Effects of intensity exercise on cardiorespiratory, autonomic function, metabolism and blood glucose in female with central obesity

Efectos de la intensidad del ejercicio en los sistemas cardiorrespiratorio y autónomo, metabolismo y glucemia en mujeres con obesidad abdominal

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Abstract

Introduction: Exercise is an activity that support for prevention and habitation of the body from central obesity. But people who have sedentary behaviors, there is more often a more than normal activity people accumulation of fat in the body. Interesting to see what causes those who exercise regularly, but still have central obesity.
Objective: To investigate the effect of intensity of exercise on cardiorespiratory, autonomic nervous system, metabolism and blood glucose responses in central obesity.
Methodology: Trained group have regular exercise (n=9) and Sedentary group (n=9). Waist circumferences > 80 cm or waist/hip > 0.85 were included, both groups need to perform graded cycling exercise test to determine actual fat and carbohydrate oxidation. Fasting blood glucose (FBG), pulmonary function and autonomic nervous system were compared between groups.
Results: The FBG at resting had strong negative correlation between carbohydrate oxidation during exercise at moderate-intensity ($r = –0.823$, $p = 0.006$) in Trained group while no correlation between fat oxidations.
Discussion: At moderated to high-intensity that uses carbohydrate more than fat. These studies showed that high-intensity uses carbohydrates. We found negative correlations between carbohydrate oxidation and FBG in the Trained group. Previous studies show an association about glucose tolerance impairment and elevation in the postprandial insulin excursion.
Conclusions: At moderate intensity, carbohydrate oxidation had negative correlation with FBG in Trained group. We suggest the best in tensity to improve fat oxidation is low-intensity and carbohydrate oxidation is high-intensity and should be more exercise pattern.

Keywords

Substrates oxidation; heart rate variability; blood glucose; pulmonary function.

Resumen

Introducción: Hacer ejercicio previene y controla la obesidad abdominal. Las personas con hábitos sedentarios acumulan grasa corporal, en comparación con otras físicamente activas. Es interesante analizar las causas de obesidad abdominal entre quienes practican deporte.
Objetivo: Investigar los efectos de la intensidad del ejercicio sobre los sistemas cardiorrespiratorio y nervioso autónomo, el metabolismo y la respuesta de la glucemia en personas con obesidad abdominal.
Metodología: Grupo Activo, ejercicio regular, (n=9) y grupo Sedentario (n=9). Se incluyó personas de cintura > 80 cm o con relación cintura/cadera > 0.85. Ambos grupos se sometieron a una prueba graduada de bicicleta para determinar la oxidación real de grasas y carbohidratos. Se realizó una comparación de la glucemia en ayunas, la función pulmonar y el sistema nervioso autónomo.
Resultados: La glucemia, en ayunas y reposo, mostró una correlación negativa con la oxidación de carbohidratos con ejercicio moderado ($r = –0.823$, $p = 0.006$) en los Activos, mientras que no hubo correlación con la oxidación de grasas.
Discusión: A intensidad moderada a alta, donde se consumen más carbohidratos que grasas, estos estudios demostraron que la alta intensidad utilizó más carbohidratos. Se hallaron correlaciones negativas entre la oxidación de carbohidratos y la glucemia en los Activos. Estudios previos indican una asociación entre intolerancia a la glucosa y aumento de insulina postprandial.
Conclusiones: A intensidad moderada, la oxidación de carbohidratos mostró una correlación negativa con la glucemia entre los Activos. Sugerimos que la mejor intensidad para la oxidación de grasas es baja, mientras que para la oxidación de carbohidratos es alta con patrón de ejercicios variados.

Palabras clave

Función pulmonar; glucemia; oxidación de sustratos; variación del ritmo cardíaco.

Introduction

The health security of Thai people today is quite reduced. It has been observed from the situation and prevailing that the trend of metabolic syndrome is increasing. A survey found that 28–50% of Thai people of working age have metabolic syndrome (Aekplakorn et al., 2021). It is considered an important health problem in which central obesity and insulin resistance are the main pathophysiology of metabolic syndrome (Kassi et al., 2011).

In addition, genetic and environmental factors include eating a high-energy diet, especially the pattern of carbohydrate-based foods (Aekplakorn et al., 2015), and low physical activity (sedentary behavior). This leads to an increase in the build-up of visceral fat within the abdominal cavity. There is evidence that fat accumulates in various organs of the body. Moreover, previous studies have found patients with this metabolic syndrome. There is also an unbalanced function of the autonomic nervous system. It has increased sympathetic nervous system activity and decreased parasympathetic nervous system activity (Koskinen et al., 2009), affecting abnormal functioning of the autonomic nervous system of the body. The case imbalance of the nervous system results in higher blood pressure. The performance and functions of the heart and circulatory system, also known as the cardiorespiratory system, are declining.

