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# Effects of weekend-focused exercise on obesity-related hormones and metabolic syndrome markers in male high school students

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To examine the changes in obesity-related hormones and metabolic syndrome markers in male high school students with obesity following a weekend-focused moderate- or high-intensity exercise program at the recommended weekly physical activity level, or a program of regular exercise 3 times a week at moderate intensity, over a 10-week period. Forty-eight male high school students who were obese with a body fat percentage of ≥25% were randomly assigned to one of three groups: a regular moderate-intensity exercise group (n=17) that freely selected and performed moderate-intensity aerobic and resistance training exercises, every Monday, Wednesday, and Friday, for a total of 150–300 min/wk; a weekend-focused moderate-intensity exercise group (n=15) that freely selected and performed aerobic and resistance training exercises every Saturday for 150–300 min; and a weekend-focused high-intensity exercise group (n=16) that freely selected and performed aerobic and resistance training exercises every Sunday for 75–150 min. Insulin and leptin levels significantly decreased in all the groups, with the greatest reduction in the regular exercise group. Abdominal circumference and triglyceride levels significantly decreased in all the groups. Fasting glucose decreased only in the regular exercise group. High-density lipoprotein cholesterol significantly increased in both the regular and weekend-focused moderate-intensity exercise groups. No significant differences in adiponectin levels, and systolic and diastolic blood pressure were observed between the groups. A weekend-focused exercise program has health effects similar to those of regular exercise, highlighting the importance of meeting the recommended weekly physical activity levels.

**Keywords:** Weekend-focused exercise, Insulin, Leptin, Adiponectin, Metabolic syndrome

## INTRODUCTION

The number of obese children and adolescents has increased tenfold globally over the past 40 years. As predicted in a previous study by The World Health Organization (WHO) and Imperial College London in 2017, the number of obese children continued to increase until 2022 (NCD Risk Factor Collaboration, 2017). The WHO reported that 81% of adolescents aged 11–17 worldwide do not meet the recommended daily guideline of 60 min of vigorous physical activity, highlighting a significant deficiency in physical activity in this age group (Guthold et al., 2018). The coronavirus disease 2019 pandemic further led to reduced physical activity in schools, and physical isolation and reliance on online connections worldwide have resulted in rising adolescent obesity, which is already a pressing societal issue (Xiang et al., 2020). Rundle et al. (2020) reported a significant increase in obesity due to a decline in physical activity since the pandemic.

Many individuals are unable to engage in physical activity during the weekdays due to work or academic commitments and therefore exercise only during the weekends. These individuals are often referred to as "weekend warriors" (Lee et al., 2004). Studies have shown no significant differences in health outcomes between those who engage in regular daily exercise and those who perform all their physical activity during the weekends (Dos Santos et al., 2022; Jang et al., 2022; Kany et al., 2024; O'Donovan et al., 2017). Dos Santos et al. (2022) reported that the mortality rate was 8% lower

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for individuals who exercised only on weekends and 15% lower for those who engaged in daily physical activity, compared to those who did not meet the recommended 150 min of exercise per week. O'Donovan et al. (2017) reported that cardiovascular mortality was 41% lower for individuals who exercised daily and 40% lower for those who exercised only during weekends, compared to those who did not engage in any exercise, indicating no significant difference in mortality rates between the two exercise regimes.

New exercise guidelines published by the WHO in 2020 recommend engaging in 150–300 min of moderate-intensity exercises, such as walking, or 75–150 min of high-intensity exercise, or a combination of both, on a weekly basis (Bull et al., 2020). For weekend warriors, weekend-focused exercise entails 150–300 min of moderate-intensity activity each week, or 75–150 min of high-intensity exercise over the weekend or spread across 1/2 days. However, the health benefits of performing the recommended amount of weekly physical activity within just the weekend, remain unknown. An effective weekend-focused exercise regimen could benefit individuals who lack the time for physical activity during weekdays. The prevalence of metabolic syndrome has increased over the past 12 years, particularly among men (Huh et al., 2019). The WHO reported that risk factors associated with metabolic syndrome elevate the likelihood of chronic illnesses. To address this issue effectively, the Adult Treatment Panel III of the National Cholesterol Education Program emphasized the necessity of lifestyle changes, including weight management, increased physical activity, and dietary modifications (National Cholesterol Education Program [NCEP] Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults [Adult Treatment Panel III], 2002). However, the minimum frequency and amount of weekly physical activity required to effectively address metabolic syndrome in individuals with limited time remain unclear.

