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Effects of Moderate and High Intensity Exercise on Body Composition and Resting Energy Expenditure in Moroccan Adolescents: A 12-Week Controlled Study

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ABSTRACT

Objective: This study aimed to compare the effects of moderate-intensity continuous training (MICT) and high-intensity interval training (HIIT) on body composition, cardiovascular parameters, and resting energy expenditure among overweight Moroccan adolescents.

Methods and Materials: A 12-week controlled intervention study was conducted among 90 Moroccan adolescents aged 12–17 years from middle and high schools in Khemisset, Morocco. Participants were randomly assigned to a control group, MICT group, or HIIT group, with 30 participants in each group. Anthropometric indices, waist-to-hip ratio, fat mass, fat-free mass, systolic and diastolic blood pressure, resting heart rate, and resting energy expenditure were assessed before and after the intervention. Body fat percentage was estimated using Slaughter skinfold equations, and resting energy expenditure was predicted using Müller equations. Data were analyzed using repeated-measures ANOVA and post hoc comparisons.

Findings: Significant BMI reductions were observed in the MICT group, 27.59 ± 1.73 to 26.32 ± 1.57, $p = .004$, and HIIT group, 27.73 ± 1.85 to 26.32 ± 1.80, $p = .004$, with a significant time × group interaction, $p = .004$, $\eta^2 = .10$. Waist-to-hip ratio decreased significantly only in the HIIT group, $p = .009$. Systolic and diastolic blood pressure decreased in MICT, $p = .009$ and $p = .006$, and HIIT, both $p < .001$. Resting heart rate decreased significantly in MICT and HIIT, both $p < .001$. Fat mass, fat-free mass, and resting energy expenditure did not change significantly within groups, $p > .05$.

Conclusion: MICT and HIIT improved BMI and cardiovascular parameters but did not significantly alter resting energy expenditure or detailed body composition.

Keywords: Exercise Intensity, Body Composition, Resting Energy Expenditure, Adolescents.

Introduction

Physical activity is defined as any voluntary bodily movement generated by the contraction of skeletal muscles, involving measurable energy expenditure (Piggin, 2020). Many studies have highlighted a positive association between regular physical activity and the improvement of health-related physical fitness (Hao et al., 2024; Malm et al., 2019). The latter corresponds to all the components of physical fitness that are directly influenced by an active lifestyle and that have a close link with the maintenance or improvement of health status (Dhuli et al., 2022; Kapoor et al., 2022). The dynamic interactions between physical activity, health-related physical fitness and overall health indicators have been extensively described by Bouchard et al., (2012).

A significant body of research has highlighted significant differences in energy expenditure patterns between youth and adults, differences attributed to biological factors such as basal metabolic rate, growth and pubertal maturation processes, and body composition (Bitar et al., 2000; Goran, 1997; Roemmich et al., 2000). It is now well established that children and adolescents do not mobilize their energy in a manner comparable to that of adults, due to both their evolving physiological profile and the specificities of their motor behaviors (Harrell et al., 2005).

In recent years, several methodological approaches have been used to assess the impact of physical activity on body composition and energy expenditure in young people, allowing the development and validation of predictive models to reliably estimate energy expenditure in this population (Acar-Tek et al., 2023; Kua et al., 2025; Porter et al., 2024; Prado-Nóvoa et al., 2024).

Health problems related to excess weight are increasingly common among children and adolescents. There is currently no database recording the energy expenditure of young people in Morocco. Various approaches and methods have been devised to determine as precisely as possible the relationships between physical activity and energy expenditure in children and adolescents (Baillot et al., 2021).

Although several studies have examined the effects of exercise on REE and body composition in adolescents, data from Moroccan populations remain scarce. Existing evidence suggests that both moderate-intensity continuous training (MICT) and high-intensity interval training (HIIT) may improve metabolic health, but their comparative effects on REE and body composition in adolescents are not well established. This study aimed to evaluate the effects of 12 weeks of MICT and HIIT on body composition and resting energy expenditure in Moroccan adolescents aged 12–17 years.

