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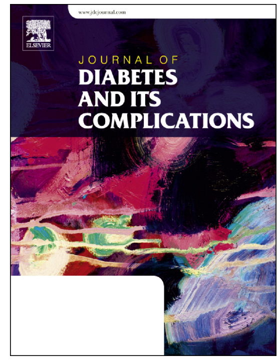

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Body-weight functional exercise promotes greater and safer blood glucose reduction compared to aerobic and strength exercises in type 1 diabetics: A randomised crossover study.

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ABSTRACT

Aims: Aerobic and strength exercises are commonly recommended for patients with type-1 diabetes (T1DM) but may not suit everyone. Body-weight functional exercise (BWFE) could offer an alternative for diabetes management. We aimed to compare blood glucose (BG), cardiovascular responses and enjoyment levels following a 30-minute session of BWFE versus interval aerobic exercise (IAE) and strength exercise (STE) in patients with T1DM.

Methods: Ten T1DM participants (seven female) completed three randomised exercise sessions. BG, heart rate (HR), blood pressure (BP) and double product (DP) were measured before (PRE), immediately after (POST-0) and 20 minutes post-exercise (POST-20). Maximum and average HR were recorded, and enjoyment levels (EL) were assessed post-exercise. Statistical analysis used generalised estimated equations, with minimal detectable difference for assessing clinical significance.

Results: We observed clinically meaningful reductions in BG after all sessions, but only BWFE showed a statistically significant drop at POST-0 (-2.2 mmol/L) without hypoglycaemia. HR, BP and DP responses were similar across sessions. BWFE showed the highest EL and maximal HR.

Conclusions: BWFE effectively lowered BG safely and provided comparable cardiovascular effects to IAE and STE while being more enjoyable. These findings support incorporating functional exercises into T1DM management to encourage sustained physical activity.

Keywords: Diabetes mellitus; Motivation; Hypoglycaemia; Blood Glucose; Blood pressure; Heart rate.

1. INTRODUCTION

Diabetes Mellitus is a chronic disease characterised by elevated high blood glucose levels. In addition to insulin therapy[1,2], effective T1DM management includes healthy eating and regular physical activity to lower the risk of cardiovascular complications and reduce mortality rates [1,3]. Different types of exercise are recommended as non-pharmacological strategies for managing T1DM. Even a single session can significantly improve blood glucose control and cardiovascular health by enhancing heart rate, blood pressure and double product [1,4-7]. Among these exercises, aerobic and strength training are particularly advised, with a recommendation to perform them at moderate intensity for at least 30 minutes per session [2,8].

Cross-sectional studies on aerobic and strength exercises in T1DM patients have identified patterns in intensity (moderate to vigorous), duration (14–90 minutes), sample size (5–20 per group), and age (children to young adults). They primarily examine blood glucose and cardiovascular effects across different exercise types (aerobic, interval, strength) and activity levels [4,5,7,9-12]. The findings indicate that aerobic and strength exercises can be directly compared in terms of their effects on blood glucose when performed at similar intensities and durations [6,7,10,12]. Interestingly, T1DM patients tend to be more motivated to participate in non-traditional exercises, such as body-weight workouts, rather than conventional exercise routines [4].

Body-weight functional exercises (BWFE) could serve as an interesting complementary tool for blood glucose control in individuals with diabetes [13,14]. Functional exercise is defined as movements performed against resistance, utilising external loads or body weight, which directly enhance the ability to perform daily activities [8,15]. However, research on BWFE in T1DM patients is limited. Mosher and their colleagues studied a 12-week program combining calisthenic, aerobic and strength exercises in adolescents with T1DM [14]. They found improved cardiorespiratory endurance, muscle strength, lipid profile and blood glucose regulation. A 30-minute active video game session, a type of body weight exercise, has been also shown to improve endothelial function, blood glucose and blood pressure in T1DM, when compared to interval aerobic exercise [4,16].

Despite ongoing research into optimal exercise for T1DM, the comparative effects of BWFE, matched aerobic and strength exercise on glucose and cardiovascular responses are yet to be established [4,6,17]. This crossover study compared blood glucose and cardiovascular responses following BWFE sessions, matched to interval aerobic exercise (IAE) and strength exercise (STE) sessions in adults with T1DM. We hypothesise that BWFE will produce similar acute reductions in blood glucose and cardiovascular as IAE and STE, offering a safe and effective exercise alternative for adults with T1DM. Additionally, we anticipate high levels of enjoyment reported following the BWFE session.

