THE EFFECTS OF HIGH-INTENSITY INTERVAL TRAINING ON THE CARDIORRESPIRATORY PARAMETERS OF ADOLESCENTS WITH EXCESSIVE BODY WEIGHT

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[1]Srećko Stanišić,
[1]Bojan Bjelica,
[2]Edi Setiawan.
[1] Faculty of Sport and Physical Education, University of East Sarajevo, BiH,
[2]Department of Physical Education, Health, and Recreation, Faculty of Teacher Training and Education, Universitas Suryakancana, Cianjur, Indonesia.

REVIEW SCIENTIFIC ARTICLE

Abstract: The aim of the systematic review is to comprehensively evaluate the existing literature on the effects of high-intensity interval training on cardiorespiratory parameters in overweight adolescents. The literature search was performed using the Google Scholar and PubMed databases. Papers were selected based on parameters: year of publication, type of intervention, age group of respondents. HIIT interventions lasting 2-24 weeks, three times a week consistently provide improvements in cardiorespiratory parameters in obese adolescents. HIIT interventions have a positive effect on cardiorespiratory parameters in overweight adolescents.

Key words: hiit, adolescents, cardiorepiratory, obese.

INTRODUCTION

Obesity in children and adolescents represents a comprehensive global health challenge, which has profound implications for long-term health outcomes. The prevalence of overweight and obesity among adolescents has led to an increased risk of cardiovascular diseases, metabolic disorders and compromised quality of life (Ozdemir, 2015). Consequently, interventions aimed at improving the cardiorespiratory fitness of overweight adolescents have significant clinical and public health importance.

Typical strategies for improving physical fitness related to this demographic have focused primarily on endurance-based exercise regimens and lifestyle modifications. In recent years, however, the attention of researchers and practitioners has turned to high-intensity interval training (HIIT) as an innovative exercise approach with the potential to significantly affect cardiovascular fitness (Camacho-Cardenosa, et al. 2016). HIIT involves alternating short vigorous exercises with short recovery intervals or low-intensity intervals, offering a time-efficient exercise modality that may particularly resonate with adolescents (Brito et al., 2014).

Cardiorespiratory parameters, which include metrics such as heart rate, blood pressure, respiratory rate, and oxygen consumption, are key indicators of

cardiovascular and respiratory health. Improvements in these parameters not only correlate with increased physical fitness, but also contribute to reduced susceptibility to chronic health conditions in adolescents (Pescatello, 2004).

While previous research (Wewege et al., 2017) has investigated the effects of HIIT in various demographic groups, including adults, children and athletes, a comprehensive assessment of the available literature specifically related to overweight adolescents is warranted.

Improved cardiorespiratory fitness in adolescents is critical for long-term health because it reduces the risk of chronic diseases such as obesity, type 2 diabetes, hypertension, and other cardiovascular conditions (Batacan et al. 2017).

Several training methods are used to improve cardiovascular fitness in adolescents. Traditional aerobic exercises such as running, swimming, cycling and dancing contribute to cardiorespiratory endurance. High Intensity Interval Training (HIIT) is gaining attention for its time-efficient and effective approach, with short bursts of intense exercise followed by short recovery periods. Circuit training combines aerobic and resistance exercises, improving both cardiovascular and muscular fitness (Batacan et al. 2017).

The importance of studying HIIT in adolescents is its effectiveness, adaptability, effectiveness and motivational appeal. HIIT offers time-efficient exercises, adapting to different fitness levels and providing promising results in a short time. Its dynamic nature keeps adolescents engaged (Pescatello, 2004).

The aim of this systematic review is to comprehensively evaluate the existing literature on the effects of high-intensity interval training on cardiorespiratory parameters in overweight adolescents. By bringing together the available evidence, this review aims to elucidate the potential benefits, limitations, and optimal implementation strategies associated with HIIT within this specific demographic group. In order to fulfill the goal of this work, a search of electronic databases, a review and translation of the collected literature, and an analysis of the research results were carried out.

