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ORIGINAL

Acute hypoglycemic and hypotensive effect of continuous and intermittent aerobic exercise in patients with type 2 diabetes

Efecto hipoglucemiante e hipotensor agudo del ejercicio aeróbico continuo e intermitente en pacientes con diabetes tipo 2

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Abstract

Objectives: Different modes of exercise could bring diverse acute responses. This study aimed to investigate the acute hypoglycemic and hypotensive effect to continuous and intermittent aerobic exercise in patients with type 2 diabetes (T2DM).
Methods: This study included one session of continuous jogging, one session of intermittent fast running, and one time of rest, which was defined as continuous group, intermittent group and control group respectively. The experiments were randomly carried out in three days with an interval of at least 72 hours between each two experimental days. Fifteen patients participated in a bout of 2 km continuous jogging, 2 km intermittent fast running, or no exercise (control) on three days with an interval of 72 h or more. Blood glucose, blood pressure (BP), and Physical Activity Enjoyment Scale (PACES) were measured.
Results: All the participants completed the study with no adverse event. Blood glucose was significant lower at post in two exercise groups ($p < 0.05$) and at 2 h post intermittent exercise than in control. Continuous and intermittent exercise significantly reduced systolic BP (by ~ 4.27 and 13.27 mmHg) and diastolic BP (by ~5.40 and 1.07 mmHg) ($p \leq 0.001$). Whereas, only intermittent exercise brought remarkably smaller pulse pressure (dropped by ~12.20 mmHg). Additionally, intermittent exercise yielded higher PACES score ($p < 0.01$).
Conclusions: Intermittent aerobic exercise produces slightly stronger acute hypoglycemic and remarkably stronger hypotensive effect than continuous exercise in patients with T2DM. Together with the better enjoyment feelings, intermittent exercise is worth to be recommended for patients with T2DM.

Key words: Blood glucose, blood pressure, aerobic exercise, type 2 diabetes.

Resumen

Objetivos: Los diferentes modos de ejercicio pueden aportar diversas respuestas agudas. Este estudio tiene como objetivo investigar el efecto hipoglucémico e hipotensor agudo al ejercicio aeróbico continuo e intermitente en pacientes con diabetes tipo 2 (T2DM).
Métodos: Este estudio incluyó una sesión de trote continuo, una sesión de carrera rápida intermitente y un tiempo de descanso, que se definieron como grupo continuo, grupo intermitente y grupo control respectivamente. Los experimentos se realizaron aleatoriamente en tres días con un intervalo de al menos 72 horas entre cada dos días experimentales. Quince pacientes participaron en una tanda de 2 km de trote continuo, 2 km de carrera rápida intermitente o ningún ejercicio (control) en tres días con un intervalo de 72 h o más. Se midieron la glucosa en sangre, la presión arterial (PA) y la escala de disfrute de la actividad física (PACES).
Resultados: Todos los participantes completaron el estudio sin ningún evento adverso. La glucosa en sangre fue significativamente más baja en los dos grupos de ejercicio ($p < 0,05$) y a las 2 h del ejercicio intermitente que en el control. El ejercicio continuo e intermitente redujo significativamente la PA sistólica (en ~ 4,27 y 13,27 mmHg) y la PA diastólica (en ~ 5,40 y 1,07 mmHg) ($p \leq 0,001$). En cambio, sólo el ejercicio intermitente aportó una presión de pulso notablemente menor (se redujo en ~12,20 mmHg). Además, el ejercicio intermitente produjo una mayor puntuación de PACES ($p < 0,01$).
Conclusiones: El ejercicio aeróbico intermitente produce un efecto hipoglucemiante agudo ligeramente más fuerte y un efecto hipotensor notablemente más fuerte que el ejercicio continuo en pacientes con DMT2. Junto con la mejor sensación de disfrute, el ejercicio intermitente merece ser recomendado para los pacientes con DMT2.

Palabras clave: Glucemia, presión arterial, ejercicio aeróbico, diabetes tipo 2.