Methods and Materials

Study Design

This study was a 12-week controlled intervention with pre- and post-measurements, conducted in the city of Khemisset (Morocco) from October 15, 2023, to June 15, 2024. The study comprised 90 students from middle and high schools were included, consisting of 45 boys and 45 girls, resulting in a sex ratio of 1. Their ages ranged from 12 to 17 years (mean: 14.2 ± 0.3 years for boys and 13.8 ± 0.2 years for girls). The target population comprised students enrolled in middle and high schools within the educational jurisdiction of Khemisset, Morocco.

Population

Ninety adolescents (45 girls and 45 boys), aged 12 to 17 years, were recruited for this study, an age range selected for its developmental significance, reflecting the transition from childhood to adolescence, and aligning with prior research. Recruitment occurred in multiple educational institutions (middle and high schools), showcasing a variety of socioeconomic backgrounds. Following a classroom presentation and the dissemination of informational materials, interested students and their parents were invited to an in-depth information session. Participation required the execution of informed consent by the minor and their legal guardian. The formation of gender-balanced groups facilitates the analysis of established disparities in energy expenditure between boys and girls, as indicated by prior research. The 90 adolescents were randomly assigned to three groups: MICT (n = 30), HIIT (n = 30), and a control group (n = 30). All baseline characteristics and anthropometric measures were similar across groups (Table 1).

Table 1

Gender of participants according to group study.

	Control	MICT	HIIT
Female	15	15	15
Male	15	15	15

Ethical Considerations

The study protocol was approved by the Faculty of science ethics committee of Ibn Tofail university, Morocco (02/2024), and written informed consent was obtained from participants and their guardians.

Physical exercise Program

The study comprised three distinct groups, each containing 30 adolescents aged 12 to 17 years, all of whom were healthy yet classified as overweight or obese (BMI > 25). In the three months preceding the experiment, no participants engaged in a structured physical activity program beyond standard physical education classes (Table 2).

The initial group (the control group) did not engage in a designated training program during the intervention and functioned as a control.

The second group engaged in a moderate-intensity continuous training (MICT) regimen, comprising continuous running sessions conducted three times weekly for a duration of 12 weeks. The exercise intensity was modified to achieve a target heart rate indicative of moderate exertion, aligning with guidelines for enhancing cardiovascular fitness and metabolic health in adolescents.

The third group underwent high-intensity interval training (HIIT), based on 30 repetitions of intermittent running, also organized into three weekly sessions for 12 weeks. The intensity of the workouts was monitored by a heart rate monitor to ensure adherence to target heart rate zones corresponding to the requirements of high-intensity training.

Each session in the intervention groups was preceded by a warm-up phase and followed by a cool-down period, including stretching exercises and slow walking, respectively.

Thus, the main difference between the groups lay in the exercise modality: no structured activity for the control group, moderate continuous training for the MICT group, and high-intensity intermittent training for the HIIT group.

Table 2

Training protocol

Training	Program	weeks 1 à 4	weeks 5 à 8	weeks 9 à 12
High-intensity interval training	Work:Recovery (s)	15 : 15	15: 15	15:15
	Training intensity	90% MAS	95% MAS	100% MAS
	Number of series	8	8	8
	Heart rate (bpm)	170	175	180
	Time (Hao et al. 2024)	11-15	11-15	11-15
Moderate-intensity continuous training	Training intensity	70% MAS	75% MAS	80% MAS
	Work: Recovery (Hao et al. 2024)	30 : 10	30 : 10	25 : 10
	Number of series	1	1	1
	Heart rate (bpm)	150	155	160
	Time (Hao et al. 2024)	30	30	30

MAS: maximal aerobic speed.

Measurement

Measurements of height (measured to the nearest 0.5 cm), weight (estimated to the nearest 0.1 kg) and skinfolds were taken before and after the study. The body mass index (BMI) was determined using the formula [Weight (kg)] / [Height (m)]^2.

The abdomen-to-hip ratio (AHR) was deduced from the values of the abdomen and hip perimeters (measurement accuracy ±1cm).

Body composition was defined as the relative proportions of fat mass Hoffman et al., (2000) and fat-free mass Hoffman et al., (2000). FFM includes metabolically active tissues such as muscle, organs, bone, and body water, whereas FM represents both essential and storage fat. In this study, body fat percentage was estimated using skinfold thickness measurements and Slaughter equations, from which FM and FFM were derived.