METHOD

A systematic and comprehensive search of the relevant literature was conducted to identify studies investigating the effects of high-intensity interval training (HIIT) on cardiorespiratory parameters in overweight adolescents. The search was performed in two prominent scientific databases: Google Scholar and PubMed. The search period included articles published from January 2013 to July 2023, which allowed for the inclusion of the most recent research findings in the scope of the review.

A combination of relevant keywords and Medical Subject Heading (MeSH) terms were used to provide a detailed search. The search terms used were "high intensity interval training", "cardiorespiratory parameters", "overweight adolescents" and "obese teenagers".

Inclusion criteria:

- Type of study: Longitudinal studies were analyzed.

• Sample of respondents: Respondents who belong to the adolescent age category were included in the study.

• Type of intervention: HIIT was applied in the study.

• Type of result: The primary result refers to some of the cardiorespiratory parameters.

Exclusion criteria:

• Studies include other age categories.

• Study published outside the corresponding time frame of 2013-2023.

• Studies do not include HIIT intervention.

RESULTS

By searching databases, 630 relevant papers were found. After eliminating 577 papers, of which 326 were duplicates and 251 papers rejected due to some of the exclusion criteria, 53 papers were analyzed, of which 18 were rejected because it was a systematic review paper. 35 papers were requested for review, 28 were received for review. A detailed analysis determined that 20 studies correspond to the set criteria. Graph 1 shows the process of selecting works.

Graph 1. Paper selection process *(Prisma 2020 flow diagram for new systematic review)*

