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Impact of Alternating Exercise Intensity Interventions on the Physical and Mental Health of Middle-Aged and Young Men

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Abstract: Exercise interventions have been shown to improve health levels; however, the effects of different exercise intervention methods remain to be studied. This study designed seven types of exercise interventions, including high-intensity interval training (HIIT), moderate-intensity continuous training (MICT), low-intensity steady-state training (LISS) and various alternating combinations. A 16-week follow-up investigation analyzed the impact of these different exercise interventions on participants' physical and psychological health. The results indicate that exercise interventions are an effective health promotion method, significantly reducing BMI and body fat percentage, improving metabolic health, cardiovascular health, and cardiorespiratory function and enhancing quality of life and psychological state. Specifically, the HIIT-LISS combination performed best in reducing BMI, regulating blood lipids, and increasing VO_2max. Furthermore, HIIT demonstrated the most significant improvement in body fat percentage and blood pressure, with body fat reduced by up to 5.65% and blood pressure decreasing by nearly 9 mmHg, whereas the MICT-LISS showed better effects on heart rate. Although the improvement in psychological health from different exercise interventions was not significant, it increased by over 10% compared to the control group. Overall, the combined effect of HIIT and MICT was found to be the most effective, with mixed exercise interventions showing more pronounced effects on physical health indicators.

Keywords: public health; interval exercise; continuous training; HIIT; MICT; LISS

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1. Introduction

The changes in modern lifestyles have significantly impacted individuals' levels of physical activity. People's lifestyles have gradually become more sedentary, leading to a continual decrease in daily exercise and a subsequent decline in overall health. Unhealthy conditions such as obesity and overweight have become increasingly common. As physical inactivity becomes more prevalent, individuals' physical fitness has also deteriorated accordingly [1]. The World Health Organization has identified physical inactivity as the fourth leading global risk factor for mortality, following hypertension, smoking, and high blood glucose, making it one of the most significant public health issues of the 21st century [2]. Prolonged lack of physical activity not only increases the risk of cardiovascular diseases, diabetes, and certain cancers, but also leads to mental health issues such as depression and anxiety [3,4]. Therefore, promoting physical activity and encouraging people to adopt healthy lifestyles has become a crucial task for governments and public health agencies worldwide.

Among the various strategies, exercise has consistently been regarded as the best method for weight loss, fat reduction, and improving overall health [5]. There are numerous precedents that have demonstrated the effectiveness of physical activity in controlling weight and reducing or improving sub-health symptoms [6]. In recent years, numerous exercise prescriptions have emerged to address obesity and improve cardiorespiratory fitness. Various combinations of exercise intensity, duration, and frequency have been proven to be effective in fat reduction for middle-aged and young adults, while also improving their cardiorespiratory fitness to some extent [7].

However, traditional forms of exercise often face challenges in being widely accepted or sustained by the general population due to specific requirements related to environment, equipment, time, and physical ability [8]. Currently, the most widely recommended form of exercise internationally is MICT, which involves performing aerobic activities at a moderate intensity for an extended duration. Common forms of this exercise include traditional aerobic activities such as running, cycling, or swimming. Regularly engaging in this type of training according to a set schedule can significantly improve body fat percentage and physical fitness [9]. However, MICT often requires a considerable time commitment and can be monotonous, making it difficult for individuals to develop a consistent exercise habit. Despite its effectiveness, the challenge of maintaining MICT has led to its limited long-term adherence. In response to the demand for more efficient workouts, HIIT has gained popularity due to its time-saving and highly effective nature. HIIT has been widely applied in the prevention and rehabilitation of various clinical conditions, with numerous studies now showing that its fat reduction effects are superior to those of MICT [10]. HIIT offers a diverse range of exercise methods and, due to its shorter duration, is well suited for today's fast-paced lifestyle. However, despite reducing barriers related to equipment and environment and saving time, the combination of "high intensity" and "inadequate rest intervals" in HIIT makes it challenging for many sedentary individuals and those with metabolic disorders to sustain [11]. Therefore, finding a convenient and efficient way to achieve health benefits similar to or better than those of traditional exercise has become a new demand in physical activity.

LISS, often overlooked, also offers unique advantages and significant health benefits [12]. LISS typically refers to low-intensity aerobic exercises performed for longer duration, such as jogging, cycling, swimming, or brisk walking. This type of exercise not only helps improve cardiovascular endurance and promote fat burning but also reduces the risk of injury, making it suitable for individuals of various ages and fitness levels [13]. Therefore, LISS is not only an exercise modality that is easy to maintain but also provides significant support for long-term health management. We should reconsider LISS and incorporate it into our daily exercise routines, as it may be an effective strategy for achieving long-term health goals. Research indicates that moderate-intensity aerobic exercise can effectively reduce the risk of hypertension, hyperglycemia, and hyperlipidemia, improve metabolic health, and thus help prevent cardiovascular diseases [14]. Additionally, low-intensity exercise can effectively reduce arterial stiffness and improve endothelial function [15]. Long-term low-intensity interval training can significantly reduce arterial stiffness in healthy women [16]. Due to its lower intensity, LISS is often considered more enjoyable [17]. The effectiveness of the LISS approach is also demonstrated by the health benefits provided by moderate to low-intensity exercise.

Exercise of varying intensities has a notable impact on cardiovascular health, metabolic function, and physical fitness improvement [18–20]. HIIT, MICT, and LISS are the three primary intervention methods in the field of exercise science. HIIT is noted for its high cardiovascular adaptability and time efficiency, MICT is renowned for its stable and enduring fitness results as a more traditional training method, and LISS is better suited for individuals who require a more relaxed and sustainable exercise regimen. However, there is still a lack of systematic research on the specific effects of these three intervention methods in the context of fragmented exercise time and their performance when alternated.

Therefore, this study aims to explore the effects of HIIT, MICT, and LISS exercise interventions, as well as their alternate combinations, during fragmented time. Through a 16-week follow-up investigation, the study will assess the impact of different exercise interventions on participants' physical and mental health, providing a theoretical and practical basis for the public to choose suitable exercise methods.