2. SUBJECTS

Participants were recruited through advertisements and flyers shared via social networks, radio, word-of-mouth on a university health campus, a regional diabetes association and the “Exercise as Daily Sugar” project by the Department of Physical Education. The inclusion criteria were as follows: (1) Males and females with T1DM, aged 18-45; (2) Using multiple daily insulin doses or continuous subcutaneous insulin infusion; (3) Irregularly physically active; (4) Prior experience with aerobic treadmill, strength and functional exercise; and (5) No medical restrictions for exercise and no micro- or macrovascular complications that could be worsened by the interventions. Participants were excluded if: (1) they failed to complete all exercise sessions; and (2) they were withdrawn from participation for any reason.

3. METHODS

3.1. Ethical and clinical trial aspects

This study adhered to the Declaration of Helsinki and participants were informed of the potential benefits and risks of the investigation before signing an informed consent document. The research protocol received prior approval from the local ethics committee, in compliance with the National Health Council (# 6.103.597/2023), and is registered with the Brazilian Randomised Clinical Trial registry (#RBR-57T7VB).

3.2. Study type and design

This randomised crossover study compared three exercise sessions: IAE, STE and BWFE designs. All sessions were matched for intensity and duration. We measured blood glucose and cardiovascular responses as primary outcomes, and maximum and average HR and enjoyment as secondary outcomes. Measurements were taken at rest (PRE), immediately after (POST-0), and 20 minutes after (POST-20) each session. Before the exercise sessions, participants completed the International Physical Activity Questionnaire (IPAQ, short form), and underwent anthropometric, cardiorespiratory fitness and repetition maximum tests. They also participated in a familiarisation session. Participants were then randomly assigned to the three exercise sessions, starting with either IAE or STE, followed by BWFE. All sessions were conducted between 4:00 and 7:00 PM, with a 48–196-hour rest period between sessions.

3.3. Sample size and randomisation

We calculated the required sample size using G*Power 3.1.9 [18], setting an alpha of 0.05, power of 0.80 and a moderate effect size (ES = 0.6). Based on these criteria, a minimum of eight participants was required to account for two experimental sessions and three repeated measures (PRE, POST-0 and POST-20) for analysis using a generalised estimation equation. This sample size is consistent with previous research in individuals with T1DM [5,7,12,16]. Participants were randomly assigned (1:1 ratio) using Excel 2024 to begin with either the IAE or STE session, based on their enrolment order. All participants then completed the BWFE session.

3.4. Techniques and procedures

3.4.1. Physical activity level and anthropometry measures

Physical activity was reported using the self-reported IPAQ, consistent with prior research in T1DM [19]. Height and weight were measured using a stadiometer and digital scale, respectively. Body circumferences and skinfold thickness (biceps, triceps, subscapular, chest, axillary, iliac supra, abdominal, thigh and calf) were measured using anthropometric tape and callipers. A single trained evaluator performed all measurements using standardised techniques.

3.4.2. Tests and recommendations before and after the session

We estimated maximal oxygen uptake (VO_{2max}) using a 12-minute test conducted on a sports court, following established guidelines and previous research with T1DM patients [7,20,21]. For the STE sessions, we estimated one-repetition maximum (1RM) [22]. Participants were familiarised with the exercises before the BWFE session. After randomisation, participants completed their first session (IAE or STE), followed by the BWFE session. Before each session, participants rested for 10 minutes, during which we measured HR, systolic blood pressure (SBP), diastolic blood pressure (DBP) and capillary blood glucose (BG). Immediately after each session (POST-0), we repeated these measurements and assessed maximum and average HR, as well as enjoyment levels (EL). Twenty minutes post-exercise (POST-20), we measured HR, SBP, DBP and BG again.

3.4.3. General recommendations

All exercise sessions were conducted between 4:00 and 7:00 PM. Participants were instructed to reduce their pre-session mealtime insulin dose, following established guidelines [1,2]. They were also asked to: (1) Maintain their normal diet, sleep, and daily routines; (2) Avoid alcohol and stimulants; (3) Refrain from moderate to vigorous physical activity 24 hours before each session; (4) Report any factors that could affect their performance, such as injuries or emotional distress; and (5) Female participants were asked to avoid scheduling sessions during their menstrual week. Any factors that could introduce bias led to rescheduling the exercise session.