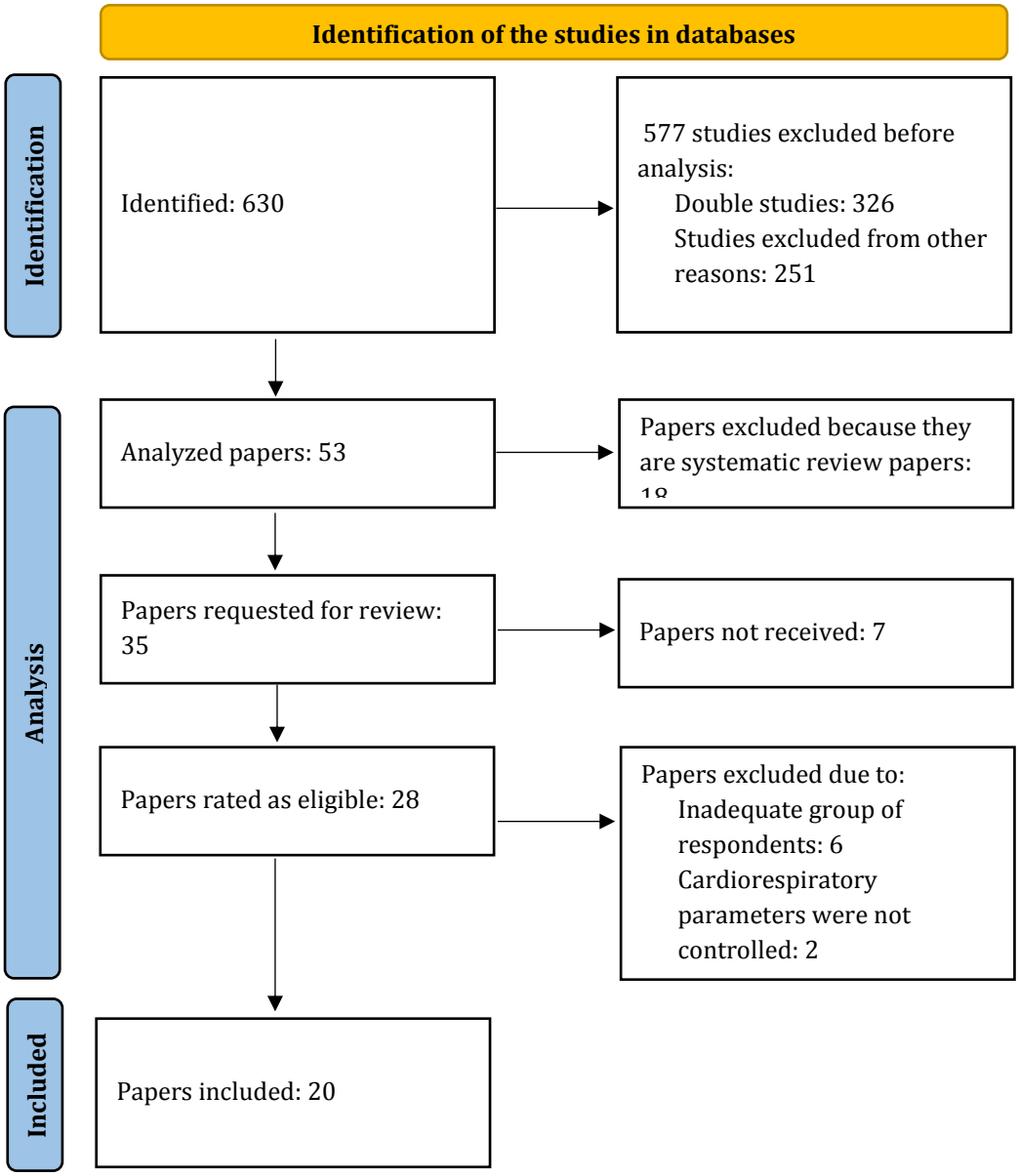

Table 1. Results

Reference	Population				Duration (sesions/ weeks)	Treatment	Results	Conclusion
	N	Sex	Age	BMI [kg/m^2]				
Tadiotto MC et al. 2023	52	M,F	11-16	BMI increased	12, 3/1	HIIT: CON: MICT	BMI-, LDL-C-,	Exercise interventions are effective in improving obesity, metabolic health, and physical fitness.
Racil et al., 2023	33	M	16.2 ± 0.7	BMI increased	16, 3/1	HIIT	RHR-, BLC+, SBP-	A long-term HIIT program is an appropriate training approach for obese adolescents with excess body fat.
Meng, Yucheng, Shu & Yu, 2022	45	M	11.2 ± 0 .7	24.2	12, 3/1	HIIT, MICT CON: NB	BMI-, FM-, HOMA-IR:-,	Running-based HIIT can be used to improve the physical health of obese adolescents in schools.
Hu et al. , 2022	40	F	19.20 ± 1.10	18.5–24.9	4,5/1	HIIT:90% HRmax CON: NB	BC+, BM+, HR+, AVI+, API+	HIIT can effectively reduce the risk of arteriosclerosis and protect cardiovascular function for college students.
Popowczak et al. 2022	52	M	16.23 ± 0.33	20.89 ± 3.53	10	HIIT CON:NB	SBP-	HIIT effectively lowers blood pressure in adolescents.
Kranen et al., 2021	19	M	13.3 ± 0.5	BMI increased	6	HIIT CON: NB	FMD+,	4 weeks of HIIT improved macrovascular function; did not measurably alter microvascular function, body composition, or blood biomarkers.
Hu et al., 2021	66	F	21.2 ± 1.4	26.0 ± 3.0	12	HIIT, SIT, MICT, CON:	VO2max+, FM-,	The training regimens are equally enjoyable

						NB	BFM-	and can lead to similar improvements in cardiorespiratory fitness and body composition in overweight/obese young women.
Abassi et al, 2020	24	F	16.5±1.36	BMI increased	12	HIIT CON:MIIT	BMI-, BM-, HOMA-IR-, TSH-, T4-,	Twelve weeks of HIIT was effective in reducing circulating TSH and T4 levels, unlike MIIT, in overweight/obese adolescent girls.
Plavšić et al, 2020	44	F	13-19	BMI increased	12	HIIT	DBP-, MHR+, BMI-, SBP-	HIIT and dietary advice increased insulin sensitivity and decreased BMI, body fat, systolic blood pressure, and diastolic blood pressure.
da Silva et al., 2019	38	M,F	14-17	BMI increased	12, 3/1	HIIT CON:NB	FMD+, CE+	A HIIT program, even without any dietary changes, can improve physical fitness and endothelial function among adolescents.
Cvetković, et al, 2018	42	M	11-13	BMI increased	12	HIIT+ RF CON: NB	DBP-, BF-, BMI-, BP-	Recreational soccer and HIIT induced improvements in all measures of muscular and cardiorespiratory fitness.
Pizzi et al, 2017	54	M,F	10-15	BMI increased	12	HIIT CON:NB	TC-, LDL-C-, BChE-, BMI-	Reduction of BChE activity with HIIT training is accompanied by reduction of biochemical markers, BChE can be used as a secondary marker for cardiovascular risk factors