The heart rate (HR), quantified in beats per minute (bpm), was assessed utilizing a portable heart rate monitor (Polar × Trainer plus™) that documented beats at five-second intervals. The system comprised a sensor affixed to the torso via a belt and a wrist-mounted receiver resembling a watch. Blood pressure, comprising systolic blood pressure (SBP) and diastolic blood pressure (DBP), was assessed on the right arm utilizing a digital sphygmomanometer.

Resting energy expenditure Dhuli et al., (2022) was estimated using the Müller predictive equations, which are commonly employed for adolescents and take into account age, sex, and body composition. Despite being formulated for European populations, these equations offer acceptable estimations for resting energy expenditure Dhuli et al., (2022) in Moroccan adolescents, given the absence of validated country-specific REE equations at present.

REE (MJ/day) = 0.07885 × FFM (kg) + 0.02132 × FM (kg) + 0.327 × sex + 2.694

where fat-free mass and fat mass (Hoffman et al., 2000) are expressed in kilograms, and sex is coded as 1 for males and 0 for females.

Statistical analysis

The collected data were analyzed utilizing R software. Continuous variables are represented as means accompanied by their standard deviations, facilitating a more accurate interpretation of data variability. Data were analyzed using repeated-measures ANOVA to evaluate time, group, and interaction effects. Normality was assessed prior to analysis. Post hoc comparisons were conducted where appropriate, with significance set at $p < 0.05$.

Findings and Results

Characteristics of participants

The study included 90 adolescents, divided equally between 45 girls and 45 boys, all of whom voluntarily agreed to participate. Before any statistical analysis, a symmetry test was applied to all data to verify sample balance. The normality of the distribution of variables was then assessed using the Kolmogorov-Smirnov test ($p > 0.05$), confirming that all variables were normally distributed (Table 3). Baseline characteristics showed minor differences between groups, including a significant age difference ($p < 0.05$), which was accounted for in the analysis.

Table 3

Characteristics of participants.

		Control (n=30)	MICT (n=30)	HIIT (n=30)	p-value
Age		15±1.63	14.5±1.8	15.2±1.44	0.045
Gender	Male	15	15	15	-
	Female	15	15	15	
BMI		27.30±1.39	27.59±1.73	27.73±1.85	0.595

Body composition

Table 3 presents the body composition and cardiovascular parameters of high school students before and after 12 weeks of moderate-intensity (MICT) and high-intensity (HIIT) physical training, compared to a control group (Table 4).

Regarding BMI, the MICT and HIIT groups showed a significant reduction after training ($p = 0.004$ for both), while no difference was observed in the control group ($p = 0.807$). For waist-to-hip ratio, only the decrease in the HIIT group was significant ($p = 0.009$). Fat mass tended to decrease more in the intervention groups, particularly the MICT (average decrease of 1.52 kg), but without reaching statistical significance. Free fat mass remained generally stable in all three groups. No significant changes were observed in fat mass or fat-free mass within groups ($p > 0.05$). On the cardiovascular level, systolic and diastolic pressures decreased significantly in the MICT ($p = 0.009$ and $p = 0.006$) and HIIT ($p < 0.001$ for both) groups, while they remained unchanged in the control group. Similarly, resting heart rate decreased very significantly in the trained groups ($p < 0.001$), while it did not vary in the controls.

The repeated measures ANOVA revealed significant time × group interactions for BMI ($p = 0.004$, $\eta^2 = 0.10$), indicating a notable reduction in the MICT and HIIT groups after 12 weeks. Fat mass in the MICT group decreased marginally (−1.52 kg) without achieving statistical significance ($p = 0.08$), whereas lean mass remained constant across all groups ($p > 0.05$).

Table 4

Body composition parameters before and after moderate- and high-intensity physical training.