This study aimed to examine the changes in obesity-related hormones and metabolic syndrome markers in male high school students with obesity following a weekend-focused moderate- or high-intensity exercise program at the recommended weekly activity level, or a program of regular exercise 3 times a week at moderate intensity over a 10-week period. The study results will provide reference data for promoting healthy living among adolescents with obesity.

# MATERIALS AND METHODS

## Subjects

Forty-eight male high school students with obesity from high school in Tangshan, China, with a body fat percentage ≥25% were randomly assigned to one of three groups: a regular exercise group performing 150–300 min of moderate-intensity exercise per week (n=17), a weekend-focused moderate-intensity exercise group exercising for 150–300 min per week (n=15), and a weekend-focused high-intensity exercise group exercising for 75–100 min per week (n=16).

**Table 1.** Physical characteristics of subjects

| Subject | Age (yr) | Height (cm) | Weight (kg) | Body fat (%) |
|---|---|---|---|---|
| Group A (n=17) | 16.06±0.70 | 170.87±4.36 | 78.35±7.56 | 31.66±3.58 |
| Group B (n=15) | 16.33±0.61 | 173.33±3.37 | 81.11±8.02 | 33.11±3.53 |
| Group C (n=16) | 15.73±0.59 | 172.80±3.38 | 76.80±7.27 | 30.29±3.27 |

Values are presented as mean±standard error.
Group A, 150–300 (min/wk) moderate intensity regular exercise group; group B, 150–300 (min/wk) moderate intensity weekend-focused exercise group; group C, 75–150 (min/wk) high intensity weekend-focused exercise group.

This study was approved by the Institutional Review Board of Kunsan National University (approval number: 1040117-202306-HR-008-03). The participants' characteristics are shown in Table 1.

## Experimental procedures

The subjects' blood samples were collected before and after the 10-week program under the same conditions and time periods. The collected blood was centrifuged at 4°C at 3,000 rpm for 10 min at the Department of Diagnostic Testing. After centrifugation, the blood was stored in a freezer at -80°C. All variable analyses were performed at the clinical laboratory and medical verification center of J hospital. Insulin, leptin, and adiponectin levels were analyzed as obesity-related hormones. Metabolic syndrome in this study was defined according to the standards suggested by the National Cholesterol Education Program-Adult Treatment Panel III in 2001 (Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults, 2001) and was categorized into 5 metabolic syndrome indicators including fasting blood glucose, triglyceride (TG), high-density lipoprotein cholesterol (HDL-C), blood pressure, and waist circumference.

The regular exercise group freely selected and performed moderate-intensity aerobic and resistance training exercises every Monday, Wednesday, and Friday, for a total of 150–300 min per week. The weekend-focused moderate-intensity group freely selected and performed aerobic and resistance training exercises every Saturday for 150–300 min. The weekend-focused high-intensity group freely selected and performed aerobic and resistance training exercises every Sunday for 75–150 min.

Aerobic exercises included brisk walking, jogging, jumping


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**Table 2.** Exercise program

| Exercise | Exercise program | | Time (min) | Frequency | Intensity |
|---|---|---|---|---|---|
| Warm-up | Stretching | | 5–10 | | |
| Main exercise | Aerobic exercise | Brisk walking<br>Jogging<br>Jump rope<br>Aerobic dance<br>Trampolines<br>Yoga<br>Badminton<br>Basketball<br>Table tennis<br>Foot ball<br>Stair climbing | Group A: 150–300/wk<br>Group B: 150–300/wk<br>Group C: 75–150/wk | Group A: (Mon, Wed, Fri)<br>Group B: (Sat)<br>Group C: (Sun) | Group A, B: HRmax 65%–75%<br>Group C: HRmax 76%–86% |
| | Resistance exercise | Weight machines<br>Free weights<br>Elastic bands<br>Gym balls<br>Bodyweight exercise | | | Groups A, B: RPE 12–14<br>Group C: RPE 15–17 |
| Cool-down | Stretching | | 5–10 | | |

HRmax, maximum heart rate; RPE, ratings of perceived exertion; group A, 150–300 (min/wk) moderate intensity regular exercise group; group B, 150–300 (min/wk) moderate intensity weekend-focused exercise group; group C, 75–150 (min/wk) high intensity weekend-focused exercise group.

rope, aerobic dance, badminton, basketball, table tennis, stair climbing, trampoline exercises, and yoga. Resistance training included free weights, weight machines, resistance bands, gym balls, and bodyweight exercises (such as push-ups, sit-ups, squats, planks, and pull-ups) (Table 2).