Physical exercise is a planned, repetitive, and purposeful activity of the body that is meant to improve or maintain health and fitness. While sedentary behavior or physical inactivity, includes sitting, lying down for long periods of time, or doing activities in low energy (< 1.5 METs), it worse metabolic health and a higher risk of obesity. The World Health Organization (WHO) divides levels of physical activity into three groups, including light (less than 3 METs), moderate (3–5.9 METs), and high (6 METs or more) (WHO, 2018). Each level causes different changes in the metabolism and physiology. WHO guidelines in 2020 change their suggestions. According to the WHO Global Action Plan on Physical Exercise 2018–2030, adults should have 150–300 minutes of moderate-intensity physical exercise or 75–150 minutes of high-intensity physical activity per week (WHO, 2018; Bull et al., 2020). Regular participation in moderate to high physical activity improves cardiorespiratory function, autonomic (heart rate variability: HRV) control (Speer et al., 2019; Goit et al., 2014), and carbohydrate (glucose) metabolism (Silva et al., 2024), while reducing the negative effects of central obesity.

Exercise is an activity that supports the prevention and rehabilitation of the body from abdominal obesity (central obesity). In people with sedentary behavior, there is more often a more than normal accumulation of fat in the body. But it is interesting to see what causes those who exercise regularly but still have central obesity. Therefore, this research focuses on the effect of intensity of exercise on cardiorespiratory, autonomic nervous system, metabolism and blood glucose responses in central obesity. We aim to determine the suitable exercise intensity for both sedentary participants and trained individuals with central obesity.

Method

Participants

The sample size were 18 participants, we divided the participants into two groups including Trained group: n = 9 and Sedentary n = 9 calculated by G*Power 3.1 (Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany) based on a Soltani et al., (2021) effect size = 1.49, with power = 0.80 and $\alpha = 0.05$. All participants were verbally and in writing informed about the study before signing a consent form. This study was approved by the Ethical Committee of Walailak University in accordance with the 1964 Declaration of Helsinki (WU-EC-MD-1-037-67).

Procedure

According to a physical activity questionnaire, the trained group engaged in regular exercise for three months in a row, averaging over 150 minutes per week. Women between the ages of 20 and 40 were eligible because this age range avoids confounding variables related to adolescence and the perimenopausal transition and reflects relatively stable hormonal and metabolic profiles (Lovejoy et al., 2008; Leeners et al., 2017). Women of reproductive age are also represented in this age group, and central obesity is particularly common and clinically significant among them (Lovejoy et al., 2008). The study included participants who did not have any chronic illnesses (Oppert et al., 2021; Zhang et al., 2024).

Instrument

Screening: Before the experiment, all participants were receiving a routine medical examination, which includes medical history, physical activity questionnaire by the 2011 Compendium of Physical Activities, which gives standardized codes and MET values to a wide variety of activities, was used to measure physical activity (Ainsworth et al., 2011). Kilocalories = MET × body weight (kg) × duration (hours) was the formula used to calculate energy expenditure, physical measurement (blood pressure and heart rate), anthropometric measurement (waist circumferences: WC > 80 cm or WC/ hip circumferences: HC > 0.85). Height, body mass and body fat distribution (body fat percentage, was measured using dual-energy X-ray absorptiometry (DXA). During the testing period and pre-testing meals (Visit 1-2), participants were asked to eat their usual diet, meaning they ate the foods they were used to eating in their daily lives, to keep their bodies in balance before the test. All participants were free of chronic illnesses, were eligible to participate. Having a chronic illness, smoking, abusing alcohol, or taking any medications that might impair cardiovascular, autonomic, or metabolic function were all grounds for exclusion.