Variables	Groups	Pretraining	Post-training	MD 95% CI	p-value
BMI (kg/m^2)	Control	27.30±1.39	27.38±1.31	-0.09 (-0.78, 0.61)	0.807
	MICT	27.59±1.73	26.32±1.57	1.28 (0.42, 2.13)	0.004**
	HIIT	27.73±1.85	26.32±1.80	1.41 (0.47, 2.35)	0.004**
Waist-to-hip ratio	Control	0.92±0.08	0.92±0.08	0.01 (-0.04, 0.04)	0.947
	MICT	0.91±0.05	0.89±0.05	0.02 (-0.01, 0.04)	0.216
	HIIT	0.88±0.04	0.85±0.03	0.03 (0.01, 0.04)	0.009**
Fat mass	Control	22.34±3.47	22.91±3.48	-0.58 (-2.38, 1.22)	0.521
	MICT	22.76±4.36	21.24±3.78	1.52 (-0.58, 3.63)	0.153
	HIIT	22.58±4.44	22.37±4.34	0.21 (-2.06, 2.47)	0.857
Free fat mass	Control	49.79±6.24	50.82±6.28	-1.03 (-4.26, 2.21)	0.529
	MICT	48.59±5.63	48.41±5.58	0.18 (-2.72, 3.07)	0.903
	HIIT	48.21±6.76	48.70±5.90	-0.49 (-3.77, 2.79)	0.767
Systolic pressure	Control	123.67±4.76	124.03±4.95	-0.37 (-2.88, 2.14)	0.771
	MICT	121.87±4/18	118.97±4.12	2.90 (0.76, 5.04)	0.009**
	HIIT	127.03±3.65	122.73±3.49	4.3 (2.45, 6.15)	<0.001***
Diastolic pressure	Control	80.67±5.02	80.63±5.03	0.03 (-2.56, 2.63)	0.980
	MICT	80.87±3.20	78.53±3.09	2.33 (0.71, 3.96)	0.006**
	HIIT	83.87±3.59	80.10±3.19	3.77 (2.01, 5.52)	<0.001***
Heart rat	Control	84.23±3.18	83.97±3.16	0.27 (-1.37, 1.90)	0.746
	MICT	79.93±3.25	76.23±3.40	3.7 (1.98, 5.42)	<0.001***
	HIIT	84.17±4.62	78.73±4.31	5.43 (3.12, 7.74)	<0.001***

** p<0.05, ** p<0.01, *** p<0.001 pre-training vs. post-training.*

Energy expenditure

The various energy expenditure measures were measured over a 3-month period. Table 5 shows the average energy expenditure of participants (in kcal/day) before and after the intervention according to three groups: control, MICT and HIIT. Before the intervention, the initial values of energy expenditure were similar between the groups ($p = 0.722$). After 12 weeks, a slight increase was observed in the control group (1754.54 ± 151.09 kcal/day vs. 1730.56 ± 149.59), while a decrease was noted in the MICT group (1685.31 ± 131.85 vs. 1710.61 ± 123.99). The HIIT group showed stability with a very slight increase (1714.13 ± 130.32 vs. 1701.81 ± 148.48). However, none of these variations reached statistical significance ($p > 0.05$), either in intra-group or inter-group comparisons.

Before training, REE is a little higher in the control group compared to the MICT and the HIIT groups (1810 vs. 1744 and 1747 kcal/d) ($p > 0.05$). After training, an increase in REE was observed in the control and HIIT groups, while the MICT group showed a slight decrease. However, neither of these variations was significant ($p > 0.05$).

In contrast, the inter-group comparison post-intervention revealed a statistically significant difference ($p < 0.001$), indicating that the groups did not respond in the same way to training.

In girls, the initial situation was reversed: the control group had a lower REE than the MICT and HIIT groups (1650 vs. 1677 and 1656 kcal/d), with no significant difference ($p = 0.722$). After the intervention, all values increased slightly in all three groups, and no intra-group variation was significant ($p > 0.05$). However, the inter-group comparison following the intervention revealed a statistically significant difference ($p < 0.001$) in males and 12-14 years students.

Table 5

Resting energy expenditure measured in participants (Kcal/day).