### Statistical analyses

All data analyses in this study were conducted using IBM SPSS Statistics ver. 26.0 (IBM Co., Armonk, NY, USA). Mean and standard errors were calculated for each variable. To assess changes in the levels of obesity-related hormones and metabolic syndrome markers among the three exercise groups, repeated measures analysis of variance was conducted. Duncan test was performed as a *post hoc* analysis to evaluate these changes. The significance level was set at 0.05.

## RESULTS

### Changes in insulin levels

Changes in the insulin level are presented in Table 3. A significant interaction was observed between group and time ($F=3.531$, $P=0.041$). In all the exercise groups, insulin levels significantly decreased compared to baseline measurements before the intervention ($P<0.05$). Group A (regular moderate-intensity exercise)

**Table 3.** Changes in the insulin (μU/mL) from pre- to postexercise in each group

| Group | Pre | Post | *F* (*P*-value) | *Post hoc* |
|---|---|---|---|---|
| A | 8.78±3.38 | 7.75±2.32 | 7.757 (0.018) | |
| B | 8.50±3.41 | 8.21±3.21 | 5.781 (0.035) | A>B, C |
| C | 9.50±2.80 | 9.25±2.73 | 5.656 (0.039) | |
| $F_{group*time}=3.531$ ($P=0.041$) | | | | |

Values are presented as mean±standard error.
Group A, 150–300 (min/wk) moderate intensity regular exercise group; group B, 150–300 (min/wk) moderate intensity weekend-focused exercise group; group C, 75–150 (min/wk) high intensity weekend-focused exercise group.

showed the most significant reduction in insulin levels.

### Changes in leptin levels

Changes in the leptin level are presented in Table 4. A significant interaction was observed between group and time ($F=3.727$, $P=0.034$). In all the exercise groups, leptin levels significantly decreased compared to baseline measurements before the intervention ($P<0.05$). The changes in leptin levels differed between group A (regular moderate-intensity exercise) and group C (weekend-focused high-intensity exercise).

### Changes in adiponectin levels

Changes in the adiponectin level are presented in Table 5. There

**Table 4.** Changes in the leptin (ng/mL) from pre- to postexercise in each group

| Group | Pre | Post | *F* (*P*-value) | *Post hoc* |
|---|---|---|---|---|
| A | 8.28±3.38 | 7.18±2.74 | 9.750 (0.010) | |
| B | 7.11±3.51 | 6.66±3.10 | 6.519 (0.025) | A>C |
| C | 7.56±2.52 | 7.33±2.27 | 5.391 (0.040) | |
| $F_{group*time}$=3.727 ($P$=0.034) | | | | |

Values are presented as mean±standard error.
Group A, 150–300 (min/wk) moderate intensity regular exercise group; group B, 150–300 (min/wk) moderate intensity weekend-focused exercise group; group C, 75–150 (min/wk) high intensity weekend-focused exercise group.

**Table 5.** Changes in the adiponectin (μU/mL) from pre- to postexercise in each group

| Group | Pre | Post |
|---|---|---|
| A | 6.62±2.23 | 7.39±1.65 |
| B | 6.12±2.09 | 6.24±1.45 |
| C | 7.31±2.30 | 7.43±1.84 |
| $F_{group*time}$=1.698 ($P$=0.195), $F_{group}$=1.578 ($P$=0.216), $F_{time}$=4.112 ($P$=0.049) | | |

Values are presented as mean±standard error.
Group A, 150–300 (min/wk) moderate intensity regular exercise group; group B, 150–300 (min/wk) moderate intensity weekend-focused exercise group; group C, 75–150 (min/wk) high intensity weekend-focused exercise group.