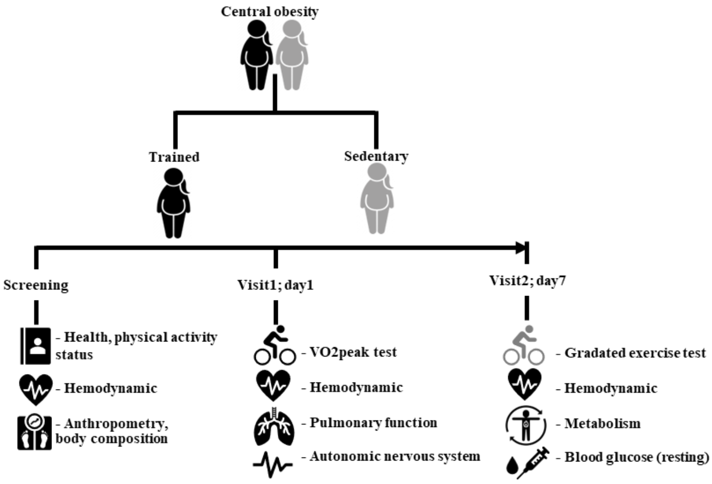
Visit 1: After arrival laboratory (participant fasting more than 8 hours), all participants rest in sitting position until heart rate (HR) and blood pressure (BP) were stable. After that their recorded HR 5 min for calculate HRV (Kubios HRV Standard) frequency-domain HRV indices were calculated as follows: low frequency (LF, 0.04–0.15 Hz), high frequency (HF, 0.15–0.40 Hz), and the LF/HF ratio. Time-domain indices included SDNN (ms) and rMSSD (ms), pulmonary function was assessed by Lungtest system, MES, Cracow, Poland. The $\dot{V}O_2$peak assuagement using a gas analyzer (VO2max Tracker Ergospirometer, MES, Cracow, Poland) following by performing 3 mins incremental exercise on the cycle ergometer (Monrk Ergomedic 828 E, Sweden) until 85 % HRmax or exhaustion indicating by rating of perceived exertion (RPE) exercise intensity was assessed using Borg's 6–20 RPE scale, where 6 indicates no exertion and 20 maximal exertion (Borg, 1982). An RPE ≥ 18 represented very high exertion, could not keep speed at 60 revolutions per minute. Throughout this visit, expired gas samples were obtained by the gas analyzer to determine $\dot{V}O_2$.

Visit 2: A week later, after arrival laboratory (participant fasting more than 8 hours) and rest in siting position until HR and BP were within normal resting values and blood glucose test by Accu-Chek Instant, Roche Diabetes Care, Inc., Germany. All participants performed cycling exercise at low (37-45 % $\dot{V}O_2$max), moderate (46-63 % $\dot{V}O_2$max), and high (64-90 % $\dot{V}O_2$max) intensity continuously (ACSM, 2025). RPE and RPD were asked before and at the end of the test by Borg's scale. They then cooled down by cycling for 4 min. Throughout this visit, expired gas samples (VO2max Tracker Ergospirometer, MES, Cracow, Poland) were obtained to determine $\dot{V}O_2$ and carbon dioxide production ($\dot{V}CO_2$). $\dot{V}O_2$ (L/min) and $\dot{V}CO_2$ (L/min) were used to calculate fat oxidation; Fat ox. g/min and carbohydrate oxidation; Carb ox. (g/min) and by the equation from Peronnet & Massicotte, 1991.

Data analysis

All descriptive data were presented as average ± SD. The data present normality was tested before applying parametric statistics. Difference between groups was analyzed by independent t-test for the normal distribution data. Pearson correlation was used for analysis correlation between FBG and oxidation rates, Pearson correlation coefficients were classified as small ($r \approx 0.10$), moderate ($r \approx 0.30$), or large ($r \geq 0.50$) following Cohen's criteria (Cohen, 1988). SPSS statistical software (version 26; SPSS, Inc., Chicago, IL, USA) was used for statistical analysis.

Figure 1. Study protocol



Results

A total of eighteen female participants were enrolled in the study. Participants were divided into two groups a Trained group and a Sedentary group.

Table 1. shows baseline characteristics of participants in age, anthropometric, body composition, physiological (heart rate and blood pressure), FBG, and physical activity levels of participants in both groups. Although baseline differences were observed (e.g., height and physical activity), the Trained group demonstrated substantially greater physical activity compared to the Sedentary group. Measures WC and the waist-to-hip ratio (WC/HC) confirmed the appropriateness of participant classification into the two groups.

Table 1. Baseline characteristics of participants in both groups.