								associated with obesity in children and adolescents.
García-Hermoso et al., 2016	100	M, F	6-17	BMI increased	4-12	HIIT	SMD-, VO2max+,	HIIT could be considered a more effective and time-efficient intervention for improving blood pressure and aerobic capacity levels in obese youth compared to other types of exercise.
Racil et al. 2016	47	F	14.2±1.2	BMI increased	12,3/1	HIIT CON:MIIT	VO2max+, IR-, BG-, RPE-, BMI-, BM-, %BF-	The results suggest that high-intensity interval training may have more positive effects on health determinants compared to the same moderate-intensity training regimen.
Kargarfard et al, 2016	60	M	NA	BMI increased	8	ET, HIIT CON: NB	ICAM-1- SBP-, DBP-, VCAM-1-	While both ET and HIIT were beneficial in lowering participants' SBP and DBP, HIIT was more effective than ET in reducing ICAM-1 and VCAM-1 content in normal and obese adolescents.
Blüher et al, 2016	28	M,F	13-18	BMI increased	24, 2/1	HIIT	SBP-, BM-	HIIT may have beneficial effects on body composition and cardiometabolic health in overweight adolescents.
Lee et al., 2016	12	M	14.9 ± 1.5	34.8 ± 3.9	12	HIIT	CRF+, SBP-	Low-volume HIIT is a useful strategy for promoting exercise participation and

								improving cardiovascular health in overweight and obese youth.
Bond et al, 2015	13	M,F	13-14	BMI increased	2, 6/1	HIIT	CVD-, HRV+, FMD-	Two weeks of HIIT improved endothelial function and HRV without improving traditional CVD risk factors.
Barker et al, 2013	10	M	15.1 ± 0.3	BMI increased	2	HIIT	VO2max+, O-, OL+	4 weeks of HIIT improved macrovascular function.
Corte de Araujo et al., 2013	30	M,F	8-12	BMI increased	12	HIIT, CON: NB	VO2max+, HOMA-IR-	HIIT and ET were equally effective in improving important health parameters in obese youth.

AVI- aortic augmentation index, API- aortic pressure augmentation index, BC- body composition, BChE-butyrylcholinesterase, BF- body fat, BFM- body fat mass, BLC- blood flow, BM- body mass, BG- blood sugar, BMI - body mass index, BP- blood pressure CE-cardiorespiratory endurance, CON- control group, CRF-cardiorespiratory health, CVD- risk for cardiovascular diseases, DBP- diastolic blood pressure, ET- classical endurance training, F- female sex, FM- fat mass, FMD- flow-mediated dilation, HIIT- high-intensity interval training, HOMA-IR- HOMA index IR, HR- heart rate, HRV- heart rate variability, ICAM-1- Intercellular adhesion molecule-1, IR- insulin resistance, LDL-C -lipoprotein cholesterol, M- male sex, MHR- maximum heart rate, MICT- medium intensity interval training, MIIT- medium intensity interval training, MST- myocardial structure, NA-data not available, NB- normal behavior, O- blood oxidation, OL- lipid oxidation, PSTV- peak systolic tissue velocity, RF- recreational soccer, RHR- resting heart rate, RPE- ratings of perceived exertion, SBP- systolic blood pressure, SIT- sprint interval training, SMD- Standardized difference in mean results, TC- total cholesterol, TSH- thioride stimulating hormone, T4- thyroxine, VCAM-1- Vascular cell adhesion molecule-1, VO2max- aerobic capacity, %BF- percentage of body fat, +-improvement, - decrease