**Table 6.** Changes in the waist circumference (cm) from pre- to postexercise in each group

| Group | Pre | Post | *F* (*P*-value) | *Post hoc* |
|---|---|---|---|---|
| A | 94.43±8.42 | 90.52±6.07 | 20.212 (0.001) | |
| B | 95.89±7.99 | 94.48±7.87 | 6.207 (0.026) | A>B, C |
| C | 92.41±9.38 | 91.63±8.70 | 5.106 (0.040) | |
| $F_{group*time}$=6.881 ($P$=0.003) | | | | |

Values are presented as mean±standard error.
Group A, 150–300 (min/wk) moderate intensity regular exercise group; group B, 150–300 (min/wk) moderate intensity weekend-focused exercise group; group C, 75–150 (min/wk) high intensity weekend-focused exercise group.

was no interaction between group and time of measurement. Although no main effect in groups observed, significant difference in times was observed ($F$=4.112, $P$=0.049).

### Changes in waist circumference

Changes in the waist circumference are presented in Table 6. A significant interaction was observed between group and time ($F$=6.881, $P$=0.003). In all the exercise groups, abdominal circumference significantly decreased compared to baseline measurements before the intervention ($P$<0.05). Group A (regular moderate-intensity exercise) had the most significant reduction in insulin levels.

**Table 7.** Changes in the systolic blood pressure (mmHg) from pre- to postexercise in each group

| Group | Pre | Post |
|---|---|---|
| A | 120.13±9.29 | 118.67±6.88 |
| B | 122.40±8.74 | 121.33±7.82 |
| C | 118.67±6.35 | 117.73±4.61 |
| $F_{group*time}$=0.078 ($P$=0.925), $F_{group}$=1.013 ($P$=0.372), $F_{time}$=4.034 ($P$=0.051) | | |

Values are presented as mean±standard error.
Group A, 150–300 (min/wk) moderate intensity regular exercise group; group B, 150–300 (min/wk) moderate intensity weekend-focused exercise group; group C, 75–150 (min/wk) high intensity weekend-focused exercise group.

**Table 8.** Changes in the diastolic blood pressure (mmHg) from pre- to postexercise in each group

| Group | Pre | Post |
|---|---|---|
| A | 77.80±8.90 | 75.93±5.28 |
| B | 75.47±5.78 | 74.13±4.14 |
| C | 77.00±6.25 | 76.13±5.46 |
| $F_{group*time}$=0.109 ($P$=0.897), $F_{group}$=0.642 ($P$=0.531), $F_{time}$=2.404 ($P$=0.129) | | |

Values are presented as mean±standard error.
Group A, 150–300 (min/wk) moderate intensity regular exercise group; group B, 150–300 (min/wk) moderate intensity weekend-focused exercise group; group C, 75–150 (min/wk) high intensity weekend-focused exercise group.

**Table 9.** Changes in the fasting blood glucose (mg/dL) from pre- to postexercise in each group

| Group | Pre | Post | *F* (*P*-value) | *Post hoc* |
|---|---|---|---|---|
| A | 93.56±8.74 | 89.87±5.05 | 8.576 (0.011) | |
| B | 92.06±8.32 | 90.87±7.21 | 3.853 (0.070) | A>B, C |
| C | 90.73±6.45 | 89.82±7.27 | 4.204 (0.060) | |
| $F_{group*time}$=3.285 ($P$=0.047) | | | | |

Values are presented as mean±standard error.
Group A, 150–300 (min/wk) moderate intensity regular exercise group; group B, 150–300 (min/wk) moderate intensity weekend-focused exercise group; group C, 75–150 (min/wk) high intensity weekend-focused exercise group.

### Changes in systolic and diastolic blood pressure

Changes in the systolic and diastolic blood pressure are presented in Tables 7 and 8. There was no interaction between group and time of measurement. No main effects in groups and times were observed.

### Changes in fasting blood glucose levels

Changes in the fasting blood glucose level are presented in Table 9. A significant interaction was observed between group and time ($F$=3.285, $P$=0.047). Group A (regular moderate-intensity exercise) showed a significant decrease in fasting blood glucose levels compared to baseline measurements before the intervention

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**Table 10.** Changes in the triglyceride (mg/dL) from pre- to postexercise in each group

| Group | Pre | Post | *F* (*P*-value) | *Post hoc* |
|---|---|---|---|---|
| A | 151.31±23.43 | 137.69±15.20 | 13.096 (0.003) | |
| B | 154.74±18.71 | 152.09±22.78 | 5.554 (0.036) | A>B, C |
| C | 147.30±27.10 | 146.50±24.73 | 6.220 (0.027) | |
| $F_{group*time}$=6.997 (*P*=0.003) | | | | |

Values are presented as mean±standard error.
Group A, 150–300 (min/wk) moderate intensity regular exercise group; group B, 150–300 (min/wk) moderate intensity weekend-focused exercise group; group C, 75–150 (min/wk) high intensity weekend-focused exercise group.