		Pretraining	Post-training	P-value (test-t)
Total	Control	1730.56±149.59	1754.54±151.09	0.539
	MICT	1710.61±123.99	1685.31±131.85	0.447
	HIIT	1701.81±148.48	1714.13±130.32	0.734
	p-value	0.722	0.155	
Males	Control	1810.17±156.56	1840.07±152.08	0.869
	MICT	1744.03±135.79	1708.65±156.79	0.467
	HIIT	1747.07±185.65	1758.25±161.61	0.578
	p-value	0.451	<0.001	
Females	Control	1650.95±91.40	1669.01±91.94	0.900
	MICT	1677.20±104.96	1661.96±101.27	0.838
	HIIT	1656.55±82.51	1669.99±69.87	0.389
	p-value	0.722	<0.001	
12-14 years	Control	1619.28±78.14	1654.57±115.17	0.379
	MICT	1615.46±55.92	1577.34±52.72	0.756
	HIIT	1613.44±95.85	1655.16±69.06	0.064
	p-value	0.982	0.031	
15-17 years	Control	1815.66±134.98	1830.99±130.66	0.802
	MICT	17.93.88±105.68	1779.79±103.90	0.953
	HIIT	1752.98±151.25	1748.27±146.13	0.825
	p-value	0.364	0.167	

Resting Energy Expenditure and weight following MICT and HIIT Programs

The figure shows two correlation graphs between body weight and resting energy expenditure Dhuli et al., (2022) according to the type of training performed (Figure1).

The graph on the left illustrates the relationship between weight and REE after moderate-intensity continuous training (MICT).

The graph on the right shows the same relationship after high-intensity interval training (HIIT).

In both cases, linear regression indicates a positive correlation between weight and REE: the higher the weight, the higher the resting energy expenditure. However, REE values were overall higher in the HIIT group than in the MICT group.

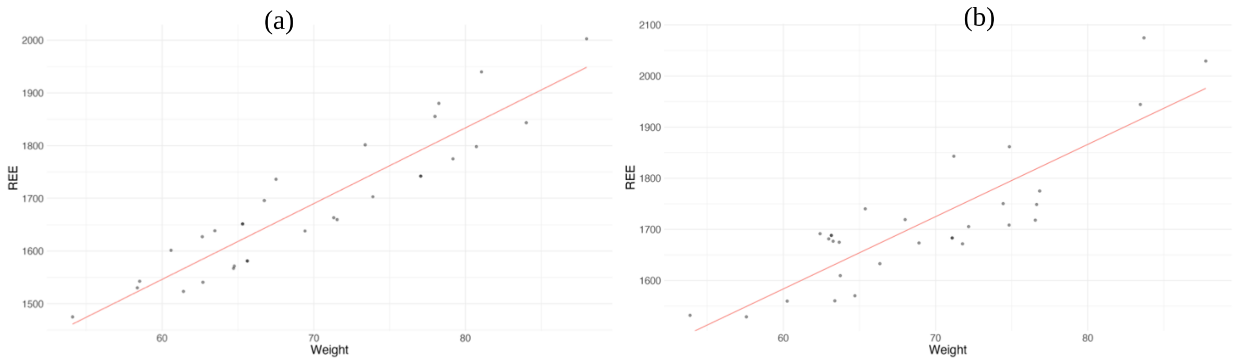

Figure 1

Correlation between REE and weight in adolescents following moderate-intensity (r=.925) (a) and high-intensity training (r=.861) (b).

Discussion and Conclusion

The primary aim of this study was to assess the energy expenditure of Moroccan adolescents aged 12 to 17 years according to the intensity of their physical activity and to present the energy expenditure of our participants in comparison with similar studies conducted in other countries.

Despite the diversity of experimental designs in terms of sample size, available resources, and study settings, the common objective of this research has been to identify the most robust methods adapted to the real-life context of young people (de Graauw et al., 2010). A major literature review conducted by Butte et al. (2012) identified six measurement methods commonly used in empirical studies: pedometers, load or power sensors, accelerometers, heart rate monitors, devices combining accelerometry and heart rate, and multi-sensor systems (Butte et al., 2012).

However, each of these methods has intrinsic limitations, particularly when quantifying energy expenditure in free and uncontrolled environments. Studies such as those by Barreira et al. (2009) and Butte et al. (2012) highlighted the potential biases associated with the isolated use of certain sensors (particularly pedometers or accelerometers), particularly with regard to estimating exercise intensity, the intermittent nature of physical activity in young people, and the inter-individual variability in the energy cost of movement (Butte et al., 2012).