Variable	Trained	Sedentary	P value
	Average ± SD	Average ± SD	
Age (yr)	35.44 ± 3.84	35.78 ± 2.91	0.838
Height (cm)	161.44* ± 4.75	156.61* ± 3.82	0.030
Body mass (kg)	61.47 ± 5.73	57.66 ± 6.52	0.206
Body mass index (kg/m^2)	23.58 ± 1.97	23.59 ± 3.03	0.993
Body fat (%)	31.67 ± 2.20	31.22 ± 4.29	0.786
Waist circumference (cm)	85.04 ± 3.07	84.22 ± 7.17	0.756
Hip circumference (cm)	100.28 ± 5.68	96.33 ± 7.17	0.211
Waist/hip circumference ratio	0.85 ± 0.05	0.87 ± 0.04	0.243
Resting heart rate (/min)	68.00 ± 6.67	67.11 ± 8.22	0.804
Systolic blood pressure (mmHg)	106.33 ± 5.24	111.00 ± 10.44	0.248
Diastolic blood pressure (mmHg)	65.00 ± 6.36	71.33 ± 8.83	0.100
Fasting blood glucose (mg/dL)	89.30 ± 16.03	83.44 ± 9.96	0.366
Physical activity (kcal)	1814.77* ± 268.73	1224.62* ± 160.72	<0.001

*Significant differences, $p < 0.05$.

Table 2. indicates no significant between-group differences in metabolic parameters. However, a notable trend was observed in substrate utilization: the Trained group exhibited a lower fat oxidation rate than the Sedentary group, particularly at moderate (more than fourfold) and high-intensity exercise (more than eightfold).

Table 2. Fat oxidation and carbohydrate oxidation of each exercise intensity during the submaximal exercise in both groups.

Intensity Oxidation	Fat ox. (mg/min)			Carb ox. (mg/min)		
	Trained	Sedentary	P value	Trained	Sedentary	P value
	Average ± SD	Average ± SD		Average ± SD	Average ± SD	
Low (37–45% $\dot{V}O_2max$)	65.25±54.17	98.43±86.18	0.343	448.36±158.85	412.00±241.53	0.711
Moderate (46–63% $\dot{V}O_2max$)	12.57±27.20	48.73±69.20	0.164	921.70±150.71	925.74±269.24	0.969
High (64–90% $\dot{V}O_2max$)	3.91±11.73	33.42±51.79	0.115	1359.45±242.47	1460.90±457.40	0.565

Abbreviation: Fat ox.; fat oxidation, Carb ox.; carbohydrate oxidation.

According to correlational analysis (Table 3.), resting FBG was strongly and negatively correlated with carbohydrate oxidation during exercise at moderate-intensity ($r = -0.823$, $p = 0.006$), and there was no correlation between FBG and fat oxidation during exercise.

Table 3. Correlation between fasting blood glucose at resting and fat oxidation and carbohydrate oxidation of each exercise intensity during the submaximal exercise in both groups.

FBG and fat oxidation (mg/min)	Trained	Sedentary	Trained	Sedentary
	r	P value	r	P value
Low intensity	0.127	0.744	0.513	0.158
Moderate intensity	0.404	0.281	0.125	0.749
High intensity	0.414	0.268	-0.200	0.605

FBG and carbohydrate oxidation (mg/min)	Trained	Sedentary	Trained	Sedentary
	r	P value	r	P value
Low intensity	-0.436	0.240	-0.414	0.269
Moderate intensity	-0.823**	0.006	-0.028	0.943
High intensity	-0.562	0.116	-0.013	0.974

**Significant differences, p< 0.01. Abbreviation: FBG; fasting blood glucose.

Table 4 demonstrates that both groups pulmonary functions were fairly comparable. While FEV1 and the FEV1/FVC ratio were nearly the same across groups, indicating normal breathing capacity, the sedentary participants had slightly higher VC and FVC. Additionally, the MVV values were very similar. Overall, sedentary and trained women with central obesity did not significantly differ in their pulmonary function.

Table 4. Pulmonary functions of participants in both groups.

Variable	Trained	Sedentary	P value
	Average ± SD	Average ± SD	
VC (L)	1.94±0.29	2.16±0.26	0.110
FVC (L)	3.00±0.42	3.12±0.45	0.595
FEV1 (L)	2.65±0.38	2.61±0.25	0.829
FEV1/FVC	0.88±0.08	0.85±0.11	0.437
MVV (L/min)	105.82±15.35	104.49±9.81	0.829

Abbreviation: FVC, Forced Vital Capacity; FEV1, Forced Expiratory Volume in one second.; MVV, Maximal voluntary ventilation.

Table 5. presents indices of heart rate variability that reflect autonomic nervous system regulation. No statistically significant differences were found between the Trained and Sedentary groups. However, it is noteworthy that the low-frequency component, an index reflecting sympatho-vagal balance, was markedly elevated in the Sedentary group.