**Table 11.** Changes in the high-density lipoprotein cholesterol (mg/dL) from pre- to postexercise in each group

| Group | Pre | Post | *F* (*P*-value) | *Post hoc* |
|---|---|---|---|---|
| A | 43.10±6.12 | 49.33±7.34 | 17.126 (0.001) | |
| B | 43.91±5.30 | 46.61±7.11 | 5.616 (0.034) | A>B, C |
| C | 41.88±4.92 | 43.28±4.87 | 4.591 (0.052) | |
| $F_{group*time}$=4.622 (*P*=0.016) | | | | |

Values are presented as mean±standard error.
Group A, 150–300 (min/wk) moderate intensity regular exercise group; group B, 150–300 (min/wk) moderate intensity weekend-focused exercise group; group C, 75–150 (min/wk) high intensity weekend-focused exercise group.

($P<0.05$). While group B (weekend-focused moderate-intensity exercise) and group C (weekend-focused high-intensity exercise) had decreased fasting blood glucose levels, the change was not statistically significant.

### Changes in TG levels

Changes in the TG level are presented in Table 10. A significant interaction was observed between group and time ($F=6.997$, $P=0.003$). In all the exercise groups, TG levels significantly decreased compared to baseline measurements before the intervention ($P<0.05$), with group A (regular moderate-intensity exercise) showing the most significant reduction.

### Changes in HDL-C levels

Changes in the HDL-C level are presented in Table 11. A significant interaction was observed between group and time ($F=4.622$, $P=0.016$). Group A (regular moderate-intensity exercise) and group B (weekend-focused moderate-intensity exercise) had significantly increased HDL-C levels compared to baseline measurements before the intervention ($P<0.05$). While group C (weekend-focused high-intensity exercise) showed a decrease in HDL-C levels, the change was not statistically significant.

## DISCUSSION

Physical activity is a critical indicator of adolescents' health development. Pediatric and adolescent obesity resulting from insufficient physical activity is likely to lead to metabolic syndrome, including adult obesity, diabetes, hypertension, and hyperlipidemia, thereby presenting a serious problem in modern society (Endalifer and Diress, 2020; Garneau et al., 2020). In adolescent obesity, fat cells increase in both size and number, greatly raising the risk of adult obesity and leading to insulin resistance due to the proliferation of fat cells (de Luca and Olefsky, 2006). Insulin, which facilitates the entry of blood glucose into human tissue cells and limits the conversion of TG to free fatty acids, is elevated in patients with obesity or diabetes with an abundance of fat cells, indicating high insulin resistance (Frystyk, 2010). Exercise effectively regulates insulin secretion. Bharath et al. (2018) and Kim et al. (2020) found that regular moderate-intensity exercise reduces insulin levels in female adolescents with obesity. Leptin regulates diet and energy expenditure to control obesity and is closely associated with body fat levels. Energy expenditure through exercise directly reduces leptin synthesis and secretion; higher frequency and intensity of exercise are associated with more favorable outcomes (Unal et al., 2004; Webber, 2003). Borfe et al. (2021) and Yetgin et al. (2018) reported reduced leptin levels in male and female adolescents with obesity following a 60-min exercise program that included cardiovascular and resistance training, conducted 3 days a week. In this study, the 10-week weekend-focused exercise regimens (both moderate and high intensity) and the regular exercise regimen (moderate intensity, 3 times a week) positively influenced insulin and leptin levels in male high school students. Insulin and leptin levels were particularly reduced in the regular exercise group, which engaged in 150–300 min of moderate-intensity workouts per week.

Adiponectin, released by adipose tissue cells, reduces fatty acids in the blood and TG in muscles, thereby enhancing insulin sensitivity (Fruebis et al., 2001). Adiponectin is recognized as a link between obesity and insulin resistance. Previous studies involving adolescents with obesity have reported an increase in adiponectin levels following regular moderate-intensity cardiovascular and resistance training (Bharath et al., 2018; Dâmaso et al., 2014; de Mello et al., 2011). In this study, adiponectin levels increased in all the exercise groups, with no significant differences between the groups. Since adiponectin is negatively correlated with weight in children and adolescents (Yang et al., 2001), the increase in adiponectin levels may result from weight and fat loss due to long-term exercise.