2. Methods

2.1. Participants

This study aims to explore the impact of different exercise interventions on the physical and mental health of middle-aged men with fragmented time in the working class. It is crucial to select a sufficient sample size to ensure the accuracy of the experimental results. A sample size that is too small can affect the credibility of the results, while a sample size that is too large can lead to wasted time and resources. To ensure balanced representation in terms of age, gender, and baseline fitness levels, this study recruited 96 adult male participants aged 25 to 45 years from China (Table 1). This age range was selected because it represents a period of personal striving during which participants typically have only fragmented time for exercise. All participants were required to be in good health, without chronic diseases, cardiovascular conditions, or injuries that could affect their ability to exercise, and to have a moderate level of fitness, which was assessed through pre-screening questionnaires and baseline fitness tests. To ensure a similar starting point for all individuals, participants were not allowed to engage in regular high-intensity or structured exercise programs within the three months prior to the study. Participants were stratified by age and baseline fitness level and randomly assigned to one of seven exercise intervention groups (HIIT, MICT, LISS) and a control group, with 12 individuals in each group, to ensure comparability in sample sizes. All participants provided informed consent, completed a 16-week self-reported exercise evaluation, and received compensation upon completion of the trial.

Table 1. Summary statistics of demographic variables.

Variables	N	%
Age		
25–30	35	36.46%
31–35	41	42.71%
36–45	20	20.83%
Frequency of exercise		
1–5 times per month	49	51.04%
6–10 times	36	37.50%
11 times or more	11	11.46%
Occupation		
Teacher	9	9.38%
Administrative agent	23	23.96%
White collar worker	54	56.25%
Others	10	10.42%

2.2. Exercise Intervention

Before the formal start of the experiment, all exercise intervention groups performed a standardized 3 min warm-up and 3 min rest at 50% HRmax, followed by the formal exercise intervention training. The specific exercise intervention methods are as follows [13,21,22]:

(1) HIIT: Perform exercise 3 times per week, with each session lasting 20 to 30 min, including warm-up, HIIT, and cool-down. During the high-intensity phases, maintain your heart rate between 80% and 90% of maximum heart rate for 30 s to 1 min. The recovery phases should be performed at a low intensity, aiming to reduce the heart rate as much as possible, ideally to 50% to 60% of maximum heart rate. Recovery time starts immediately after the high-intensity interval ends and is set to be slightly longer than the high-intensity phase, considering the time needed to reach the target heart rate range. The ratio between high-intensity and recovery phases is approximately 1:1. Sprinting is used as the exercise form, either on a treadmill or outdoors.

(2) MICT: Perform exercise 3 times per week, each session lasting 30 to 45 min. Maintain exercise intensity at 60% to 75% of maximum heart rate. Participants should experience noticeable breathlessness but still be able to engage in brief conversations. The

exercise form is running, which can be performed outdoors or on a treadmill, at a steady pace.

(3) LISS: Perform exercise 3 times per week, each session lasting 30 to 45 min. Maintain exercise intensity at 50% to 60% of maximum heart rate. Participants should be able to maintain a comfortable conversation during the exercise. The exercise form is jogging at a comfortable pace for a longer duration.
(4) HIIT-LISS: Combine HIIT and LISS by alternating these two exercise modes in a weekly schedule of 3 sessions.
(5) MICT-LISS: Combine MICT and LISS by alternating these two exercise modes in a weekly schedule of 3 sessions.
(6) HIIT-MICT: Combine HIIT and MICT by alternating these two exercise modes in a weekly schedule of 3 sessions.
(7) HIIT-MICT-LISS: Combine HIIT, MICT, and LISS by alternating these three exercise modes in a weekly schedule of 3 sessions.
(8) Control: No specific exercise intervention was given.

All experimental procedures used heart rate monitors or other monitoring devices to ensure that the target heart rate was reached during high-intensity phases. The training intensity and interval times were adjusted based on participants' fitness levels and feedback to ensure safety and effectiveness. Additionally, due to the relatively low exercise levels of most participants in this study, a progressive approach was adopted. In the first two weeks, participants performed 50% of the prescribed exercise regimen. In the third and fourth weeks, the volume progressed to 75% of the total duration of the program. Finally, participants completed the full duration of the prescribed exercise in the remaining sessions.

2.3. Intervention Effectiveness Evaluation Indicators

(1) Physical health

Physical health indicators encompass various aspects, including body composition, cardiovascular health, and metabolic health. Body composition metrics (such as body fat percentage and Body Mass Index (BMI)) are used to assess participants' weight changes and their response to the intervention [23]. Cardiovascular health is assessed by measuring blood pressure, heart rate, and maximal oxygen uptake (VO_2max) to understand the impact of the intervention on the cardiovascular system [24]. In terms of metabolic health, the focus is primarily on lipid levels (low-density lipoprotein LDL and high-density lipoprotein HDL) to assess the impact of exercise interventions on metabolic indicators [25]. Through a comprehensive assessment of these indicators, one can gain a thorough understanding of the specific effects of exercise interventions on physical health.

(2) Cardiorespiratory endurance

Cardiopulmonary endurance will be measured using two methods: maximal oxygen uptake (VO_2max) and the 6 min walk test. Participants will undergo a standardized Bruce protocol treadmill test to assess VO_2max and HRmax [26]. VO_2max is the gold standard for assessing cardiovascular endurance. By measuring the maximum amount of oxygen consumed by participants under maximal exercise conditions, it accurately reflects their cardiovascular function and overall aerobic endurance [27]. Typically, normal values for young adult males range from approximately 35 to 45 mL/kg/min, while for females, they range from about 30 to 40 mL/kg/min. Meanwhile, the 6 min walk test will be used to assess the distance participants can walk in six minutes, thereby indirectly measuring their cardiovascular endurance and exercise stamina [28]. By combining these two testing methods, a comprehensive evaluation of participants' cardiovascular function can be achieved and changes before and after the exercise intervention can be compared to ensure an accurate assessment of the intervention's effects.

