INFLUENCE OF HIGH INTENSIVE INTERVAL TRAINING ON STUDENTS

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REVIEW SCIENTIFIC ARTICLE

Summary: High-intensity interval training (HIIT) appeared as a replacement for long-term exercise programs, primarily continuous aerobic exercise in adults, while in adolescents it represents a more natural way of exercise, unlike traditional moderate-intensity exercise. The aim of this systematic review is to examine the impact of high-intensity interval training in elementary school students, based on the collected data and analyzed research. The literature search was performed using the following databases: PubMed, Google Scholar, DOAJ, MEDLINE. After a detailed analysis, 11 studies met the set criteria and were included in the systematic review. The results indicate that HIIT for a duration of 12 weeks gives statistically significant results in reducing body weight and visceral fat, lowering arterial blood pressure, reducing BMI and increasing VO2max and improving fitness parameters of children. HIIT is an effective way of improving various fitness parameters and health conditions in a school population, with our review research indicating significant improvements in body composition parameters, fitness parameters as well as cardiovascular disease compared to a non-exercising control group.

Keywords:high-intensity interval training, children, adolescents, fitness

INTRODUCTION

Experts from the field of physical education and sports try to solve the phenomenon of weight gain in children and various health problems that arise due to insufficient physical activity with a traditional continuous form of exercise with moderate intensity (McMurray et al., 2002; Meyer, Kundt, Lenschow, Schuff-Werner & Kienast, 2006). One of the main barriers to achieving sufficient levels of exercise according to the World Health Organization is insufficient free time for exercise (Zabinski, Saelens, Stein, Hayden-Wade, & Wilfley, 2003). By observing the intensity of children's activity during play, we can conclude that this form of exercise is the opposite of the intensity during children's play. A characteristic of children's games is the constant alternation of high and low activity intensity in a short time interval (Bailey et al., 1995). Therefore, high-intensity interval training was initially presented as an eventual form of exercise that would lead to the required results in a short time, and as such was used to promote health improvement (Gibala & McGee,

2008; Gibala, Little, MacDonald, & Hawley, 2012). Although continuous aerobic exercise of moderate intensity has effects on the improvement and regulation of cardiometabolic processes (insulin regulation, blood glucose level, systolic and diastolic arterial blood pressure and lipid profile) (García-Hermoso, Saavedra, & Escalante, 2013) and aerobic capacity VO2max (Saavedra, Escalante, & Garcia-Hermoso, 2011) in overweight children, the high-intensity interval program proved to be an effective method of exercise in a short time, leading to the improvement of numerous indicators essential for maintaining health (Baquet, Berthoin, Gerbeaux, & Van Praagh, 2001; Baquet et al., 2002; Gibala et al., 2012). In some studies, a program of high-intensity interval training, when compared to traditional aerobic exercise, shows better results in improving aerobic capacity and health in healthy (Ramos, Dalleck, Tjonna, Beetham, & Coombes, 2015) and overweight people (Lunt et al., 2014). A meta-analysis by García-Hermoso et al. (2016) shows that high-intensity interval training has better effects in reducing diastolic blood pressure in children and adults (Bond, Hind, Williams, & Barker, 2015) compared to other exercise programs. High-intensity interval training can lead to improvements in the cardiorespiratory system in overweight children in just 6-12 weeks of exercise (Lambrick, Westrupp, Kaufmann, Stoner, & Faulkner, 2016; Saavedra et al., 2011), better blood flow to muscles (Tremblay, Simoneau, & Bouchard, 1994), reducing BMI (De Araujo et al., 2012) and regulating body weight and visceral fat (Koubaa et al., 2013). All the mentioned results can be achieved in only 29 minutes, which is the average time of high-intensity interval training (García-Hermoso et al., 2016) compared to 45 minutes of traditional aerobic exercise of moderate intensity (Helgerud et al., 2007).