Table 5. Heart rate variability of participants in both groups

Variable	Trained	Sedentary	P value
	Average ± SD	Average ± SD	
SDNN (ms)	25.71±7.81	35.12±27.08	0.342
rMSSD (ms)	25.06±9.84	28.79±23.97	0.674
LF (nu)	142.21±140.49	315.81±413.98	0.262
HF (nu)	44.68±20.72	43.65±31.84	0.937
LF/HF	1.85±1.34	3.00±3.07	0.324

Abbreviation: SDNN, Standard deviation of all normal to normal R-R (NN) intervals; rMSSD, Square root of the mean of the squares of successive NN interval differences; HF, High frequency; LF, Low frequency

Discussion

We aimed to find the appropriate intensity of exercise in participants with sedentary behaviors and trained behaviors who have central obesity and to investigate the effect of intensity of exercise on cardiorespiratory, autonomic nervous system, metabolism and blood glucose responses.

At moderate to high intensity, it uses carbohydrate more than fat in Thais (Janyacharoen et al., 2009), the same as our studies showed that high-intensity uses carbohydrates. Liu & Chen, 2022 showed that medium- and low-intensity exercise in the fasted state (6 hours) improves fat oxidation.

Both groups showed similar central obesity profiles despite the Trained group's higher levels of physical activity, supporting previous observations that exercise alone may not be sufficient to completely prevent abdominal fat accumulation if diet is not optimized (Aekplakorn et al., 2021). Notably, we found that there were no appreciable variations in the rates of substrate oxidation during submaximal activity across the groups, but the Trained group had a tendency toward reduced fat oxidation. Carbohydrate oxidation is particularly relevant in the context of obesity and central obesity. According to recent research, obese individuals exhibit greater rates of carbohydrate oxidation during rest and activity than lean individuals. This behavior could be due to metabolic impairment or a decreased ability to switch between lipid and carbohydrate fuels. (Kelley et al., 2002; Bergouignan et al., 2016). Metabolic impairment showed association with insulin resistance, a cause of central obesity and metabolic syndrome, and may be caused by mitochondrial dysfunction in skeletal muscle. (Kelley et al., 2002; Parish & Petersen, 2005).

In our study, we found a strong negative correlation between FBG and carbohydrate oxidation at moderate intensity, particularly in the Trained group. Previous studies have demonstrated that people with central obesity frequently have increased rates of carbohydrate oxidation during exercise, which is linked to decreased insulin sensitivity and increasing fasting glucose levels. Goodpaster et al. (2003) and related research found that enhanced fat oxidation through physical activity correlates with improved insulin sensitivity among obese individuals. Previous research has shown that obese individuals may have attenuated blood glucose reductions after acute bouts of exercise, possibly due to reduced muscle glucose uptake, even while exercise intensity had no significant influence on our participant blood glucose levels. (McClean et al., 2009).

Delaying oxygen uptake and decreasing exercise capacity in patients with several chronic diseases showed abnormal oxidative metabolism at the skeletal muscle level. Interestingly, we found negative correlations between carbohydrate oxidation and FBG in the Trained group. This issue might be our participant fasting (not eating anything for 8 hours before a blood test). Previous research has established a link between elevated postprandial insulin responses and reduced glucose tolerance (Horton et al., 2001). FBG is a way to test how well the body uses glucose, while carbohydrate oxidation reveals how much the body uses carbohydrates for energy. Impairment of glucose metabolism is a common condition in central obesity, often attributable to insulin resistance. On the other hand, during exercise, the difference in intensity indicated that it did not affect blood glucose levels (Liu & Chen, 2022). Exercise intensity did not significantly affect our participants blood glucose levels, corroborating findings indicating that at low to moderate intensities, fat serves as the primary energy source, with a transition to carbohydrate oxidation occurring at 50% $\dot{V}O_2$max (Brun et al., 2022). This substrate shift is not exclusive to central obesity; it constitutes a general physiological reaction.

Although exercise intensity was not significant in our participants regarding the effect of blood glucose, previous studies found that participants with obesity may have blunted reductions in blood glucose following acute bouts of exercise, possibly due to impaired muscle glucose uptake. (McClean et al., 2009; Merz & Thurmond, 2020; Collins et al., 2022)

However, besides the intensity of exercise, prolonged exercise changes substrate oxidation. Previous studies indicated that long-time exercise induces fat oxidation. Exercise duration has effects on the origin of fatty acids for oxidative purposes. (Purdom et al., 2017). For long-term weight maintenance, 60–90 minutes of exercise per day may be required because prolonged exercise can improve fat oxidation more than carbohydrate (Powers & Howley, 2007). On the other hand, a study conducted by Horowitz & Klein (2000) indicated that during moderate-intensity sustained exercise, women with abdominal obesity demonstrated reduced glucose oxidation and enhanced fat oxidation. The research once again shows that obesity is associated to a change in how fat is used during exercise instead of carbs when metabolic flexibility is maintained (Brun et al., 2022).