3.5. Primary outcome (blood glucose)

BG levels were measured using a handheld glucose meter (Accu-Check Active, Roche, Switzerland) with lancets and test strips (Accu-Check Softclix, Roche, Switzerland), following established protocols [1,2]. Capillary samples were taken at three time points of PRE, POST-0 and POST-20. Participants remained seated and still during each measurement.

3.6. Secondary outcomes (cardiovascular and enjoyment measures)

HR was continuously monitored (FT4, Polar Electro, Finland), and SBP and DBP were measured on the left arm (HEM 7122, Omron, Japan). Cardiovascular measures were taken at three time points of PRE, POST-0 and POST-20. Participants remained seated, still and silent during these measurements. Double product (DP), a measure of cardiac workload, was calculated as HR multiplied by SBP (bpm × mmHg) for each time point. Maximum and average HR were recorded to assess session intensity [4,7]. EL was assessed using a 100-mm visual analog scale, ranging from 0 (very boring) to 100 (very enjoyable) [4,7,23].

3.7. Exercise prescriptions

Prior to the study, participants completed an exercise familiarisation session. Table 1 provides an overview of all exercise sessions [1,8]. The IAE session consisted of 30 minutes of aerobic exercise, adhering to basic exercise recommendations. To ensure accurate comparisons across exercise types, a standardised intensity was used, differing from previous studies that employed varied protocols [4,6,7,11]. This session was designed to reflect typical beginner-level training programs found in gyms or parks. VO_{2max} (mL/kg/min) was estimated from the individual 12-minute test results. During the IAE session, participants alternated between one minute at 40% VO_{2max} and one minute at 60% VO_{2max} on a treadmill, consistent with previous research [6,7,10].

The STE session involved strength training at 60% of 1RM, including bench press, leg press, biceps curl, knee extension, shoulder press, hip adduction and abdominal floor exercises. This selection reflects typical twice-weekly gym strength training routines [7]. Participants performed three sets of 10–12 repetitions for each exercise, with 50–60 seconds of rest between sets. The repetition cadence was approximately three seconds (1.5 seconds eccentric, 1.5 seconds concentric), resulting in a 30-minute session. A warm-up set at 50% of estimated 1RM was performed for the first upper-body (bench press) and lower-body (leg press) exercises.

The BWFE session included front support, deep squats, triceps bench pulls, lunges, solo adduction, moving Superman abs and shoulder circles, performed on the floor [13,14]. Exercises were modified to accommodate individual abilities; for example, front support could be performed with knees on the floor, triceps bench pull elbow angles were adjusted and hand support was allowed during lunges. Similar to the STE and IAE sessions, BWFE used an interval structure: three sets of each exercise, 10–12 repetitions or 30–40 seconds of muscle contraction per set, and 50–60 second rest intervals. The repetition cadence was approximately three seconds (1.5 seconds eccentric, 1.5 seconds concentric). The moderate intensity of this BWFE session was confirmed in a non-diabetic population prior to the study.

- Table 1 about here -

3.8. Statistical analysis

To examine the effects of different exercise conditions (IAE, STE, and BWFE), we used distinct statistical approaches based on the nature of the measured parameters. For intensity variables (HR_{max}, $HR_{average}$) and EL, which were repeatedly measured, we used generalised linear mixed models (GLMMs). These GLMMs were configured with a normal distribution, an identity link function, a robust estimator and the Satterthwaite approximation for degrees of freedom. Model selection was based on the lowest corrected Akaike Information Criterion (AICc).

For primary outcomes (BG and HR) and secondary outcomes (SBP, DBP and DP), which were measured once at each time point (PRE, POST-0, and POST-20), we used generalised estimating equations (GEEs). These GEEs incorporated an unstructured working correlation matrix, a robust estimator, gamma distribution and a log link function. The best-fitting GEE model was determined by the lowest quasi-likelihood under the independence model criterion (QIC).

Main effects were assessed using Wald's χ^2 statistics, and sequential Sidak post hoc tests were conducted for pairwise comparisons. In both GLMM and GEE analyses, the normality of raw residuals was confirmed using Q-Q plots, showing satisfactory adherence to assumptions. All statistical analyses were performed using IBM SPSS Statistics 24.0 (IBM SPSS Inc., USA), with statistical significance set at $p \leq 0.05$.