HIIT programs performed in physical education classes should be independently evaluated. Schools are an ideal environment for the promotion of physical activity among children and adolescents because they can support physical activity with their practices, existing infrastructure and teachers who are trained (Booth & Okely, 2005). Such programs in schools can be implemented or are implemented with minimal investment (Lonsdale et al., 2021). However, this setting presents unique challenges, including time constraints, curriculum demands, and teacher workload (Naylor et al., 2015). Previous research on school-based physical activity has had limited success in increasing physical activity levels (Harris, Kuramoto, Schulzer, & Retallack, 2009 Love, Adams, & Sluijs, 2019), further indicating that new and improved approaches are needed. HIIT can be effective in PE classes as it aligns with common forms of physical activity in children and the intermittent style of most modern sports (Baker, Rollo, Stein, & Jeukendrup, 2015; Sanders, Cliff, & Lonsdale, 2014).

METHOD

Search strategy

Research data for the purposes of this paper were collected through electronic databases PubMed, Google Scholar, DOAJ, MEDLINE. When researching databases, the following keywords were used (individually or in combination): high-intensity interval training, children, adolescents, fitness. The research titles, abstracts and full texts found were then read and analyzed. Specific studies were obtained when the

studies met the inclusion criteria, after detailed analysis. Wherever possible, the research design was modified and adapted to each study and database in order to increase the sensitivity of this review. A systematic review of papers was performed in accordance with the methodological instructions and in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) consensus (Moher, Liberati, Tetzlaff, & Altman, 2019).

Research that met the set criteria was then analyzed and presented based on the following parameters: reference (first letter of the author and year and year of publication of the research, sample of respondents (age, total number and subgroups of respondents), exercise program, duration of the program, research results.

RESULTS

The procedure of collection, analysis and elimination of found works is shown in Figure 1. Based on keywords, it was identified 93 works. After excluding research based on the title, duplicate papers, as well as papers that were excluded based on the review of abstracts, 68 researches remained, while 33 papers were included in further analysis. After further analysis of 33 papers, 15 papers were excluded based on several criteria: because it was a systematic survey research, as well as the lack of adequate information needed for the research. After detailed analysis and the final screening process, 11 studies (Table 1) met the set criteria and were included in the systematic review.