Introduction

Type 2 diabetes is a metabolic disorder characterized by chronic hyperglycemia caused by insulin secretion defects and/or insulin resistance, which has become one the most pressing and prevalent issue of worldwide. The deteriorating glycemic control lead to adverse heath outcomes and multisystem complications[1], including impairments with cardiovascular system. The presence of diabetes increases the mortality risk from cardiovascular diseases (CVDs) across different ethnicity groups and sex[2].

As one of the basic therapies for T2DM, exercise can improve glycemic metabolism, confer wide-ranging health benefits, and delay the progress of disease. However, the optimal exercise style, intensity and duration, etc. were not fully discovered. Traditionally recommended exercise approaches usually include low to moderate intensity sustained physical activity. Continuous aerobic exercise is proven to be able to reduce blood glucose, decrease blood pressure, and improve lipid profile by increasing heat consumption, elevating muscle glycogen content, regulating neuroendocrine and reducing insulin resistance[3-5]. However, recent research has shown that high-intensity interval training (HIIT) can promote improvements in glucose control and cardiovascular health in individuals with T2DM[6]. Compared with continuous exercise, there are studies demonstrating that intermittent aerobic exercise has better effect in improving body composition, blood glucose and energy consumption and oxygen consumption[7-9]. Studies have found that intermittent fast running can quickly improve glucose metabolism and prolong insulin sensitivity6. Meanwhile, it positively affects the metabolic system of patients and improve their cardiopulmonary adaptability[10].

Studies on intermittent exercise applied in T2DM treatment so far at present are insufficient, and only couple of studies compared the acute effect of intermittent and continuous exercises on glycometabolism and associated parameters in patients with T2DM. Santiago et al. examined the acute glycemia and pressure response of continuous and interval aerobic exercise in patients with T2DM[11]. However, some limitations make further studies are still necessary. Firstly, the subjects in Santiggo et al's study had a eight-week pre-training, thereby they were slightly trained instead of sedentary. The responses may be different in these people. Secondly, the study lack a control group (no exercise) which made it hard to differentiate the effects of exercise. Thirdly, the observation of glycemia was limited to 30 minutes after the end of exercise and longer time response was missed. Additionally, although pulse pressure has been shown to be an important predictor, better than systolic blood pressure, for the risk of CVDs in diabetes[12,13], it was missing in Santiggo's study.

The main purpose of the present study is to explore the acute hypoglycemic and hypotensive effect of continuous and intermittent aerobic exercise in patients with T2DM. Clarifying the role of single exercise in regulating blood glucose and blood pressure will help to enhance patients' confidence about the benefits of exercise to the health outcome and be helpful for appropriate, efficient and safe exercise prescription.

Material and methods

Subjects

Patients with T2DM in Department of Endocrinology at the Second People's Hospital of Changshu were recruited through convenience sampling. All participants were screened based on their health history and the American College of Sports Medicine guidelines to ensure their suitability and safety in participating exercise. Eligible participants were 18 to 65 years old and met the diagnostic criteria of T2DM in Guideline for Preventions and Treatment of Type 2 Diabetes in China (2013 Edition)[14]. Exclusion criteria include the patients who had any underlying complications unsuitable for exercise or could not tolerate moderate intensity exercise, including but not limiting to the diseases of heart, vascular, brain, kidney, eye, foot, nervous system, and malignant tumor; who had rest heart rate > 120 beats/min, rest blood pressure > 160/100 mmHg, or fasting blood glucose >16.7 mmol/L[15].

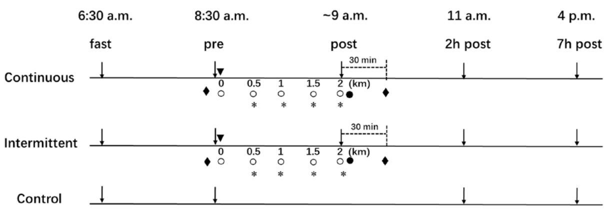
Fifteen qualified patients participated in this study. The study protocol was reviewed and approved by the Medical Ethics Committee of the Second People's Hospital of Changshu, and conducted in compliance with the guidelines stated in the World Medical Association (WMA) Declaration of Helsinki. All patients were fully informed orally and in writing of the nature of the study as well as the possible risks, and signed the informed consent.