The effect size (ES) and minimal detectable difference (MDD) were calculated for the primary responses (BG). ES was computed in the repeated measures design by comparing PRE (baseline) with POST-0 and POST-20 using the formula:

$$d = ((\text{POST-0 or POST-20} - \text{PRE})/SD_{PRE})/(\sqrt{2} \cdot (1 - r))$$

where SD_{PRE} represents the standard deviation at PRE, and *r* is the correlation between repeated measures. Effect sizes were interpreted as trivial for *d* < 0.20, small for *d* ranging 0.20–0.59, moderate for *d* ranging 0.60–1.19, large for *d* ranging 1.20–1.99, very large for *d* ranging 2.00–3.99 and almost perfect for *d* ≥ 4.0. MDD values were calculated based on methodologies from prior studies with diabetic populations [4,13,14].

4. RESULTS

17 individuals with T1DM were initially assessed for study eligibility. Of these, ten participants successfully completed all three randomised crossover exercise sessions. The primary reasons for exclusion were: not meeting the inclusion criteria (n=3), failure to complete all sessions (n=1), and withdrawal or other personal reasons (n=3). Table 2 presents the anthropometric, clinical and insulin delivery characteristics of the ten participants who completed the study.

- Table 2 about here -

Table 3 shows significant statistical differences ($p < 0.05$) in HR_{max} and EL across sessions. No adverse events were reported after the BWFE session. One hypoglycaemic episode (BG ≤ 70 mg/dL^{-1}) was observed in a female participant at POST-0 after the IAE session, with a BG of 70 mg/dL^{-1}.

- Table 3 about here -

BG responses showed a significant main effect for time ($\chi^2 = 24.8$, $p < 0.001$; Figure 1). A significant BG reduction occured only at POST-0 following the BWFE session (ES = 1.0; Δ = -2.2 mmol/L or 40 mg/dL), with a moderate ES. The MDD value was 2 mmol/L or 36 mmol/L. Clinically meaningful reductions were observed across all sessions. Specifically, reductions were clinically significant at POST-0 for IAE and BWFE, and at POST-20 for the STE session, compared to pre-session values.

- Figure 1 about here -

Table 4 shows acute cardiovascular responses to BWFE, IAE and STE sessions. HR had significant main effects for time ($\chi^2 = 73.3$, $p < 0.001$) and condition × time interaction ($\chi^2 = 114.1$, $p < 0.001$). HR increased at POST-0 compared to PRE for all sessions (BWFE, IAE and STE). Elevated HR was maintained at POST-20 for BWFE and STE. HR at POST-0 was higher for BWFE and STE than for IAE at POST-0 and PRE. SBP and DBP showed no significant main effects or interactions ($p > 0.05$). DP had significant main effect for time ($\chi^2 = 30.1$, $p < 0.001$) and condition × time interaction ($\chi^2 = 31.1$, $p < 0.001$). DP increased at POST-0 compared to PRE for all sessions. Elevated DP was maintained at POST-20 only for BWFE.

- Table 4 about here -

5. DISCUSSION

We investigated BG and cardiovascular responses to 30-minute moderate-intensity BWFE compared to IAE and STE in adults with T1DM. We hypothesised that BWFE would result in similar BG reductions and cardiovascular responses acutely post-exercise and would represent a safe and enjoyable alternative. Findings largely supported our hypotheses: (1) BWFE resulted in greater post-exercise BG reductions without hypoglycaemia; (2) HR, BP and DP responses were similar across sessions; (3) maximal HR was higher during BWFE, although average HR was comparable; and (4) EL was higher following BWFE compared to IAE and STE.

5.1. Blood glucose responses

While exercise types have been studied in T1DM, their impact on BG responses, especially with detailed metabolic profiles, requires further investigation. Metabolic control significantly affects glucose changes in T1DM [6,17]. Studies indicate the largest glucose drops after continuous exercise, followed by interval exercises like IAE and STE. This pattern has been observed in individuals with both well-controlled (HbA1c: 6.6 ± 0.8%) [6] and irregular (HbA1c: 8.1 ± 1.3%) [10] metabolic profiles. In our study, involving T1DM adults with irregular physical activity and metabolic control (HbA1C = 7.9 ± 1.0%), BWFE led to lower BG levels compared to IAE and STE. However, this finding contrasts with a study on T1DM adults with similar metabolic control (HbA1C = 8.1 ± 1.3%), where intensity- and duration-matched functional bodywork (exergame) and aerobic exercise showed similar BG levels at PRE, POST-0 and POST-30 [4].