Figure 1. Study selection flow chart

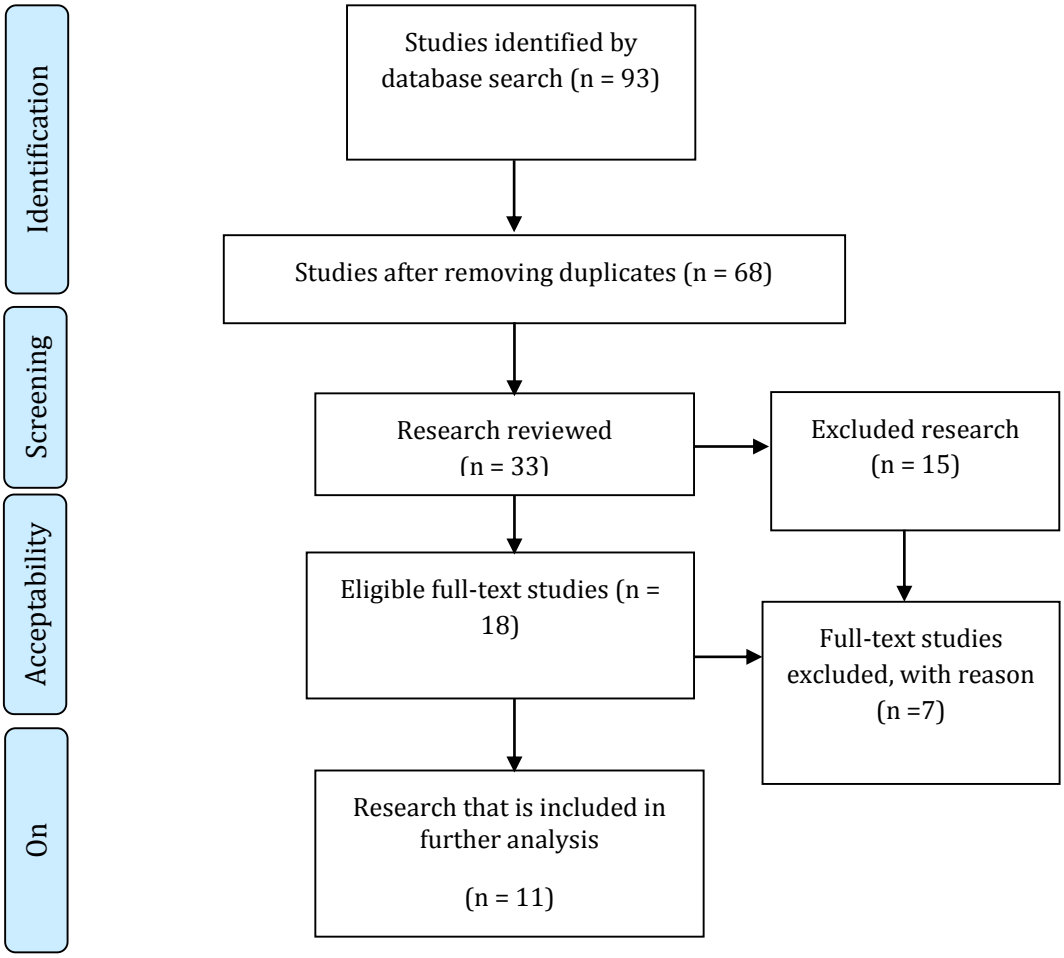

Table 1.Presentation of analyzed research

The author	Population, year, issue number groups	Duration of treatment	Exercise intensity, no. repetitions	The results
De Araujo et al. (2012)	Obese children (n=30), age: 8-12, HIIT, END	12 weeks	HIIT-100%HRmax 39 END-80% HRmax 48	HIIT and END equal ↑↑VO2max; ↓BMI; ↑↑ metabolic parameters and aerobic fitness 21%, ↓↓insulinemia HOMA-index, HIIT: ↓↓ body mass, END: NC in body mass,
Baquet et al. (2001)	Healthy students (n=551), age: 11-16, HIIT, CON	10 weeks	HIIT-100%HRmax 90 CON-75% HRmax	HIIT: ↑ aerobic capacity (+7.6%), SBJ (+2.9%), endurance test (+3.8%)

			90	CON: NC in EUROFIT performance
Barker at al. (2014)	Healthy adolescent active recreational players (n=10), age: 14-16, HIIT	2 weeks	HIIT-Max 33	HIIT has a beneficial effect on the increase VO2 capacity, carbohydrates and fat (changes 90%) NC in BMI, SBP and DBP
Buchan et al. (2011)	Healthy students (n=57), age: 16, HIIT, CON	7 weeks	HIIT-100%HRmax 111 MOD-70% HRmax	%BF ↓↓ in MOD, SBP ↓ in HIIT, DBP ↓↓ in CON cardiorespiratory fitness ↑↑ HIIT and MOD, NC in HDL-C, LDL-C, TC in neither group
Buchan et al. (2013)	Healthy students (n=89), age: 16, HIIT, CON	7 weeks	HIIT-100%HRmax 111	HIIT: ↓↓ SBP; ↑↑ CMJ, ↑↑ 10m sprint, HIIT and CON: ↓↓LDL
Cvetkovic et al. (2018)	Obese boys (n=42), age: 11-13, HIIT, AT, CON	12 weeks	HIIT-100%MAS	HIIT and AT equal ↑↑VO2max; ↓BMI, HIIT: ↓% body mass, ↑ agility
Koubaa at al. (2013)	Obese students (n=29), age: 13+0.8 HIIT, END	12 weeks	HIIT-80-95% vVO2max END-60-70% vVO2max	HIIT: ↓↓ Weight and Fat Mass, ↓↓ SBP and DBP, HIIT and CON ↓↓ BMI, ↓↓ WC, ↑↑ HDL, ↓↓ RHR, ↑↑ VO2max, MAS and RI
Lau et al. (2015)	Overweight children (n=48), age: 10+0.9 HIIT, LIT, CON	6 weeks	HIIT-120% MASS 288 LIT-100% MAS 216	HIIT: ↓↓ body fat, HIIT and LIT: ↑↑ aerobic endurance, body fat, number of repetitions NC in BMI
Murphy at al. (2015)	Overweight children (n=13), age: 12-18 HIIT, AT	4 weeks	HIIT-80-90%HRmax 120 AT-65% HRmax 12	HIIT and AT ↑↑ VO2max improvement,↑↑ fitness improvement HIIT: ↓↓ lean body mass, HIIT and AT – NC in BMI and %body fat
Racil et al. (2013)	Adolescent girls with excess weight (n=34), age: 15.9 HIIT, MIT, CON	12 weeks	HIIT-100-110% MASS 132 MIT-70-80% MASS 132	HIIT and MIT ↓↓ BMI and %BF, ↑↑ VO2peak and MAS; HDL-C,LDL-C positive changes (more with MIT), ↓↓HOMAIR HIIT: ↓↓TC, TG, waist circumference
Tjønna at al. (2009)	Overweight students (n=62) AIT, MTG	48 weeks	AIT-90-95%HRmax 384 MTG-65% HRmax 48	AIT ↓↓ BMI by 0.7 and 1.8 kg/m2 after 3 and 12 months; ↓↓ body fat % 1.3 and 2%; total fat 0.9 and 2.4 kg after 3 and 12 months; ↓↓5.5 mmHg after 3 months and after 12 months ↓↓ 4.9