The duration of the intervention in the reviewed studies varied, with the shortest being 2 weeks and the longest being 24 weeks. Specifically, the lengths of the intervention were as follows: 24 weeks: Blüher et al. (2016), 16 weeks: Racil et al. (2023), 12 weeks: Hu et al. (2022), Meng et al., (2022) Tadiotto MC et al. (2022), Cvetković et al. (2018), da Silva et al. (2019), Racil et al. (2016), Pizzi et al. (2017), Plavšić et al. (2020), Kargarfard et al. (2016), Lee et al. (2016), Kranen et al. (2021), Hu et al. (2021), Corte de Araujo et al. (2012), 10 weeks: Popovczak et al. (2022), 8 weeks: Kargarfard et al. (2016), 6 weeks: Bond et al. (2015), Kranen et al. (2021), 2 weeks: Barker et al. (2013), and the study performed by Garcia-Hermoso et al. (2016), lasted from 4 to 12 weeks.

Studies included both men and women, and there were studies exclusively focused on each gender. Studies where the respondents are only male participants: Racil et al. (2023), Lee et al. (2016), Popovczak et al. (2022), Kargarfard et al. (2016),

Barker et al. (2013), Kranen et al. (2021), Meng et al., (2022), Cvetković et al. (2018). Female participants only: Hu et al. (2022), Hu et al. (2021), Abassi et al. (2020), Plavšić et al. (2020), Racil et al. (2016). Mixed male and female participants: Tadiotto MC et al. (2022), da Silva et al. (2019), Corte de Araujo et al. (2012), Pizzi et al. (2017), Garcia-Hermoso et al. (2016), Bond et al. (2015).

The age range of participants varied in different studies, subjects were participants aged 6-17 years: Garcia-Hermoso et al. (2016), participants aged 11-13 years: Cvetković et al. (2018), participants aged 11-16 years: Tadiotto MC et al. (2022), participants aged 13-14 years: Bond et al. (2015), participants aged 13-18 years: Blüher et al. (2016), participants aged 14-17 years: da Silva et al. (2019), participants aged 14.2 ± 1.2 years: Racil et al. (2016), participants aged 14.9 ± 1.5 years: Lee et al. (2016), participants aged 15.1 ± 0.3 years: Barker et al. (2013), participants aged 16.2 ± 0.7 years: Racil et al. (2023), participants aged 19.20 ± 1.10 years: Hu et al. (2022), participants aged 21.2 ± 1.4 years: Hu et al. (2021), participants age 11.2+0.7: Meng et al., (2022), participants age 16.23±0.33: Popovczak et al. (2022), participants age 16.5±1.36: Abassi et al. (2020), participants aged 10-15: Pizzi et al. (2017), participants aged 9-16 Corte de Araujo et al. (2012), participants aged 13-19: Plavšić et al. (2020), participants aged 13.3±0.5: Kranen et al. (2021), and in the study by Kargarfad et al. (2016) did not specify the age of the respondents.

Many studies (Barker et al. (2013), Racil et al. (2016), Hu et al. (2021)) have reported significant improvements in variables such as peak oxygen consumption (VO2max), reduced resting heart rate (RHR) (Racil et al. (2023)) and reduced systolic blood pressure (SBP) (Blüher et al. (2016), Racil et al. (2023), Plavšić et al. (2020), Kargarfard et al. (2016))) after HIIT interventions. In addition, beneficial changes in markers such as cardiovascular fitness (CRF), blood flow-mediated dilation (FMD) and adiposity reduction were observed.

In particular, certain studies have shown improvements in blood flow-mediated dilation (FMD) and positive effects on high-density lipoprotein cholesterol (HDL-C) levels. These consistent results highlight the potential of HIIT as an effective strategy for improving cardiovascular health and fitness in overweight and obese adolescents.