(3) Quality of life and psychological state

At the end of the 16-week exercise intervention experiment, we evaluated exercise enjoyment and self-efficacy. The Perceived Enjoyment of Physical Activity Scale (PACES) was used to assess the perceived enjoyment of the three different interventions. Participants were asked to complete the scale to determine which intervention they found more enjoyable. PACES is a psychological measurement tool used to assess individuals' enjoyment during physical activities. This scale is designed to quantify participants' level of enjoyment of exercise, thereby revealing the impact of physical activity on their emotions and motivation [29]. In addition, the General Health Questionnaire (GHQ-12) is used to assess participants' mental health status and emotional distress [30].

2.4. Variable Control

(1) Exercise consumption control

In exercise intervention studies, controlling exercise duration is a key factor in ensuring the validity and consistency of the results. It is essential to ensure that the total intervention duration, the duration of each exercise session, and the exercise frequency are consistent. To minimize the impact of potential time factors on the outcomes, participants should engage in exercise during similar time periods each day, preferably in the evening. For interventions such as HIIT, it is also necessary to strictly control the intervals between high-intensity and recovery phases to ensure that all participants have consistent rest and training times. By recording and monitoring each participant's actual exercise duration and frequency, the implementation of the exercise intervention can be ensured to meet the research requirements, thus making the study results more reliable.

(2) Diet control

Based on existing exercise intervention studies, participants were instructed to maintain their usual diet throughout the intervention period [31]. Validated three-day food diaries (covering two weekdays and one weekend) were used to assess dietary intake before and after the intervention to control for dietary effects and ensure that all observed changes post-intervention were due to the exercise intervention. Additionally, dietary advice was provided, but no intervention was made in the participants' diets, and the total intake of calories and macronutrients (i.e., carbohydrates, fats, and proteins) was evaluated.

(3) Lifestyle control

To effectively control participants' lifestyle habits, we first assessed their sleep quality, work stress, and daily activity levels through interviews before the study began, in order to select individuals who meet the research criteria. Next, we established standardized lifestyle guidelines for participants, including recommended sleep duration, reasonable work hours, and stress management advice. We regularly collected and monitored data on participants' sleep quality, work stress, and daily activity levels to ensure these lifestyle habits were effectively controlled throughout the study. We provided education and guidance on healthy lifestyle habits to help participants improve their sleep, manage stress, and maintain healthy daily activities. Additionally, if lifestyle habits were found to potentially impact the study results, we offered additional support and intervention measures, such as psychological counseling or stress-relief activities.

2.5. Data Collection and Processing

Before data collection, we ensured that participants avoided vigorous exercise for at least 24 h and caffeine intake for at least 12 h before each test. Each test was conducted at the same time of day (between 8:00 AM and 10:00 AM). In the 24 h preceding the baseline test, participants were also required to record their food intake and were instructed to repeat the same diet the day before subsequent tests. Based on this, we obtained physical assessment data for all participants before and after the exercise intervention, with data provided by hospital reports. We performed a descriptive statistical analysis of the exercise intervention data using SPSS 25 software, describing participants' basic characteristics, exercise records, and intervention effects. Differences between the intervention group and the control group were compared using ANOVA, and the effectiveness of different exercise interventions was analyzed using the RSR method for a comprehensive evaluation.

3. Results

3.1. Descriptive Statistics

The total of 96 participants completed all required tests, and their data were included in subsequent analyses. The average intensity for all exercises met the requirements and was suitable for effective analysis. Additionally, we collected pre- and post-intervention data for all participants (Table 2). Improvements were observed in physical health indicators, cardiorespiratory endurance, quality of life, and psychological status following the exercise intervention.

Table 2. Anthropometric, cardiometabolic, and psychological health outcomes in all groups at baseline and post-intervention (mean ± SD).