	mmHg,; ↓↓ 13.4 mmHg; ↑↑ VO2 max18.7 ml · min−1; ↑↑ HDL ATM and MTG ↓↓ SBP and DBP
	MTG: NC in % fat, fat weight
	DBP , mean arterial BP

HIIT- high-intensity interval training; LIT- low-intensity training, AT- aerobic training, MIT- moderate intensity training, AIT- aerobic interval training, END- endurance training, CON- control group, VO2max- maximum oxygen consumption, vVO2max - running speed at VO2max, VO2peak – maximum oxygen consumption rate, MTG – multidisciplinary training, NC – no change p>0.05, HDL- high-density lipoprotein, LDL- low-density lipoprotein, BP- blood pressure, SBP- systolic blood pressure, DBP - diastolic blood pressure, TC - total cholesterol, HRmax - maximum heart rate, RHR - resting heart rate, BMI - body mass index, MAS - maximum aerobic speed, %BF - body fat percentage, ↑ - statistically significant increase in the level p<0.05, ↑↑ - statistically significant increase at the level of p<0.01, ↓ - statistically significant decrease at p<0.05 level, ↓↓ - statistically significant decrease at p<0.01 level.

DISCUSSION

High intensity interval training (HIIT) has emerged as a replacement for long-term exercise programs, primarily continuous aerobic exercise in adults (Billat, 2001; Gibala, 2007). High intensity exercise of short duration with low to moderate intensity of rest can be an effective method to improve a person's health status in a shorter period of exercise because lack of time is cited as a key problem for participation (Trost, Owen, Bauman, Sallis, & Brown, 2002). In addition, HIIT reduces the risk of cardiovascular disease to a greater extent than continuous aerobic exercise in healthy, obese, and type 2 diabetic subjects (Punthakee et al., 2006). It has also been shown to be an effective method of exercise in restoring vascular functions in people with heart disease (Gibala & McGee, 2008; Whyte, Gill, & Cathcart, 2010). High-intensity exercise in a short period of time with short rest intervals is a more natural way of exercising for adolescents, in contrast to traditional moderate-intensity exercise (Crisp, Fournier, Licari, Braham, & Guelfi, 2012; Buchan et al., 2013). In order for high-intensity interval training to have an impact on improving cardiorespiratory fitness and improving health, it is recommended that the exercise program last longer than seven weeks (Steene-Johannessen, Kolle, Andersen, & Anderssen, 2013).