Research design and procedure

This study included one session of continuous jogging, one session of intermittent fast running, and one time of rest, which was defined as continuous group, intermittent group and control group respectively. The experiments were randomly carried out in three days with an interval of at least 72 hours between each two experimental days. The experiment orders were defined as the following four kinds: 1. control—continuous—intermittent 2. control—intermittent—continuous 3. continuous—intermittent—control 4. intermittent—continuous—control. Four lots of each order were prepared and the subjects decided the experimental order by drawing lots. In the continuous and intermittent groups, patients had continuous and intermittent exercise respectively and in the control group the patients did not do any exercise training and maintain their usual daily activities.

All patients accepted the measurements of fasting blood glucose at fast (6.30 a.m.), and thereafter had the identical breakfast delivered by the Nutrition Department of the hospital. During the exercise day, the patients start to exercise at 8:30 a.m. Patients' blood glucose, the rate of perceived exertion (RPE), heart rate (HR), blood pressure (BP) and Physical Activity Enjoyment Scale (PACES) were measured at different time points. The measurement time points for each parameter were presented in **figure 1**.

Figure 1: Detection time points of each parameter.↓: blood glucose, ▼:: exercise start, ◆: blood pressure, ❍: heart rate, *: RPE, ●: Physical Activity Enjoyment Scale.



Exercise intervention

At 6 days before the first formal test day, the patients were asked to do 500 m running exercise once a day for 3 days as adaptational training. The running time and speed were not strictly prescribed, and it was specified that patients should keep their rating of perceived exertion (RPE) within 12~15 and the exercise should not bring over fatigue. In the 3 days before the first formal test, patients were required to rest without specially prescribed exercise.

For the formal test, the patients in the continuous group were required to continuously jog at a speed close to or reach a moderate degree of rating of perceived exertion (RPE) 12~15. According to the results of the pre-trial test, the exercise speed was set at 4-6 km/h, and the exercise time was expected to be 20-30 min. The patients were instructed to finish the jogging in the continuous exercise session and avoid fast walking.

In the intermittent exercise session, patients were required to run at a preset speed of 6-8 km/h for 3 minutes and rested for 4 minutes and then completed the whole exercise process following this pattern. The total running time for the intermittent group was expected to be 15-20 minutes, and the total rest time 9-12 minutes, with a total experiment time being 24-32 minutes.

Research scientists were responsible for supervise exercise sessions. For the subjects whose jogging or running speed out of the specified range, they were reminded to speed up or down to meet the requirement. Both continuous and intermittent exercise sessions included warm-up and cool-down period. The warm-up consisted of 5 min of jogging and gentle stretching and the cool-down consisted of 5 min of walking and gentle stretching. Patients were asked to put on their jogging shoes and cotton socks during exercise. In the 2 h before exercise, patients were encouraged to consume 400~500 ml water to ensure the adequate hydration.

Measurements

Subjects' basic information, including age, sex, BMI, course of disease, and complication were asked or measured and recorded. Some blood biochemical indexes, were recorded from patients' current hospitalization medical record.

In the two exercise groups, patients put on a polar heart rate meter (FR1, Boneng company, Finnish) during exercise to continuously monitor the heart rate. The heart rate before exercise (HR-0), at 0.5 km (HR-0.5), 1 km (HR-1.0), 1.5 km (HR-1.5) and 2 km (HR-2.0) during exercise were recorded. Meanwhile, Borg rating of perceived exertion (RPE) was evaluated at every 500 m, thus the RPE scores at 0.5 km (RPE-0.5), 1 km (RPE-1.0), 1.5 km (RPE-1.5) and 2 km (RPE-2.0) were recorded respectively.

Fingertip blood glucose was tested in fast state (~6.30 a.m.), immediately before (pre, at 8.30 a.m.) and after exercise (post, ~9.10 a.m.), 2h and 7h post exercise (at ~11:00 a.m. and 4:00 p.m.). Blood glucose was detected by Ritter blood glucose meter (glucose peroxidase method, GM300, Daqing plant of Huaguang Biotechnology Co., Ltd., China) and corresponding reagent strips.