The statistically significantly higher enjoyment reported during BWFE sessions (8.4 ± 1.0) compared to IAE (6.0 ± 1.0) and STE (6.2 ± 0.9) sessions may explain our findings. This increased enjoyment could have increased sympathetic nervous system activity, as indicated by the higher HR_{max} during BWFE (157 ± 17 bpm) compared to IAE (132 ± 11 bpm) and STE (147 ± 12 bpm). This sympathetic activation likely stimulated increased glycogenolysis [4,7,16,24].

Additionally, during moderate-intensity BWFE sessions, T1DM patients predominantly rely on plasma glucose for ATP resynthesis in muscle, driven by enhanced counter-regulatory responses [17,25]. These metabolic differences during BWFE likely contribute to sustained exercise capacity while minimising the risk of acute hypoglycaemia [6,10,17,26]. Consequently, no hypoglycaemic episodes were observed following the BWFE session, suggesting it as a safe exercise option for BG reduction.

5.2. Cardiovascular, enjoyment, and intensity monitoring responses

We hypothesised BWFE would lead to similar cardiovascular reductions acutely post-exercise and serve as a safe alternative to traditional exercise for adults with T1DM. Our findings showed comparable HR, SBP, DBP and DP responses across all exercise sessions. These findings align with previous crossover studies comparing functional bodywork, IAE and STE sessions in T1DM patients [4,6,7,10]. It was anticipated that adrenergic elevation during and immediately following the aerobic sessions would induce changes in HR, SBP, DBP and DP [4,25,27]. Although SBP and DBP did not show statistically significant differences over time × condition, cardiovascular adjustments were observed in HR and SBP across all sessions, with the BWFE session showing a high magnitude of response. This was also reflected by sustained higher DP values at the POST-20, well below the safety threshold of 30,000 mmHg × bpm [2]. These findings could be explained by increased catecholamine release, notably elevated in the HR and DP responses following BWFE [4,17,25].

An important observation is that while average HR stays consistent when aerobic sessions match intensity and duration, EL can increase HR_{max}, especially in T1DM patient with irregular physical activity patterns. Similar responses were observed after functional bodywork exercises (exergames) compared to IAE [4]. Additionally, using internal monitoring variables in clinical practice is beneficial, particularly for T1DM patients with inconsistent activity and metabolic control. For example, hypoglycaemia represents a significant barrier to exercise adherence. Frequent hypoglycaemic episodes can hinder patients from fully benefiting from the positive physiological responses associated with exercise [10,28].

Our 30-minute moderate-intensity exercise sessions did not require carbohydrates intake during the sessions. However, one hypoglycaemic episode occurred immediately after the aerobic session (~3.8 mmol/L or 70 mg/dL) in a female patient who used multiple insulin doses but had no bolus insulin. This required carbohydrate intake to prevent further complications. We recommend that health professionals, families and patients carefully consider exercise type and duration when prescribing exercise for T1DM patients with inconsistent activity. Special attention should be paid to aerobic exercise risks, and BG responses should be monitored.

5.3. Study limitations and practical applications

Our study has limitations to consider. First, although we used a crossover design with T1DM patients of similar characteristics, we did not measure gas exchange ratios or hormone levels (counterregulatory and adrenergic) during or after exercise. These measurements could provide further understanding into the mechanisms underlying the observed BG and cardiovascular changes [27,29]. Second, while capillary BG measurements are practical, continuous glucose monitoring would provide more detailed glucose data by tracking both acute and longer-term glucose fluctuations. Finally, our exercise prescription is a limitation. While previous studies used 12-minute and maximum repetition tests [7,10], using VO_{2max} via spirometry and 1RM tests would have strengthened our findings.

An important strength of this study is its strong external validity, achieved through research in a real-world gym setting. This approach, using aerobic, strength and functional exercises, makes the findings highly applicable to everyday situations. Furthermore, to our knowledge, this is the first study to directly compare BG, cardiovascular responses and EL following intensity- and duration-matched aerobic, strength and BWFE sessions in T1DM adults with irregular metabolic control and varying activity levels.

From a practical perspective, this study suggests exercise prescriptions for T1DM patients should consider individual preferences and enjoyment. As some T1DM individuals find traditional exercise demotivating but prefer BWFE [4], these exercises can effectively control acute BG while improving motivation and exercise adherence.