High TGs, resulting from increased free fatty acids in adipose tissue, low HDL-C, and abdominal obesity, which promotes hyperglycemia and hypertension, are major risk factors for metabolic syndrome (Shulman, 2000). Abdominal circumference is strongly associated with weight, and regular exercise generally reduces both weight and abdominal circumference (Li et al., 2020). In studies involving children and adolescents with obesity, various types of physical activities, as well as moderate-intensity cardiovascular and resistance training, significantly reduced abdominal circumference (de Mello et al., 2011; Kim et al., 2020). In this study, abdominal circumference significantly decreased in all the exercise groups, with greatest reduction in the regular moderate-intensity exercise group.

Physical activity and exercise enhance glucose utilization by muscles, thereby regulating blood glucose levels, increasing insulin sensitivity, and effectively preventing the progression to metabolic disorders (Koutroumpi et al., 2008). In this study, the regular exercise group (3 times a week) showed a significant decrease in fasting blood glucose levels, while the weekend-focused exercise groups demonstrated a decrease that was not statistically significant. Decrease in fasting blood glucose in response to changes in fat distribution from weight loss, specifically the reduction of visceral fat relative to subcutaneous fat, which increases insulin sensitivity, enhances glucose absorption by peripheral tissues, and inhibits glucose synthesis by the liver (Sarafidis and Bakris, 2006). The reduction in fasting blood glucose observed in this study may be associated with increased muscle mass and a decreased percentage of abdominal visceral fat relative to subcutaneous fat, resulting from reductions in body fat percentage and abdominal circumference.

While previous studies have reported varying results regarding the effects of exercise on TG and HDL-C, Dâmaso et al. (2014) found that combining cardiovascular training with resistance training yielded more favorable outcomes for these markers. The study by Monteiro et al. (2015) investigating effective exercise regimens for improving blood lipid levels concluded that both a hybrid regimen combining cardiovascular and resistance training and a cardiovascular-only training program can enhance blood lipid profiles.

In this study, both regular moderate-intensity exercise and weekend-focused moderate-intensity exercise positively impacted TG and HDL-C levels. The weekend-focused high-intensity exercise group showed a significant reduction in TG and an increase in HDL-C. Although ≥ 150 min of moderate to high-intensity physical activity weekly typically reduces hypertension risk factors, this study found no significant differences in systolic and diastolic blood pressure between the exercise groups, probably because the adolescents maintained normal blood pressure levels despite obesity.

It is easy to assume that performing all physical activity during the weekend may not yield effective outcomes. However, since many find it more convenient to engage in physical activity during weekends or part-time, O'Donovan et al. (2018) emphasized the importance of meeting the recommended physical activity levels, regardless of the number of exercise sessions per week. He et al. (2014) and Zhang et al. (2017) conducted a meta-analysis on physical activity and metabolic syndrome and suggested that more vigorous physical activity than what is recommended by the WHO is necessary to prevent metabolic syndrome. Jang et al. (2022) recommended incorporating not only moderate-intensity but also high-intensity physical activity for weekend warriors.

In this study, a significant but small difference in the risk of metabolic syndrome was observed between the regular moderate-intensity exercise group and the weekend-focused moderate- or high-intensity exercise group, supporting Jang et al. (2022), who reported that both regular moderate-intensity exercise and weekend-focused moderate- or high-intensity exercise effectively reduce the risk of metabolic syndrome. This highlights that meeting the weekly recommended physical activity amount is more important than the frequency of exercise, suggesting that the timing of workouts is less critical. It underscores the importance of engaging in at least 150 min of moderate-intensity exercise each week. According to a recent study by Kany et al. (2024), weekend-focused exercise is associated with a reduced risk of 264 disorders, suggesting that the amount of exercise is more important than the pattern of exercise. Finally, given the association between dietary intake and metabolic syndrome, we recommend that future studies should use accurate dietary intake data. In conclusion, while regular exercise is essential, adolescents with decreasing physical activity levels at school and limited opportunities for exercise during the week should be encouraged to adopt a regimen that effectively combines moderate and high-intensity exercises on weekends, ensuring they meet the recommended physical activity levels in a way that suits their lifestyles.

## CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.


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