Training Approaches	Baseline	BMI	Body Fat Percentage (BFP)	LDL-C (mg/dL)	HDL-C (mg/dL)	Systolic Blood Pressure (SBP) (mmHg)	Diastolic Blood Pressure (DBP) (mmHg)	Heart Rate (HR) (BPM)	VO_2max (mL/kg/min)	Six min Walk Test (WT)	PACES	GHQ-12
HIIT	Pre	23.03 ± 5.77	20.06 ± 3.81	121.26 ± 14.65	48.59 ± 6.53	107.64 ± 16.66	71.47 ± 5.01	76.48 ± 8.93	41.46 ± 5.35	545.27 ± 32.44	54.25 ± 4.67	39.92 ± 3.87
	Post	22.22 ± 5.67	18.92 ± 3.53	112.11 ± 14.85	51.35 ± 6.74	98.63 ± 16.73	63.31 ± 4.58	72.44 ± 8.88	46.99 ± 5.61	614.44 ± 40.76	60.51 ± 6.55	44.85 ± 5.43
MICT	Pre	23.39 ± 3.43	20.69 ± 4.58	108.87 ± 13.47	48.06 ± 7.21	108.82 ± 13.53	72.97 ± 8.61	81.94 ± 7.18	38.67 ± 3.82	551.14 ± 50.91	56.58 ± 4.66	39.75 ± 3.22
	Post	22.56 ± 3.30	19.94 ± 4.52	101.02 ± 11.62	51.06 ± 7.48	101.49 ± 14.03	65.09 ± 8.43	76.35 ± 7.06	43.11 ± 4.35	611.08 ± 60.65	62.00 ± 5.35	44.27 ± 4.89
LISS	Pre	20.87 ± 3.79	20.28 ± 5.03	112.64 ± 16.94	43.03 ± 8.44	110.01 ± 14.61	69.57 ± 11.41	85.71 ± 7.05	41.04 ± 4.15	555.89 ± 45.12	52.92 ± 5.00	40.42 ± 4.74
	Post	20.48 ± 3.67	19.90 ± 4.98	104.86 ± 15.86	43.93 ± 8.63	107.90 ± 14.17	66.88 ± 11.52	82.94 ± 7.06	44.11 ± 4.93	583.40 ± 50.77	57.62 ± 5.57	45.32 ± 5.87
HIIT-LISS	Pre	20.83 ± 2.87	19.09 ± 2.89	110.40 ± 14.88	41.41 ± 8.64	115.26 ± 14.52	74.20 ± 11.44	84.04 ± 8.57	37.98 ± 4.36	545.12 ± 29.72	56.08 ± 5.98	39.08 ± 3.20
	Post	19.74 ± 2.94	18.17 ± 2.63	100.49 ± 13.90	44.45 ± 10.04	108.89 ± 14.17	67.14 ± 11.34	76.85 ± 8.52	43.79 ± 4.82	618.77 ± 38.31	61.54 ± 6.26	43.42 ± 4.33
MICT-LISS	Pre	21.37 ± 3.85	19.19 ± 3.31	114.45 ± 18.45	48.75 ± 11.86	110.16 ± 16.34	67.98 ± 7.33	77.96 ± 8.26	38.71 ± 3.71	532.59 ± 25.61	57.42 ± 4.96	41.00 ± 3.98
	Post	20.32 ± 3.62	18.41 ± 3.12	105.11 ± 17.18	51.70 ± 12.55	104.51 ± 16.84	60.85 ± 7.41	69.94 ± 8.12	44.36 ± 4.87	594.01 ± 35.64	62.36 ± 5.31	46.09 ± 5.30
HIIT-MICT	Pre	21.49 ± 4.75	20.20 ± 4.12	112.39 ± 18.85	45.49 ± 11.53	109.73 ± 17.06	69.84 ± 7.81	72.05 ± 9.78	36.45 ± 5.98	546.77 ± 37.50	51.50 ± 4.42	40.00 ± 4.53
	Post	20.54 ± 4.42	19.01 ± 3.76	102.09 ± 16.80	48.42 ± 11.99	101.87 ± 17.32	61.46 ± 8.48	66.72 ± 9.49	41.6 ± 6.86	626.54 ± 44.88	58.10 ± 4.74	44.76 ± 5.41
HIIT-MICT-LISS	Pre	21.24 ± 3.88	19.40 ± 4.66	117.15 ± 16.19	43.18 ± 6.80	106.80 ± 16.44	74.58 ± 9.40	78.33 ± 9.69	40.36 ± 5.82	535.71 ± 45.82	54.25 ± 6.33	38.42 ± 6.10
	Post	20.53 ± 3.68	19.01 ± 4.62	111.50 ± 15.18	45.16 ± 7.27	99.29 ± 16.39	67.15 ± 9.30	75.95 ± 9.89	44.55 ± 5.83	580.11 ± 47.68	60.58 ± 7.59	43.57 ± 7.67
Control	Pre	21.34 ± 3.96	20.12 ± 3.43	120.38 ± 15.68	47.94 ± 11.03	113.15 ± 12.03	74.21 ± 10.16	78.8 ± 11.33	40.33 ± 4.86	536.63 ± 41.34	54.08 ± 3.99	40.58 ± 4.76
	Post	21.23 ± 3.71	20.15 ± 3.40	120.94 ± 15.47	47.68 ± 10.74	112.84 ± 11.98	74.43 ± 9.80	78.99 ± 11.09	40.99 ± 4.64	538.35 ± 41.07	55.84 ± 3.98	42.18 ± 4.08

3.2. Physical Health

BFP is an important indicator of fat levels within the body and reflects an individual's body composition. A high body fat percentage is typically associated with obesity and may increase the risk of health issues such as cardiovascular disease and diabetes. While BMI is a key indicator for assessing whether an individual is underweight, normal weight, overweight, or obese, it does not distinguish between fat and muscle mass. Therefore, when evaluating weight changes and their response to interventions, it is essential to consider body fat percentage alongside BMI. An analysis of the collected data revealed that different exercise interventions significantly impact both BMI and body fat percentage ($F(7, 88) = 781.282$, $p < 0.001$, $\eta^2 = 0.899$; $F(7, 88) = 534.876$, $p < 0.001$, $\eta^2 = 0.859$).

As shown in Figure 1, the HIIT-LISS, MICT-LISS, and HIIT-MICT exercise interventions are the most effective for improving participants' BMI, with the mixed approach of high-intensity exercise interspersed with low-intensity exercise being the most effective. Compared to pre-intervention levels, this approach achieves an improvement of up to 5.37%. On the other hand, the alternating intervention of HIIT-MICT-LISS is less effective, only surpassing the LISS intervention. Regarding body fat percentage improvement, the alternating combination of two exercise interventions also shows better results. Notably, continuous HIIT proves more effective in reducing body fat percentage, with a maximum reduction of 5.65%, highlighting the crucial role of high-intensity exercise in improving body fat percentage.

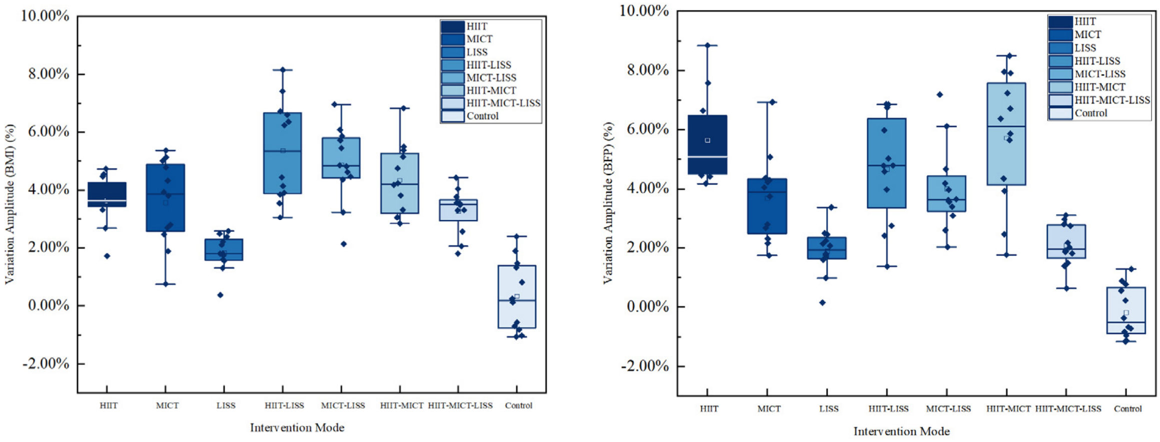

Figure 1. The change trends in body composition under different exercise intervention methods.