6. CONCLUSION

When aerobic, strength and body-weight functional exercise sessions are matched for intensity and duration in T1DM patients with irregular metabolic control and physical activity levels, body-weight functional exercises result in safer, lower post-exercise blood glucose levels. Cardiovascular responses are similar across the exercise types, but functional exercise is linked to higher enjoyment. Based on these findings, we strongly recommend considering exercise type-specific strategies when prescribing exercise to T1DM patients with inconsistent physical activity patterns, as these approaches may improve exercise adherence and blood glucose management.

7. ACKNOWLEDGMENTS

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Figures

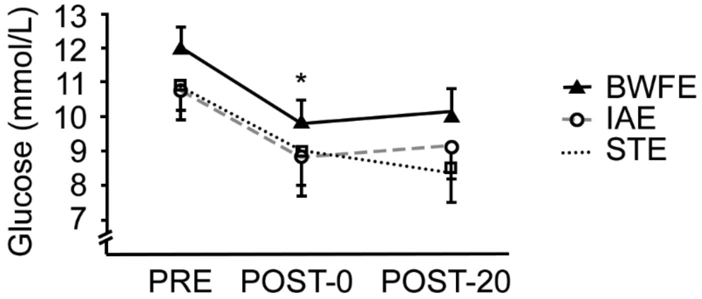


Figure 1. Acute blood glucose responses of T1DM at rest (PRE), immediately (POST-0) and 20 minutes (POST-20) after the BWFE, IAE and STE sessions (n = 10). Data expressed as mean ± standard error of the mean. *: Differed from their respective PRE values.

Tables

Table 1. Summary of exercise prescriptions.

Session	Intensity/ Duration	Load	Rest (s)	Types (exercise)
IAE	Moderate/ 30 minutes	40 and 60% VO_{2max}	60	Regular treadmill gym (walking/jogging)
STE		60% 1 RM	50 to 60	Regular strength gym exercises: bench press, leg press, biceps curl, knee extension, press shoulder, hip adduction, and abdominal on the floor exercise
BWFE		Own body weight	50 to 60	Functional and multiarticular movement exercises: Front support (chest), deep squat, triceps bench (pull), walking lunge, solo adduction, solo Superman abs (moving), and shoulder-circular lying on the floor.

IAE: Interval aerobic exercise; STE: Strength exercise; BWFE: Body weight functional exercise; RM: Repetition maximum.

Table 2. Characteristics of the participants who completed all sessions (n = 10).

		n = 10
Anthropometric	BMI (kg·m^{-2})	25.7 ± 3.8
	Skinfolds (sum)	199.0 ± 83.2
Clinical	Age (years)	32.9 ± 8.1
	Duration of T1DM (years)	9.7 ± 6.6
	HbA_{1C} (%)	7.9 ± 1.0
Insulin Delivery	Multiple daily injections (n)	10
	Continuous insulin infusion (n)	0
	Basal insulin (type)	NPH (1) and Glargine (9)
	Bolus insulin (type)	Aspart (6), Humalog (1), Apidra (2), and Regular (1)

Data expressed as mean ± standard deviation. BMI: Body mass index; HbA1C: Glycated haemoglobin; NPH: Neutral Protamine Hagedorn; Ui: Unit; A single male and female use only basal insulin.

Table 3. Intensity monitoring and descriptive variables in each session (n = 10).

	Exercises			
Intensity monitoring	BWFE	IAE	STE	*p*
HR_{max} (bpm)	157 ± 17 *	132 ± 11	147 ± 12 *	< 0.001
Average (bpm)	117 ± 12	115 ± 10	116 ± 10	0.981
EL (0-10 points)	8.4 ± 0.4* #	6.0 ± 1.0	6.2 ± 0.9	< 0.001
Descriptive data	n / un			
Bolus insulin before until 4h exercise (Ui)	2 / 4.0	0 / 0.0	2 / 3.5	-
Volunteers who need CHO		n / g		
Pre-exercise (g)	0 / 0	0 / 0	0 / 0	-
During exercise (g)	0 / 0	0 / 0	0 / 0	-
After exercise (g)	0 / 0	1 / 15	0 / 0	-
Twenty minutes after exercise	0 / 0	0 / 0	0 / 0	-
Hypoglycemia episodes after exercise (n)	0	1	0	-