For body composition, our findings show no significant effect of training on fat mass or free fat mass in both males and females. This result is different from findings from other countries (Lazzer et al., 2011; Pulido et al., 2021). Consistent with the conclusions drawn on morphological aspects, girls show few differences according to age. Boys, on the other hand, show an increase in FFM, which is perfectly consistent with a growth spurt. These no significant changes may be explained by the short duration of the training (12 weeks) or, probably, by uncontrolled nutritional intake. The observed improvements in BMI and blood pressure are empirically supported by the data. Physiological explanations, such as enhanced vascular function, improved cardiac output, and qualitative shifts in body composition, are proposed mechanisms but remain speculative and require further investigation.

This study demonstrated that both MICT and HIIT interventions led to significant improvements in BMI, waist-to-hip ratio, and cardiovascular parameters in Moroccan adolescents. However, no significant within-group changes were observed in detailed body composition measures or resting energy expenditure. The substantial decrease in BMI in the MICT and HIIT groups indicates a positive effect of training on weight management. The significant impact of HIIT on the waist-to-hip ratio indicates that high-intensity interval training may be especially efficacious in diminishing abdominal fat distribution, linked to heightened cardiometabolic risk. A reduction in blood pressure and resting heart rate in the MICT and HIIT groups indicates enhanced cardiovascular adaptation, affirming the functional advantages of consistent physical activity, particularly high-intensity exercise.

The energy expenditure results indicate that neither MICT nor HIIT produced statistically significant alterations in energy expenditure among Moroccan high school students following the 12-week intervention. Our findings indicate that 12 weeks of moderate- or high-intensity exercise improved cardiovascular parameters and body composition measures but did not produce significant changes in REE. These results suggest that exercise induces qualitative adaptations rather than direct increases in basal energy expenditure. The minor increase noted in the control group may indicate natural fluctuations or be attributable to other uncontrolled variables (growth, academic schedule, dietary patterns).

The apparent discrepancy between the absence of significant intra-group changes and the presence of significant inter-group differences in REE after the intervention can be explained by the nature of the statistical comparisons. Within-group analyses assess changes over time in each group independently and showed that the increases in REE were modest and did not reach statistical significance. In contrast, inter-group comparisons evaluate differences between groups at a given time point. The significant post-intervention differences ($p < 0.001$) suggest that the exercise interventions influenced REE trajectories differently across groups, even though the magnitude of change within each group was insufficient to achieve statistical significance individually.

This pattern may reflect variability in baseline characteristics, differential responsiveness to training, or limited statistical power due to sample size. In particular, the significant differences observed in males and younger adolescents (12–14 years) may indicate age- and sex-specific sensitivity to exercise stimuli, although these findings should be interpreted cautiously.

Additionally, the use of predictive equations to estimate REE rather than direct calorimetry may have limited the sensitivity to detect small within-group changes. Therefore, while the interventions did not significantly increase REE within groups, the observed between-group differences suggest that exercise intensity and modality may still influence energy expenditure patterns in adolescents.

The maintenance or relative reduction in the trained groups suggests that physiological adaptation to exercise may be more accurately represented by qualitative alterations in body composition (e.g., fat mass and lean mass) rather than by a net change in resting energy expenditure. It should be noted that REE values were estimated using predictive equations, which may not fully capture inter-individual variability in Moroccan adolescents. Therefore, the lack of observed changes in REE should be interpreted with caution.

The statistical analysis of energy expenditure provides crucial information for our study and allows us to answer one of the research questions of this study: we note that a large number of variables reveal a significant difference between sexes and by age. First, as also shown in other similar studies (Corder et al. 2008; Yamauchi et al., 2007), TMR, DEA, and TEE are significantly higher in boys than in girls and increase with age. Hoffman et al. (2000), on the other hand, found that only total energy expenditure is related to sex, although DEA is lower in girls than in boys (Hoffman et al., 2000). Roemmich et al. (2000) noted that total energy expenditure varies according to sex and pubertal stage (Roemmich et al., 2000). Despite these findings regarding energy expenditure, PRR is not significantly different between girls and boys, nor across age groups. This observation varies from one study to another. Indeed, the male and female subjects in Bratteby et al. have similar PRR, unlike the analysis conducted by Hoos et al. (2003), Bratteby et al. (1997), Hoos et al. (2003). Guo et al. (2025) also specify that younger people engage in longer periods of activity than older people (Guo et al., 2025). This diverse gender-related information indicates that boys are generally more metabolically active than girls.