In terms of metabolic health, maintaining low LDL levels and high HDL levels is crucial for good metabolic health. Exercise interventions have a significant impact on the levels of LDL and HDL ($F(7, 88) = 37.701$, $p < 0.001$, $\eta^2 = 0.75$; $F(7, 88) = 18.596$, $p < 0.001$, $\eta^2 = 0.597$). Regular aerobic exercise helps lower LDL levels in the blood, reducing cholesterol accumulation on arterial walls and lowering the risk of cardiovascular diseases. Simultaneously, exercise can increase HDL levels, enhancing cholesterol clearance and further protecting cardiovascular health. As shown in Figure 2, HIIT has a more pronounced effect on increasing HDL and decreasing LDL levels. However, combining two exercise intervention methods seems to enhance these effects further. After extended periods of exercise intervention, this combined approach can increase HDL levels by approximately 9% and reduce LDL levels by about 7%.

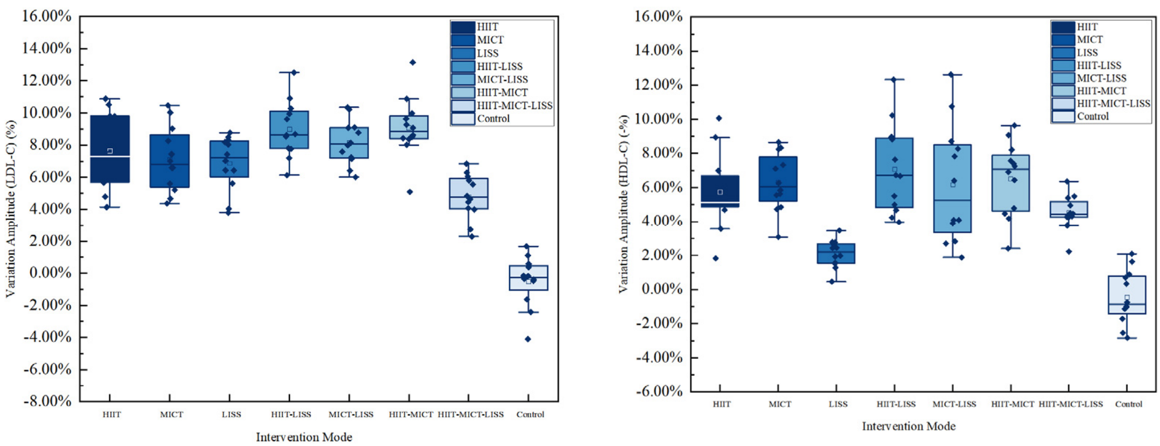

Figure 2. The change trends in LDL and HDL under different exercise intervention methods.

In terms of cardiovascular health, measurements of participants' blood pressure and heart rate before and after the intervention indicate that the exercise interventions have a significant impact on heart rate and blood pressure levels. Specifically, systolic pressure, diastolic pressure, and heart rate show significant effects ($F(7, 88) = 84.118$, $p < 0.001$, $\eta^2 = 0.87$; $F(7, 88) = 65.332$, $p < 0.001$, $\eta^2 = 0.839$; $F(7, 88) = 95.53$, $p < 0.001$, $\eta^2 = 0.884$). As shown in Figures 3 and 4, HIIT is more effective in improving blood pressure, with a reduction of nearly 9 mmHg after prolonged adherence to the exercise. This method shows a slightly greater effect on diastolic pressure compared to systolic pressure. Meanwhile, MICT-LISS demonstrates a more significant improvement in heart rate, reaching 8 BPM. This alternation allows participants to better adjust their physical condition. Additionally, LISS, as a low-intensity exercise intervention, seems to have a less pronounced effect on cardiovascular health improvement, suggesting that more time may be needed to validate its benefits.

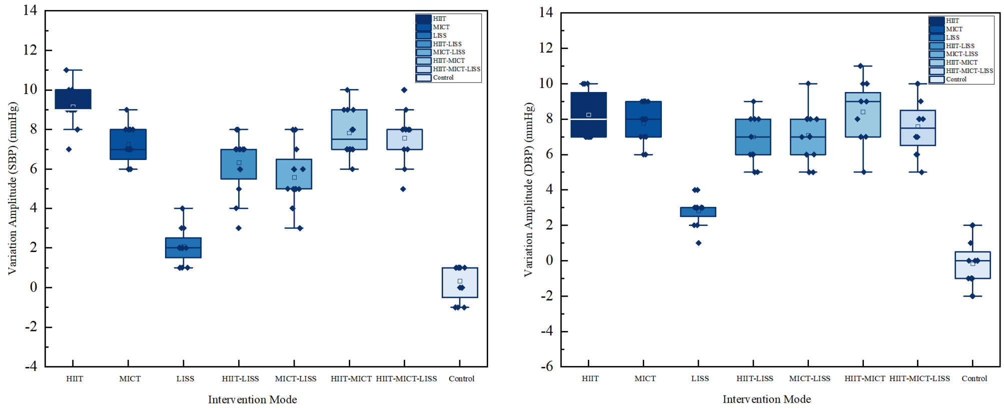

Figure 3. The change trends in blood pressure under different exercise intervention methods.

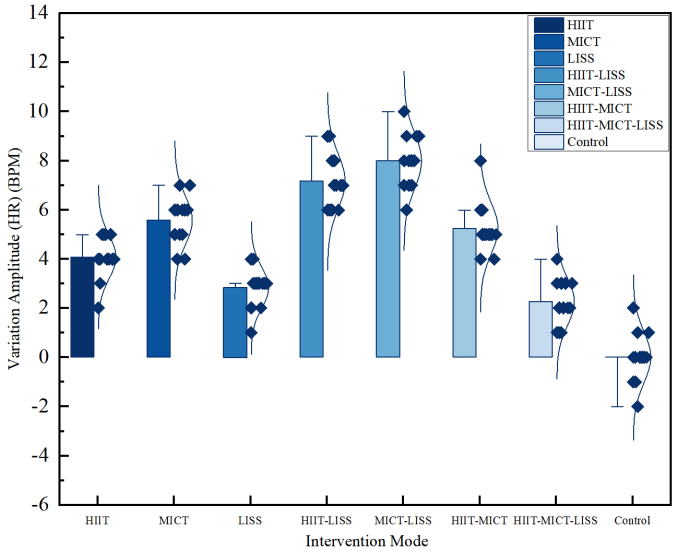

Figure 4. The change trends in heart rate under different exercise intervention methods.