Meng et al. (2022) observed improvements in body composition, heart rate (HR), aortic vascular index (AVI), and aortic pressure index (API) following HIIT and moderate intensity continuous training (MICT). Studies by Plavšić et al. (2020) and da Silva et al. (2019) demonstrated improvements in FMD following HIIT interventions.

DISCUSSION

Collective evidence from the reviewed studies suggests that HIIT interventions consistently produce improvements in cardiorespiratory parameters in obese adolescents. These positive results highlight the potential of HIIT as an effective strategy for improving cardiovascular health and fitness in this population. Nonetheless, variations in study design, intervention protocols, and outcome measures warrant further investigation to establish optimized HIIT protocols for maximal benefit.

The culmination of findings from the reviewed studies provides a comprehensive perspective on the effects of high-intensity interval training (HIIT) on different adolescent subpopulations. The studies analyzed in this review offer essential insights into the different responses of adolescent males and females to HIIT. In particular, Abassi et al. (2020) and Racil et al. (2016) provided evidence of beneficial outcomes associated with HIIT for women. In particular, improvements in body mass index (BMI), insulin resistance and cardiovascular fitness (CRF) were noted. Together, these results highlight the potential of HIIT as a powerful strategy to improve overall health and fitness in adolescent girls. In contrast, studies such as Popovczak et al. (2022) and Tadiotto MC et al. (2023) with predominantly male participants, demonstrated the ability of HIIT to reduce BMI and systolic blood pressure (SBP). This demonstrates the effectiveness of HIIT in addressing weight-related problems and cardiovascular risk factors among adolescent boys.

One compelling aspect of the reviewed studies is the adaptability of HIIT interventions across age groups within the adolescent population. Whether aimed at early adolescents or college students, HIIT has consistently shown positive effects on cardiovascular health and body composition. For example, Lee et al. (2016) and Hu et al. (2022) demonstrated this adaptability by reporting improvements in CRF, blood pressure, and vascular health in adolescents of different age groups. The versatility of HIIT in providing health benefits for adolescents ranging from early to late adolescence underscores its potential as a holistic approach to exercise.

A recurring finding in these studies is the significant improvements in markers of cardiovascular health associated with HIIT interventions. Racil et al. (2023) reported reductions in resting heart rate (RHR) and favorable changes in blood lipid profiles in adolescents following a 16-week HIIT program. Similarly, studies such as Popovczak et al. (2022) observed a significant reduction in systolic blood pressure (SBP) among adolescent males following a 10-week HIIT intervention. Together, these findings highlight the potential of HIIT in ameliorating cardiovascular risk factors in adolescents.

The significant variability in individual responses observed in these studies highlights the need for personalized exercise prescription in the context of HIIT interventions for adolescents. Factors such as baseline fitness levels, genetic predispositions and lifestyle habits can significantly affect the extent of improvements achieved through HIIT.

CONCLUSION

In conclusion, this comprehensive review highlights a growing body of evidence supporting the efficacy of high-intensity interval training (HIIT) as a versatile and vigorous exercise modality for improving adolescent health and fitness. Combining findings from different studies highlights the potential of HIIT to address various health parameters in this population. Analysis reveals that HIIT interventions lead to positive outcomes, including reductions in body mass index, improvements in cardiovascular fitness and respiratory parameters. Moreover, this review highlights the adaptability of HIIT across different age groups within the adolescent spectrum, emphasizing its effectiveness from early adolescence to late

adolescence. However, it is critical to recognize that individual response varies, requiring personalized exercise programs to maximize benefits for each adolescent.

Finally, gender-specific effects of HIIT interventions, as elucidated in the reviewed studies, reveal different responses among adolescent males and females. HIIT interventions lasting 2-24 weeks, three times a week consistently provide improvements in cardiorespiratory parameters in obese adolescents.

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Correspodence:
Srećko Stanišić
Faculty of Physical Education and Sports,
University of East Sarajevo, BiH
e-mail: sreckostanisic@gmail.com