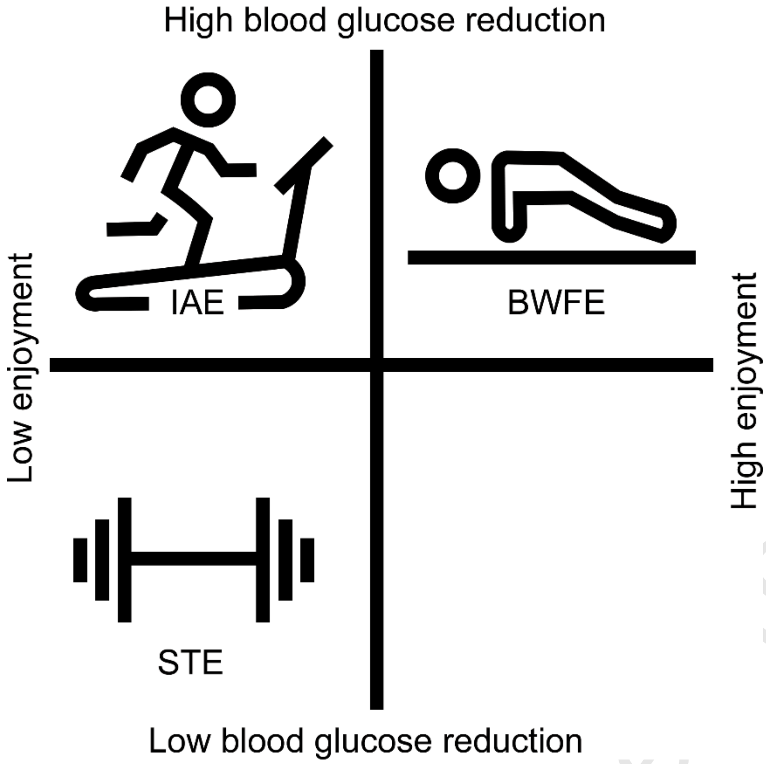
Data expressed as mean ± standard error of the mean (SE). HR_{max}: Maximal heart rate; $HR_{average}$: Average heart rate; EL: Enjoyment level; CHO: Carbohydrate; Ui: Units; IAE: Interval aerobic exercise; STE: Strength exercise; BWFE: Body-weight functional exercise. RM: Repetition maximum. * < 0.05 compared to IAE. # < 0.05 compared to STE.

Table 4. Acute cardiovascular responses before and after (post-0 and post-20 minutes) the functional, aerobic and strength sessions of T1DM patients by sex (n = 10).

Variable	Time	Exercises		
		BWFE	IAE	STE
HR (bpm)	PRE	82 (4)	83 (3)	83 (3)
	POST-0	115 (8) [a b c]	107 (5) [a b]	115 (7) [a b c]
	POST-20	98(5) [a b]	88 (3)	96 (4) [a]
SBP (mm Hg)	PRE	125 (5)	125 (5)	121 (4)
	POST-0	114 (5)	129 (5)	128 (6)
	POST-20	116 (4)	121 (6)	124 (6)
DBP (mm Hg)	PRE	83 (3)	84(2)	82 (1)
	POST-0	79 (2)	84 (3)	78 (2)
	POST-20	81 (3)	84 (3)	79 (2)
DP (mm Hg × bpm)	PRE	9212 (491)	10317 (536)	10093 (646)
	POST-0	14551 (1325)[a b]	13793 (962)[a b]	14843 (1330)[a b]
	POST-20	11346 (705)[a]	10647 (705)	11906 (674)

Data expressed as mean ± standard error of the mean (SE). [a] Difference from PRE session; [b] Difference from the other sessions at PRE moment; [c] Difference from POST-0 for the IAE sessions.

GRAPHICAL ABSTRACT



HIGHLIGHTS

1- Body-weight functional exercise sessions lead to greater and safer reductions in post-exercise glucose levels.

2- Cardiovascular responses are similar across exercise types, but the body-weight functional sessions are more enjoyable.

3- Tailored exercise recommendations may be beneficial for individuals with type-1 diabetes.

CRediT Author Statement

PS: Conceptualisation, Formal analysis, Investigation, Methodology, Validation, Visualization, Writing – review and editing

FMA: Formal analysis, Resources, Methodology, Project administration, Writing – original draft

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