The pulmonary functions in both groups are no different between groups. Our results showed that VC and FVC in the Trained group were less than in the Sedentary group. In this case, we suggest that exercise intensity should be serious on this point because physical activity is associated with metabolism, and metabolic syndrome patients (WC > 80 cm component) have impairment in pulmonary functions. It's shown that they have increased abdominal obesity and this affects thoracic and diaphragm compliance (Salome et al., 2010). This may be due to effects of interfering with mechanical compression of the diaphragm, lungs, and chest cavity, effects of pulmonary damage and reduced respiratory muscle strength (Mafort et al., 2016). Sespheng et al. (2019) found arm swing exercise (low intensity) to improve pulmonary functions. Consistent with previous studies on body composition, BMI is associated with FEV1 in COPD; the researchers found that a lower BMI is linked to a faster rate of FEV1 decline compared to normal BMI, while a higher BMI is associated with a slower decline (Sun et al., 2019). Aerobic exercise training improved the FEV1, but high-intensity interval training did not have the same effect on the same parameter (Shadmehri et al., 2021). Previous studies suggest that individualized training approaches, such as aerobic exercise with intermittent high-intensity intervals, may be effective in improving both cardiorespiratory and metabolic outcomes in women with central obesity (Bergouignan et al., 2016).

The autonomic nervous system concentrates on heart rate variability, showing no distinctions between groups. It is significant that the SDNN variable indicates equilibrium in the sympathetic and parasympathetic nervous systems in the Trained group compared to the Sedentary group. The alteration in the HF domain and LF/HF ratio was markedly greater during high-intensity exercise compared to moderate-intensity exercise in adolescents with obesity (Su et al., 2024). We recommend that the exercise regimen be characterized by high validity and intermittent sessions to activate the sympathetic nervous system. In line with the LF domain variable, it should be more than just a sedentary lifestyle. The autonomic nervous system's role during exercise, characterized by the dominance of sympathetic over parasympathetic activity, facilitates fat oxidation (Grabner et al., 2021). The prior investigation involving sedentary, healthy young and middle-aged adults indicated no correlation between HRV and maximal fat oxidation (González et al., 2022).

Our investigation, however, revealed significantly elevated values for the LF variable in the Sedentary group, indicating autonomic nervous system equilibrium. This study corresponds with prior research involving overweight and obese individuals aged 18-40 years, indicating that LF (nu) and the LF/HF ratio were elevated compared to normal-weight individuals, implying that overweight and obese individuals display modified characteristics of the autonomic nervous system (Muthukrishnan et al., 2025). So, we suggest that those who don't move around much should get more exercise to assist their autonomic nervous system work normally again by using moderate-intensity exercise training. Multiple studies indicate that moderate-intensity exercise can enhance LF. Moderate-intensity aerobic training (50-65% heart rate reserve, progressively raised over 12 weeks) enhances autonomic regulation in obese people, namely by augmenting parasympathetic activity (HF and RMSSD) during exercise initiation and recovery. The LF shows how the sympathetic and parasympathetic systems function together when workloads are higher. According to Davidson et al. (2021), In addition, research has shown that exercise training greatly improves HRV parameters in people with type 2 diabetes. This can be done with moderate-intensity (40–60% $\dot{V}O2max$) aerobic training and combination training, three to five times a week for 30 to 60 minutes per session, for 8-24 weeks (Picard et al., 2021). We suggest preventing central obesity, which is a risk and cause of higher cardiovascular disease in obese individuals, with moderate-intensity exercise training.

In our limitations, we did not control dietary intake in participants; this might be effective for substrate oxidation. However, future studies would like to control diet and confirm our findings in populations with different clinical conditions, such as the elderly, metabolic syndrome, cardiovascular disease, etc.

Conclusions

At moderate intensity, carbohydrate oxidation had a negative correlation with FBG in Trained group. While as pulmonary function, autonomic nervous system has no difference between Trained and Sedentary group. And we suggest intensity of exercise for central obesity person were low-moderate intensity.

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