Blood pressure was measured before exercise (BP-0) and 30 minutes after exercise (BP-30) on left upper limb in supine position. Pulse pressure was calculated by systolic and diastolic blood pressure.

After exercise finished, patients were asked to fill in the PACES scores according to their own feelings. The PACES contains 18 items and each item is divided into 7 levels with a total score of 126. The higher the total score means the higher acceptance of the physical activity.

Safety consideration

Before exercise, the researchers provided exercise education for the patients, and helped to check the feet, shoes and socks of the patients. During exercise, all patients and researchers carried candy in case of hypoglycemia and water was accessible all the time. When the patient has dizziness, nausea, palpitations, chest pain and other discomfort, or the patient's self-reported exercise is beyond the tolerance range, extremely tired, unable or unwilling to continue exercise, the exercise would be stopped immediately. Medical doctors and nurses were responsible for supervise one-to-one the whole exercise process. The heath history investigation during screening, and the HR, RPE and BP monitored during exercise also ensure the safety.

Statistical analysis

Data were analyzed using SPSS 22.0 software (IBM, NY). Descriptive data are presented as mean ± standard deviation (SD). Differences of blood glucose at different time points among the three groups were analyzed using two factor repeated measurement analysis of variance, when needed, the Bonferroni *post hoc* was used. Paired t test was used to compare the difference of exercise execution, RPE, HR, blood pressure and PACES scores at the same monitoring points between the two exercise sessions. One way ANOVA was used to compare the differences of HR and RPE among different monitoring points in the exercise groups. If the data does not conform to the normal distribution, nonparametric test is used. $P < 0.05$ showed that the difference was statistically significant.

Results

1. General characteristics of subjects

Anthropometric and physiologic characteristics of the study patients (n = 15) are outlined in **table I**. In the 15 subjects (11 males, 4 females), 6 had hypertension, 1 fatty liver, 2 hepatitis B and 1 gastritis. All patients were treated with insulin, and 9 of them took additional oral hypoglycemic drugs.

Table I: Study population characteristics.

Variable	Mean ± SD	Range
Age (years)	48.87 ± 6.77	33-56
Body weight (kg)	72.07 ± 13.57	50-103
Height (cm)	167.53 ± 9.65	150-183
BMI (kg/m²)	25.33 ± 3.22	22-34
Course of disease (years)	5.53 ± 4.52	1-14
Glycosylated hemoglobin (%)	9.03 ± 2.65	5.1-16.4
C-peptide (ng/ml)	2.40 ± 1.05	1-4.82
Insulin (ng/ml)	6.64 ± 4.49	0.91-18.41
Triglyceride (mmol/L)	2.47 ± 2.57	0.75-11.1
Cholesterol (mmol/L)	4.76 ± 1.37	2.11-6.68

Values are mean ± SD

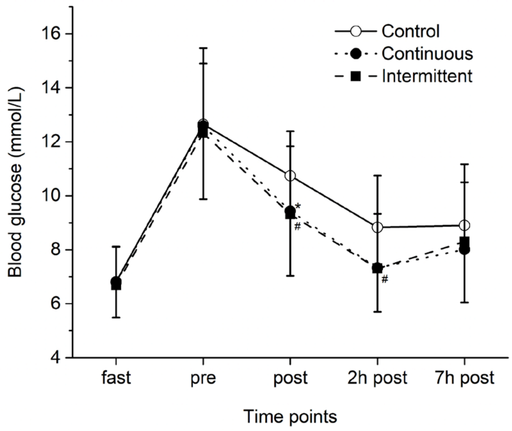
2. Exercise execution data and physical response of HR and RPE

There was no hypoglycemia (blood glucose < 3.9mmol/l) happened in the two groups at each time point in this study.

Patients in both exercise sessions finished a 2-km distance running or jogging. The speed in the intermittent group (7.25 ± 0.67 km/h) was significantly larger than that in the continuous group (6.06 ± 0.50 km/h) ($P < 0.001$). The running time was 19.53 ± 1.81 min and 16.40 ± 1.35 min in continuous and intermittent groups respectively and there was an additional intermittent rest time of 10.40 ± 1.55 min in the latter.