A high-intensity interval exercise program of obese children, aged 8-12 years with a BMI of 30.8±3.7 kg/m^2, which lasted 12 weeks, resulted in statistically significant improvements in maximal oxygen consumption (VO2max) and a reduction in BMI (De Araujo et al., 2012). The frequency of exercise was three to six times a week with a duration of exercise of 60 seconds of sprinting at 100% HRmax (the ratio of rest to work was 0.33). Statistically, metabolic parameters and aerobic fitness improved significantly by 21.0%. A 10-week exercise program investigated by Baquet et al. (2001) in healthy students aged 11-16 years with ten seconds of sprint exercise 100-120% HRmax gave statistically significant results in improving aerobic capacity (+7.6%), reducing systolic blood pressure (SBP-2.8%), as well as better cardiorespiratory abilities, which was reflected in better achieved results on the endurance test (+3.8%). A seven-week duration of high-intensity interval training, with a load of 30 seconds of sprinting at 100% HRmax (rest-to-work ratio is

one), statistically significantly improved explosive power and reduced systolic blood pressure (Buchan et al., 2013). An exercise program lasting 12 weeks is considered sufficient for realizing many changes in the body with the aim of improving health. However, if HIIT exercise lasts for two weeks, there will not be enough time for changes in the cardiorespiratory system, nor is there any possibility of changes in subjects' BMI or arterial blood pressure (Barker et al., 2014). HIIT programs that improve the metabolic profile of adolescents are: four to six repetitions of 30-second sprints with 30 seconds of rest (1:1 ratio of active work to rest) (Buchan et al., 2013; Buchan et al., 2011), four repetitions of 30-second sprints at 90% HRmax with active three-minute rest between sets (Tjønna et al., 2009), six repetitions of 60-second sprints at 100%VO2max with three-minute active rest (De Araujo et al., 2012), ten repetitions of 60-second sprints at 100% maximum aerobic speed (MAS) with an active rest of 60 seconds (Cvetkovic et al., 2018), and two sets of six repetitions of 30 seconds of 100% MAS sprints with 30 seconds of active rest between sprints (Racil, 2013).

High-intensity interval training for 12 weeks (HIIT- two minutes 80-90% VO2max with four minutes rest) compared to aerobic continuous endurance training (END) of the same duration (END 60-70% VO2max for 30-40 minutes) gives statistically significant results in reducing body weight and visceral fat, lowering arterial blood pressure, reducing BMI and increasing VO2max and HDL cholesterol (Koubaa et al., 2013). In similar research, HIIT gave better results compared to CON in increasing cardiorespiratory capacity, improving fitness, reducing body fat (Cvetkovic et al., 2018; Lau et al., 2015; Murphy et al., 2015). In a review study, Gibala & McGee (2008) state that in young healthy individuals with an average level of fitness, HIIT represents a more effective exercise system in the adaptation of numerous skeletal muscles compared to traditional END training. The same authors emphasized the fact that the answer to the question of what is the minimum amount of exercise needed to improve physiological changes in different populations remains unclear.

Based on the previous examples, we can see that there are different high-intensity interval training exercise programs. The load can vary from ten seconds to five minutes. Most programs were performed at an intensity of 90-100% VO2max (De Araujo et al., 2012). Rest between sets can be of low intensity (jogging or walking) or passive rest, the ratio of work and rest is different. In some studies it is 1:1 (30 seconds sprint, 30 seconds rest) or 1:1.5 (eight seconds sprint, 12 seconds low-intensity active rest) (Trapp, 2008). It is still not fully understood which program of high-intensity interval training (program duration, work-rest ratio, exercise intensity) can bring the best results.

CONCLUSION

High-intensity interval training is an effective way to improve various fitness parameters and health conditions in a school population, with our review research indicating significant improvements in body composition parameters, fitness parameters as well as cardiovascular disease compared to a non-exercising control group. However, there is a risk of biasing the results and we emphasize that more high-quality research is needed in this area. Currently, there is not enough evidence,

that is, it is not fully understood which program of high-intensity interval training can produce the best results, or which would suggest that HIIT is superior to moderate continuous exercise or other types of comparative exercise. It is recommended that future research address the lack of information on physical activity and nutrition outcomes associated with school-based HIIT interventions.

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