3.3. Cardiorespiratory Endurance

Cardiopulmonary capacity refers to the ability of the heart, lungs, and circulatory system to effectively supply oxygen and expel carbon dioxide during exercise, typically measured by VO_2max. Cardiopulmonary capacity reflects an individual's endurance during aerobic exercise and overall cardiovascular health. A higher cardiopulmonary capacity indicates greater resistance to fatigue during prolonged exercise and a higher tolerance for intense exercise loads. Exercise interventions have a significant impact on cardiopulmonary function, and different types of exercise interventions have varying effects on its improvement. HIIT, MICT, and LISS aerobic exercise all positively affect cardiopulmonary function, but the effects vary by type and intensity of exercise. One-way ANOVA shows that different exercise interventions significantly impact VO_2max and the 6 min walk test ($F(7, 88) = 23.836$, $p < 0.001$, $\eta^2 = 0.655$; $F(7, 88) = 46.474$, $p < 0.001$, $\eta^2 = 0.787$).

As shown in Figure 5, different intensity alternations of HIIT-LISS, MICT-LISS, and HIIT-MICT have demonstrated a significant improvement in VO_2max, increasing by approximately 14%. This indicates that these alternating intensity approaches are highly effective exercise methods. Additionally, HIIT alone, with its high-intensity intervention, also results in about a 13% increase in VO_2max, proving to be an effective strategy through short bursts of high-intensity exercise. Similar patterns were observed in the 6 min walk test, with the HIIT-MICT combination producing the best results. However, the low-intensity LISS exercise, when used alone, appears to have limited effectiveness in the short term.

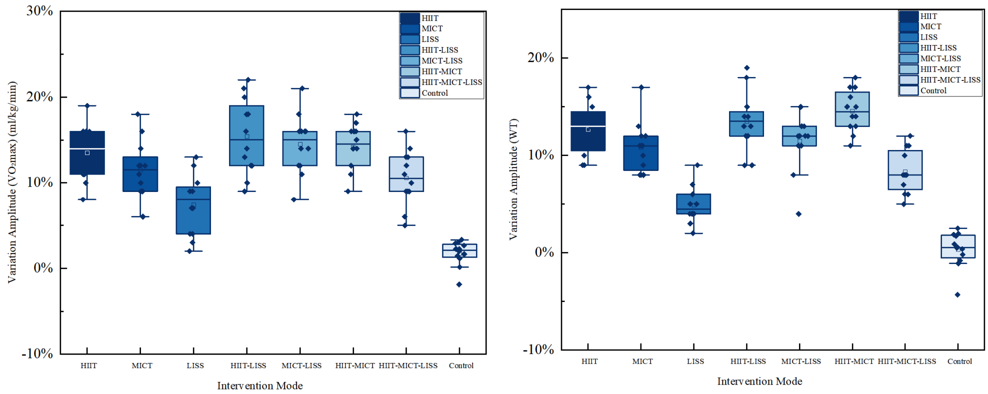

Figure 5. The change trends in VO_2max and 6 min walk test under different exercise intervention methods.

3.4. Quality of Life and Changes in Psychological Status

Higher scores on the PACES and GHQ-12 questionnaires indicate better psychological states and greater comfort during exercise for participants. According to the one-way ANOVA, there are no significant differences among different exercise interventions ($p > 0.05$). However, as illustrated in Figures 6 and 7, participants in the exercise intervention groups experienced a certain degree of improvement in quality of life and psychological state. Specifically, all exercise interventions, except for the control group, increased PACES scores by approximately 10%, suggesting that participants derived some enjoyment from exercise, which contributed to enhanced life satisfaction. In terms of mental health, exercise interventions improved mental health scores by more than 12%, indicating that exercise has a positive effect on participants' psychological well-being.

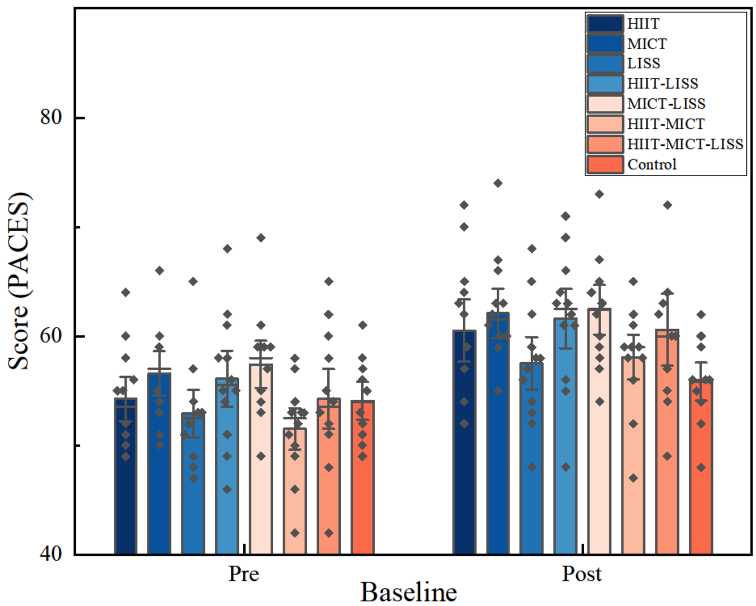

Figure 6. The change trends in score (PACES) under different exercise intervention methods.

