c levels in type 2 diabetes: A systematic review and meta-analysis. JAMA, 305(17), 1790–1799. https://doi.org/10.1001/jama.2011.576

Zhu, D., Xu, J., Bu, X., Zhang, X., Li, X., Guo, Y., & Song, Y. (2018). Effects of Tai Chi exercise on glucose control, lipid profiles, and quality of life in patients with type 2 diabetes. Journal of Diabetes Research, 2018, Article 8287436. https://doi.org/10.1155/2018/8287436