Heart rate of the patients during continuous and intermittent exercise were presented in **Figure 2**. There was no significant difference in the baseline heart rate (HR-0) between two exercise groups ($P > 0.05$). However, the heart rate during the whole period of exercise was significantly higher in the intermittent group than those in the continuous group ($P < 0.01$). Intra-group comparison showed, compared with HR-0, significantly higher HR-0.5, HR-1.0, HR-1.5 and HR-2.0 were found in both exercise groups (P < 0.01), whereas no significant difference among HR-0.5, HR-1.0, HR-1.5 and HR-2.0 in either group (P > 0.05) (**Figure 2**).

Figure 2: Blood glucose levels at different time points in the three experimental groups,x̄±S. *: continuous group compared with control group, $P< 0.05$; #: intermittent group compared with control group, $P< 0.05$. To avoid confusion, the significance of intra-group comparison in each group were not marked.



Percentage of maximal heart rate (HRmax) which equals to (220-age) was calculated, and the values during continuous exercise session were more than 70% and during intermittent exercise more than 80% (**Table II**).

Table II: $\%HR_{max}$ at different time points of two exercise groups (%).

	Continuous group	Intermittent group	*t*	*P*
%HRmax-0	45.2 ± 3.7	45.6 ± 3.7	-1.580	0.136
%HRmax-0.5	71.6 ± 3.3	80.8 ± 3.7**	-12.198	<0.001
%HRmax-1.0	72.9 ± 3.4	81.4 ± 3.7**	-10.563	<0.001
%HRmax-1.5	73.4 ± 3.8	81.9 ± 3.8**	-10.975	<0.001
%HRmax-2.0	73.7 ± 3.8	82.5 ± 3.6**	-16.793	<0.001

**: compared with Continuous group, $P< 0.001$

There was no significant difference with RPE between the two exercise groups except for the larger RPE-0.5 in the intermittent group than that of continuous group ($P < 0.01$). Intra-group comparison, RPE increased with the extension of exercise time in both exercise groups, and the score at each time point was significantly higher than the previous one ($P < 0.01$) (**Table III**).

Table III: RPE scores during exercise in two exercise groups (points).

	Continuous group	Intermittent group	*t*	*P*
RPE-0.5	11.00 ± 1.00	12.73 ± 1.10**	-3.926	<0.001
RPE-1.0	13.73 ± 1.94	13.93 ± 1.62	-0.276	0.787
RPE-1.5	14.93 ± 2.12	15.00 ± 1.81	-0.098	0.923
RPE-2.0	16.87 ± 1.13	17.07 ± 1.03	-0.494	0.629

**: compared with Continuous group, $P< 0.001$.

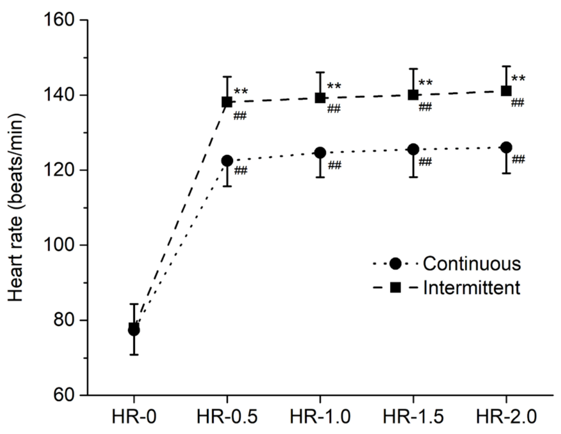
3. Blood glucose

The exercise x time interaction (P = 0.311) was not existed. Therefore, main effect of exercise and time were analyzed respectively. There was a significant main effect of exercise (P = 0.027) and of time (P < 0.001).

Pairwise comparison results showed that the intermittent exercise caused slightly lower blood glucose from control which close to be significant (P = 0.085), whereas the continuous exercise did not (P = 0.132). There was no significant difference of fasting, pre and 7h post blood glucose among the three groups (all P > 0.05); the post blood glucose of the two exercise groups was significantly lower than that of the control group (P =0.033 and 0.012, respectively); the 2h post blood glucose of the intermittent group was significantly lower than that of the control group (P = 0.040) (**Figure 3**).