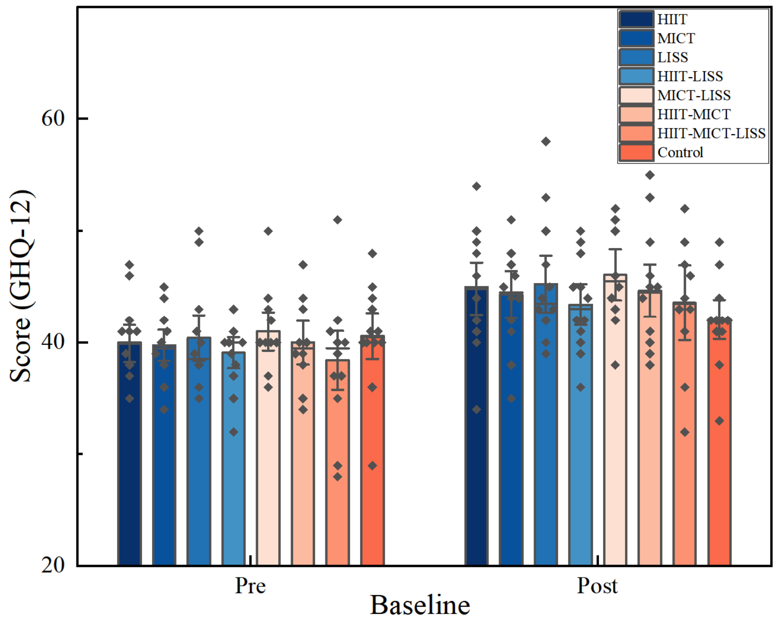

Figure 7. The change trends in score (GHQ-12) under different exercise intervention methods.

3.5. Comprehensive Evaluation

This study employs a comprehensive evaluation to measure the effects of different exercise interventions, allowing for a thorough analysis of multidimensional health indicators while fully considering individual differences and the complexity of multiple factors. Compared to single indicators, comprehensive evaluation avoids partiality, making the assessment more objective and comprehensive. This approach provides scientific evidence for optimizing and selecting exercise intervention programs, ensuring the achievement of the best health improvement outcomes. Therefore, using the RSR (rank sum ratio) model to evaluate exercise intervention effects effectively integrates data from multidimensional indicators and simplifies the complex evaluation process. The RSR model standardizes and ranks various indicators, addressing issues of inconsistent dimensions among different indicators and enabling comparisons within the same evaluation framework. This model also demonstrates good robustness and sensitivity, accurately reflecting the overall effect of exercise interventions and providing objective evidence for scientific decision-making [32].

Before conducting the comprehensive evaluation, we first established an evaluation index system based on the impact of exercise interventions on participants' physical health indicators, cardiorespiratory fitness, and psychophysiological status indicators. We then applied the entropy weighting method to assign weights to these indicators. The entropy weighting method is based on the principle of information entropy and measures the variation in each indicator by calculating its entropy value. The greater the variation, the smaller the entropy value, indicating that the indicator provides more information in the comprehensive evaluation and, consequently, a higher weight [33]. The results of the entropy weight method are shown in Table 3.

Based on the weighting results from the entropy weight method, the RSR method is used to evaluate the effectiveness of exercise interventions. The main idea is to rank the samples based on their performance across various indicators and calculate the comprehensive RSR value to achieve a multi-indicator comprehensive assessment. The basic principle involves standardizing each indicator, ranking them, and calculating the rank sum ratio for each sample to measure their relative performance. A higher RSR value indicates better overall performance of the sample. The calculated results are shown in Tables 4 and 5. The RSR rankings for different exercise intervention programs are as follows: HIIT-MICT > HIIT > HIIT-LISS > MICT > MICT-LISS > HIIT-MICT-LISS > LISS > Control.

Table 3. Indicator weight calculation results.

Item	Information Entropy Value	Information Utility Value	Weight
BMI	0.911	0.089	9.647
BFP	0.905	0.095	10.274
LDL-C	0.928	0.072	7.737
HDL-C	0.916	0.084	9.054
SBP	0.903	0.097	10.451
DBP	0.917	0.083	8.957
HR	0.901	0.099	10.736
VO_2max	0.92	0.08	8.596
WT	0.913	0.087	9.419
PACES	0.926	0.074	8.008
GHQ-12	0.934	0.066	7.119

Table 4. Critical value table for ranking and classification.

Level	Percentile Threshold	Probit	RSR Critical Value (Fit Value)
1	<3.593	<3.2	<0.228
2	3.593~	3.2~	0.228~
3	27.425~	4.4~	0.5073~
4	72.575~	5.6~	0.7866~
5	96.407~	6.8~	1.0659~

Table 5. Comprehensive evaluation result.

Training Approaches	RSR Ranking	Probit	RSR Fitted Value	Level
HIIT-MICT	1	6.86	1.08	5
HIIT	3	5.67	0.80	4
HIIT-LISS	2	6.15	0.91	4
MICT	5	5.00	0.65	3
MICT-LISS	4	5.32	0.72	3
HIIT-MICT-LISS	6	4.68	0.57	3
LISS	7	4.33	0.49	2
Control	8	3.85	0.38	2

4. Discussion

Exercise has been shown to effectively improve physical condition and health levels. Different durations and intensities of exercise produce varying effects [34]. However, most current studies focus on single-intensity intervention methods, with limited research on alternating between different intensities, especially the alternation between high, moderate, and low intensities. This study expands the methods of exercise intervention by proposing HIIT, MCIT, and LISS, as well as their alternations, based on the real-world situation of social work stress. A 16-week experiment was conducted to explore the effectiveness of different exercise intervention methods.

Exercise intervention is widely regarded as the most effective treatment for fat loss and weight reduction [35]. Without calorie restriction, it has demonstrated good clinical efficacy for weight loss and weight maintenance. Moreover, a combination of various types of exercise, such as aerobic exercise and strength training, has shown even better results for weight reduction [36]. Our study validated the effectiveness of exercise in improving body composition. Participants in all exercise intervention groups experienced varying degrees of reduction in BMI and BFP. The results indicate that the HIIT-LISS, MICT-LISS, and HIIT-MICT intervention methods were most effective in improving participants' BMI, with the combination of high-intensity and low-intensity exercise proving to be particularly effective, achieving a 5.37% improvement. This highlights the effectiveness of alternating exercise modalities in enhancing health indicators [37] and suggests that both HIIT and MICT can induce moderate improvements in body composition [38]. Continuous HIIT is more effective in reducing body fat percentage, with the highest reduction reaching 5.65%. Similar results have also been observed in studies involving obese women [39] and obese adolescents [40]. It is worth noting that the isolated LISS appears to be less effective, as the components of energy balance tend to be compensated, resulting in the calories burned not achieving the desired effect in the short term [41].