Consistent with the studies by Manini and Bartke et al., energy expenditure variables also tend to decrease with age, leading us to assert that energy expenditure in young people is not similar to that of adults and that it tends to decrease with age (Bartke et al.; Manini, 2010).

The study by Colley et al. (2019), conducted on Canadian children and adolescents aged 6 to 17 years, assessed physical activity using an accelerometer (Actical) worn for seven days (Colley et al., 2019). The findings indicated a rise in sedentary behavior with advancing age, greater physical activity levels in boys compared to girls, and minimal adherence to international guidelines, with merely 7% of participants meeting the requirement of 60 minutes of moderate to vigorous activity daily. Moreover, 44% reached this benchmark within merely three days, indicating sporadic rather than consistent practice. The authors determined that the activity level was concerning, possibly linked to a heightened risk of chronic diseases in the long term.

Elevated active energy expenditure may be construed as indicative of high-intensity physical activity. A study by Bandini et al. (2010) demonstrated that obese individuals exhibit greater energy expenditure than their normal-weight counterparts, indicating that elevated BMI mechanically results in increased energy expenditure due to the heightened physiological demands of sustaining and mobilizing this mass. Zakeri et al. identify body weight as the primary factor influencing total energy expenditure (Zakeri et al., 2006).

Marked disparities between training groups indicate that exercise intensity affects energy expenditure variably across genders. The high intensity of physical exercise promoted an increase in basal metabolism, particularly in males. Conversely, moderate intensity exercise results in stability or a minor reduction in resting energy expenditure (Dhuli et al., 2022), indicating that high-intensity exercise may enhance metabolic adaptation, potentially through increased muscle mass or an afterburn effect. The linear regression analysis demonstrates a positive correlation between weight and resting energy expenditure: as weight increases, resting energy expenditure also increases. Nonetheless, REE values were generally superior in the HIIT group compared to the MICT group. The findings indicate that HIIT promotes a higher resting energy expenditure compared to moderate continuous training for the same body weight. This may be ascribed to an augmentation in active muscle mass due to interval training, an elevation in post-exercise metabolism (EPOC effect, Excess Post-exercise Oxygen Consumption), and enhanced metabolic efficiency stemming from the high intensity of the sessions. Consequently, HIIT seems to be a superior approach for enhancing basal metabolic rate, potentially facilitating more efficient weight management and improved body composition, in contrast to moderate-intensity continuous training (Bi et al., 2019; Roemmich et al., 2000).

While HIIT showed trends toward greater improvements in some parameters, the evidence does not support a definitive superiority over MICT for enhancing REE. Physical exercise, whether moderate or high-intensity, induces significant improvements in certain markers of body composition and cardiovascular health in Moroccan high school students.

Limitations

The research possesses certain limitations. The limited sample size, resulting from the voluntary recruitment process, constrains the representativeness of the Moroccan adolescent demographic. Secondly, resting energy expenditure was approximated using a predictive equation rather than being accurately measured through indirect calorimetry. This method may introduce an error in the evaluation of resting energy expenditure from a methodological perspective. The training occurred over a brief duration of 12 weeks, disregarding seasonal fluctuations in physical activity. Training exceeding one year, with data collection distributed throughout the year and multiple measurement sessions for each participant, would enable enhanced monitoring of seasonal variations and yield more accurate assessments of physical activity levels. The participants' nutritional status was not regulated, potentially skewing our results.

Conclusion

A 12-week program of moderate- and high-intensity exercise improved BMI and cardiovascular health markers in Moroccan adolescents. However, neither intervention produced significant changes in resting energy expenditure or detailed body composition.

These findings suggest that while exercise is effective for improving general health indicators, its impact on metabolic rate and body composition may require longer interventions or more precise measurement methods.

The findings also highlight the importance of combining physical activity interventions with nutritional and behavioral strategies to support long-term energy balance and body composition improvements. Regular monitoring of anthropometric and metabolic parameters, along with the promotion of school- and community-based programs that facilitate access to physical activity, may play an important role in preventing obesity and reducing cardiometabolic risk in adolescents.

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Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

The study protocol adhered to the principles outlined in the Declaration of Helsinki, which provides guidelines for ethical research involving human participants. Ethical considerations in this study were that participation was entirely optional.

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

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Authors' Contributions

All authors equally contribute to this study.

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