Intra-group pairwise comparison found that blood glucose at pre and post were significantly increased compared with fasting blood glucose in all three groups (P < 0.01); 2h and 7h post blood glucose in the control group were significantly higher than fasting blood glucose (P < 0.01, P < 0.05); the 2h post blood glucose of continuous group and 7h post blood glucose of intermittent group were significantly higher than fasting blood glucose (P <0.05) (**Figure 3**).

Figure 3: HR at different time points of two exercise groups,$\bar{x}$±S. **: compared with continuous group, P< 0.01; ##: compared with HR-0 of the corresponding group, P< 0.01.



4. Blood pressure

Both SBP and DBP decreased significantly at 30 min after the exercise in two groups. SBP at 30 min (SBP-30) after intermittent group was lower than that of continuous group (P < 0.01), while DBP-30 was higher (P < 0.01). The pulse pressure became significantly smaller in intermittent group (dropped by ~12.20 mmHg, P < 0.01), whereas had no change in continuous group (**Table IV**).

5. PACES

PACES scores in the continuous and intermittent groups were 81.4 ± 1.84 and 92.7 ± 1.62 respectively and the latter was significantly higher than the former (P < 0.001).

Discussion

In this study, acute reduction response of glycemia and blood pressure to two different modes of exercise, continuous jogging and intermittent fast running, in patients with T2DM were explored. The results found that both continuous and intermittent aerobic exercise significantly decreased blood glucose and systolic and diastolic blood pressure levels. Moreover, intermittent exercise caused remarkably smaller pulse pressure whereas continuous exercise did not.

During exercise execution, the heart rate immediately after exercise in the continuous jogging group (73.7% ± 8.0% of HR_{max}) and the intermittent fast running group (82.5% ± 6.0% of HR_{max}) demonstrated that the exercise has reached moderate and high intensity respectively. RPE gradually increased with the extension of exercise time. Except for the higher value in intermittent exercise when running to 0.5 km, no difference in RPE scores between the two groups in the later period, suggesting that intermittent aerobic exercise did not lead to increased subjective exertion in the case of higher intensity. Through communication with patients, we learned that patients felt more difficult in the early stage of intermittent exercise because of the faster speed. However, in the middle and late stage during the continuous jogging, fatigue continued to increase, and some patients felt difficult to complete the prescribed distance without encouragement, whereas in the intermittent exercise, due to recovery of physical vigor after a short rest period, subject felt easier to complete the whole distance. Guiraud et al.[16] showed that, when healthy young people were trained with intermittent exercise and continuous exercise with same energy consumption, the RPE score during the intermittent exercise was lower, and it was easier to accept this kind of exercise. Although there was no significant difference in the final RPE score in this study, from communication

Table IV: BP before and 30 minutes after exercise in two exercise groups (mmHg)

	SBP-0	SBP-30	DBP-0	DBP-30	Pulse pressure-0	Pulse-pressure-30
Continuous	125.6±10.82	120.2±10.06#	75.3±8.61	71.0±7.96#	50.33±12.32	49.20±11.39
Intermittent	125.7±8.42	112.5±9.33#**	75.5±8.96	74.5±9.01#**	50.20±9.63	38.00±10.64##**
T(Z)	-0.081	4.864	-0.647	-3.344		
P	0.937	< 0.001	0.518	0.001		

#, ##: compared with the corresponding value before exercise, P < 0.05 and < 0.001.
**: compared with the corresponding value at the Continuous group, P < 0.001.

with patients, we know that intermittent fast running was easier to complete than continuous jogging.