Existing research indicates that the effects of prolonged moderate- to high-intensity aerobic exercise on HDL levels are still inconsistent. Some studies suggest that exercise can directly increase HDL level [42], while others propose that exercise only enhances apolipoprotein expression without directly elevating the HDL level [43]. In our study, HIIT shows a significant effect on increasing HDL and decreasing LDL levels. Additionally, alternating between the two types of exercise interventions appears to have an even more pronounced effect. This highlights that the timing and intensity of exercise are two major factors influencing HDL level. However, it is important to note that noticeable changes in serum HDL level typically occur only when weekly exercise exceeds 2 h or caloric expenditure reaches over 900 kcal [44]. A key finding of our study is that exercising approximately 1.5 h per week, three times a week, can also result in more than a 5% increase in HDL levels.

In terms of cardiovascular health, both high-intensity and low-intensity HIIT significantly improves outcomes compared to baseline, with HIIT performed at an intensity of over 70% of HRmax showing more pronounced benefits [45]. In terms of cardiac function, HIIT intervention led to significant improvements in both vascular contraction and relaxation [46]. We also demonstrated the effectiveness of HIIT, finding that different exercise interventions have certain improvements on blood pressure and heart rate. Specifically, HIIT was more effective in reducing blood pressure, with a reduction of nearly 9 mmHg. The MICT-LISS showed a more significant improvement in heart rate, reducing it by approximately 8 BPM. However, a comparative study between HIIT-MICT and MICT alone showed that MICT alone (5 days per week) and MICT combined with one weekly HIIT session (4 days per week) were both effective for cardiovascular health over 12 weeks, but there was no significant difference between the two approaches [47]. This is inconsistent with our research results, which may be attributed to the longer duration of our exercise intervention, highlighting the importance of exercise duration [48].

Cardiorespiratory endurance, as a crucial component of exercise enhancement [34], has been shown to improve VO_2max effectively in comparative studies of regular HIIT, full-body HIIT, and MICT [49]. Both self-directed HIIT and MICT exercises can enhance cardiovascular and respiratory function in individuals [50]. We found that alternating between different intensities, such as HIIT-LISS, MICT-LISS, and HIIT-MICT, leads to more pronounced improvements in cardiovascular fitness, particularly in VO_2max and 6 min walking distance, with a potential maximum increase of about 14% in VO_2max.

In terms of lifestyle and mental health, no significant group differences were found among different intensity intervention methods, although the physiological benefits of HIIT have been confirmed in this study and others [51]. Different exercise intervention methods have a significant impact on participants' enjoyment levels, with HIIT showing a more pronounced effect compared to MICT [52]. However, there are also differing conclusions in the literature [53]. Our research also highlights that exercise interventions significantly improve participants' physical and psychological health, underscoring the crucial role of exercise interventions in fragmented time.

Different exercise intervention methods have demonstrated varying effects on physical health indicators, cardiorespiratory function, and psychological health. Another significant finding from our study is that the HIIT-MICT intervention method is the most effective, showing the best improvement, compared to HIIT alone. In contrast, the HIIT-MICT-LISS and LISS-only interventions appear to be less effective. This also confirms that HIIT-MICT is more effective than single HIIT in fragmented time exercise [21]. Nevertheless, the results also emphasize that when engaging in prolonged exercise, an excessive combination of different exercise modalities may not always be optimal. Instead, alternating between two types of exercise might sometimes yield better outcomes. In summary, exercise interventions can enhance physical health and psychological well-being by improving cardiovascular endurance, increasing strength, and releasing endorphins. Exercise reduces anxiety and depression, while also enhancing emotional stability and overall happiness [54]. Additionally, regular exercise can enhance individuals' self-esteem and confidence, promote social interactions, and overall improve psychological health and quality of life [55].

Despite controlling for multiple variables to investigate the effectiveness of exercise interventions, this study still has some limitations. Firstly, all participants in this study were middle-aged men, so the results only represent this specific demographic. Secondly, the sample size was relatively small, and future research could benefit from including a larger number of participants. Finally, the selection of outcome measures for evaluating exercise intervention effects was limited, although these measures adequately reflect participants' physical health levels. In the future, it may be beneficial to consider changes in muscle mass to evaluate their potential impact on BMI and overall health.

5. Conclusions

This study examines the effects of different exercise interventions on participants' physical and mental health during fragmented exercise sessions. A 16-week follow-up investigation was conducted, and the conclusions drawn have practical significance for the development of public health. The findings can be summarized as follows:

(1) Exercise interventions have been proven to be an effective method for improving both physical and mental health. They can reduce BMI and body fat levels, enhance metabolic health, cardiovascular health, and cardiorespiratory fitness, and have a positive impact on quality of life and mental well-being.

(2) Among the three exercise interventions—HIIT-LISS, MICT-LISS, and HIIT-MICT—the HIIT-LISS is the most effective in improving participants' BMI, showing a reduction of 5.37% compared to pre-intervention levels. Similarly, alternating between two types of exercise interventions yields the best results for lipid profiles and VO_2max, with an increase of 9% in HDL cholesterol, a reduction of approximately 7% in LDL cholesterol, and a 14% improvement in VO_2max. Additionally, the HIIT is most effective in reducing body fat percentage and blood pressure, with a maximum reduction of 5.65% in body fat and nearly 9 mmHg in blood pressure. This exercise mode shows a slightly greater effect on diastolic blood pressure compared to systolic blood pressure. In contrast, the MICT-LISS combination has a greater impact on heart rate, reducing it by 8 BPM. Although the different exercise interventions do not show significant effects on psychosocial health, there is a notable improvement of over 10% in psychological well-being compared to the control group.

(3) The comprehensive evaluation results indicate that the HIIT-MICT is the most effective, followed by HIIT. The HIIT-MICT-LISS has a greater effect than LISS alone, while MICT performs better than MICT-LISS. Our study demonstrates that LISS, when used alone, is less effective as an exercise modality, but it often shows better results when alternated with other types of exercise.

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