The study found that, with similar blood glucose at fasting and pre-exercise in the three groups, no difference in blood glucose in the each time point post exercise between the continuous jogging and the intermittent fast running groups, suggesting that the transient regulatory effects of two kinds of exercise on blood glucose were similar. Entin et al.[17] pointed out that, when exercise intensity exceeds 60% $VO2_{max}$, sugar is the main energy material of skeletal muscle. According to the correlation between oxygen uptake volume and percentage of maximum heart rate[18], it is concluded that the exercise intensity in continuous jogging and intermittent fast running (~71.6-82.5%, except for the rest intervals) is above 60% $VO2_{max}$. The same exercise volume (2 km of distance) may be the main reason contributing to the similar hypoglycemic effect. Chao et al.[19] found no difference in fasting blood glucose, glycosylated hemoglobin, and lipid profile after the continuous jogging and the intermittent fast running aerobic exercise intervention for 12 weeks in 45 patients with T2DM. Our results showed that the blood glucose changes after a single continuous jog and intermittent fast run were similar, which is consistent with results from Santiago et al[11].

However, intermittent exercise caused slightly lower blood glucose from control, whereas the continuous exercise did not, and blood glucose at 2h post in the intermittent group instead of in the continuous group was significantly lower than that in the control group. These results suggested that intermittent exercise might had more pronounced influence on blood glucose in couple of hours post exercise. Previous research found that intermittent fast running causes increased energy consumption not only during exercise, but also after exercise, whereas continuous exercise has no such effect[20]. This may account for the lower blood glucose level found in intermittent group in this study. There was no significant difference in 7h post blood glucose level among the three groups, suggesting that the regulatory effect of single acute exercise on blood glucose in patients with T2DM may last for only short time (probably couple of hours).

One of the widely recognized important risk for CVDs in patients with T2DM is hypertension[12]. Our result found that, at 30 minutes after 2km exercise training, systolic and diastolic blood pressure levels were significantly lower than before exercise in both exercise groups. This is consistent with the existing study which has proved that a single acute exercise can reduce the systolic and diastolic blood pressure of patients with hypertension after exercise[11,21]. In this study, we observed that a much remarkable systolic blood pressure reduction in the intermittent group while a slightly less reduction of diastolic blood pressure than continuous group, demonstrating that two modes of exercise lead to different hemodynamics and neural regulation. Additionally, pulse pressure became significantly smaller following intermittent exercise instead of continuous exercise. Ramírez-Vélez found that single intermittent exercise and continuous exercise with the same amount can improve the elasticity of arterial blood vessels and vascular function parameters, while intermittent exercise has a stronger effect[22]. This may be the reason for the greater reduction of systolic blood pressure and the significantly smaller pulse pressure after intermittent exercise. The reduction of blood pressure after a single exercise suggests that repeated regular exercise is likely to produce antihypertensive or other cardiovascular improvement effects in such patients and the intermittent exercise has superior effects in this aspect than continuous exercise. More studies are needed to confirm the conclusion.

PACES score, as a secondary observation, was found to be larger after intermittent fast running than after continuous jogging, demonstrating that patients were more willing to engage in intermittent exercise. This is consistent with the conclusion from Bartlett et al[23]. The running time in intermittent exercise time is short, and the rest time is a buffer period, which helps to relieve runner's difficult feeling, increase exercise interest and improve exercise compliance[24]. The combination of rest and exercise is more relaxed and lead to less psychological pressure, brings more enthusiasm for exercise participants to join in exercise and persist[25]. The long running time during continuous jogging causes some patients' lack of confidence to finish the whole process and little pleasure of exercise. There was no hypoglycemia (blood glucose < 3.9mmol/l) happened in the two groups at each time point in this study. However, due to the small sample size, the safety of patients with T2DM needs to be further confirmed with larger sample size.

Conclusions

The more significantly reduced blood glucose, remarkably decreased systolic blood pressure and significantly smaller pulse pressure prove that the intermittent aerobic exercise produces slightly stronger acute hypoglycemic and remarkably stronger hypotensive effect than continuous exercise in patients with T2DM. Together with the better enjoyment feelings, intermittent exercise is worth to be recommended for patients with T2DM. Our result has major implications for the practice of diabetes education in clinical rehabilitation. Patients can easily adopt the exercise method in this study making it possible to start exercise and continue exercise in their daily life.

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Interests conflict

The authors declare that they have no conflict of interest.

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