JESPAR
REVİEW ARTICLE

Journal of Exercise Sciences
& Physical Activity Reviews

Positive and Negative Effects of High-Intensity Interval Training on Athletic Performance

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ABSTRACT

In recent decades, high-intensity interval training (HIIT) has become popular among athletes. This training method involves repeating short training periods with regular recovery intervals. This popularity of HIIT and its effects on athletic performance has made it a primary focus of interest among researchers, conditioners, and coaches. This study aims to examine the positive and negative impact of HIIT on athletic performance in depth and to bring the findings to the literature. In this framework, the current study will address the potential of HIIT to improve performance in different sports, its health effects, and potential risks. In this study, a review of current literature examining the positive and negative effects of HIIT on athletic performance was conducted. This study was structured to include studies and meta-analyses in various scientific databases such as "Web of Science", "PubMed", "Google Scholar" and "TR Index". For the analysis of the studies, literature was searched in these databases with keywords such as "High-Intensity Interval Training", "HIIT", "Sportive Performance", "Athletic Performance", "HIIT and Sportive Performance", "Effects of HIIT", "Sports Injuries" and "Injury Risks in Sports" and the conclusion section of the current study has created according to the results of these studies. Findings in the literature show that HIIT has the potential to improve performance in many sports. Studies have shown significant improvements in performance measures such as strength, endurance, speed, and anaerobic capacity. However, HIIT training protocols are not without negative impacts, such as overtraining risks, muscular injuries, and excessive fatigue. Both coaches and athletes should understand that HIIT is an effective way to improve performance but should avoid overdoing it in their training protocols. As such, training programs should be individualized, considering individual needs and tolerances. Furthermore, further research is recommended to test the negative impact of HIIT.

Keywords: High-intensity interval training, athletic performance, exercise physiology, injury risk

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Journal home page: www.e-jespar.com
Academic Editor: Dr. Mehmet Gülü
https://doi.org/10.5281/zenodo.11545579

ARTICLE HISTORY
Received: 03 May 2024
Accepted: 27 May 2024
Published: 01 July 2024

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INTRODUCTION

Exercise is a non-pharmacologic intervention, and has fewer side effects compared to drug treatments (Rajizadeh et al. 2024; Morcillo-Losa et al. 2024). The importance of regular exercise for health is indisputable. Sports health specialists, physicians, and conditioners recommend lifelong regular physical activity and an active lifestyle for a healthy and happy life. The "American College of Sports Medicine" and the "World Health Organization" recommend at least 150 minutes of moderate-intensity or 75 minutes of high-intensity physical activity per week for adults (Batacan et al. 2017; Alansare et al. 2018; Da Silva et al. 2019) and a minimum of 60 minutes of moderate or vigorous physical activity for children and adolescents (Costigan et al. 2017; Barker et al. 2014). However, despite the recognized importance of sports, physical activity, and active lifestyles, sedentary lifestyles prevail worldwide, and a large proportion of adults particularly do not meet even minimal physical activity guidelines (Batacan et al. 2017; Griffiths et al. 2024). These people often cite "lack of time" as the biggest obstacle to participation in physical activity (Batacan et al. 2017; Selmi et al. 2018; Weston et al. 2014; Arazi et al. 2017). To save society from this lack of time and to have an active lifestyle, sports health scientists, conditioners, and coaches have searched for new training techniques that can be an alternative to traditional training methods. In this search, *High-Intensity Interval Training (HIIT)* training protocols have attracted a lot of attention and have become widespread as the subject of many researches. Because HIIT saves time with short loading intervals interspersed with recovery periods and is easily modified according to the individual, it is gaining widespread interest from both coaches and athletes (Batacan et al. 2017; Wewege et al. 2017; Griffiths et al. 2024; Weston et al. 2014). One of the most attractive aspects of HIIT is that training sessions are easily adaptable to athletes. This adaptability is seen as a potentially more efficient way for athletes to reach their goals (Arazi et al. 2017). The basis of the HIIT protocol is shown in Figure 1.

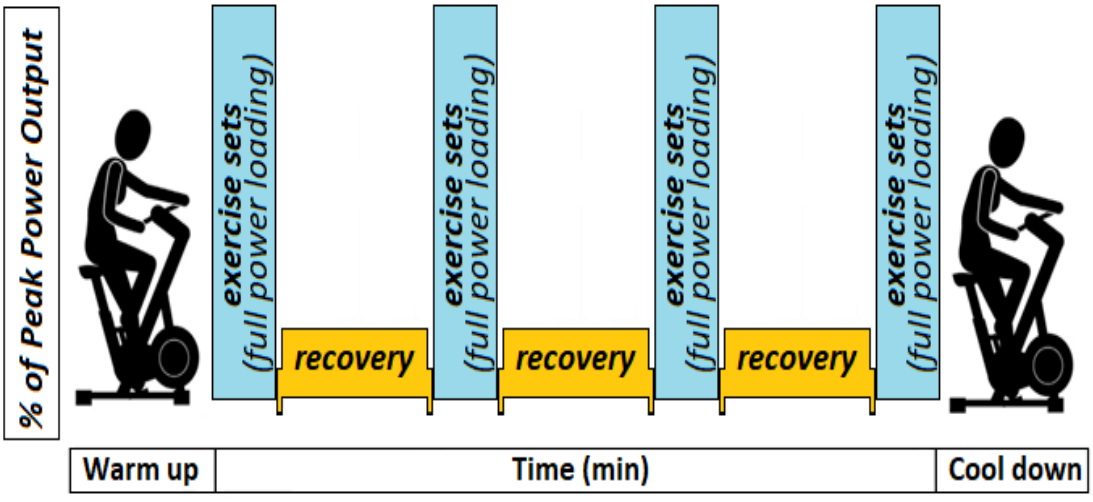

Fig. 1. The basis of the HIIT protocol (Lee et al. 2018).

High-intensity interval training sets can last from a few seconds to several minutes (Mabhout Moghadam et al. 2020; Morcillo-Losa et al. 2024). HIIT is in harmony with short, high-intensity training sets and recovery periods of equal duration between sets. This harmonious interplay of intense training and strategic recovery cycles makes HIIT an excellent choice for those seeking a highly efficient and effective workout (Liuet al. 2024; Juránková et al. 2015; Sabag et al. 2018). An example of a HIIT protocol is shown in Fig 2.

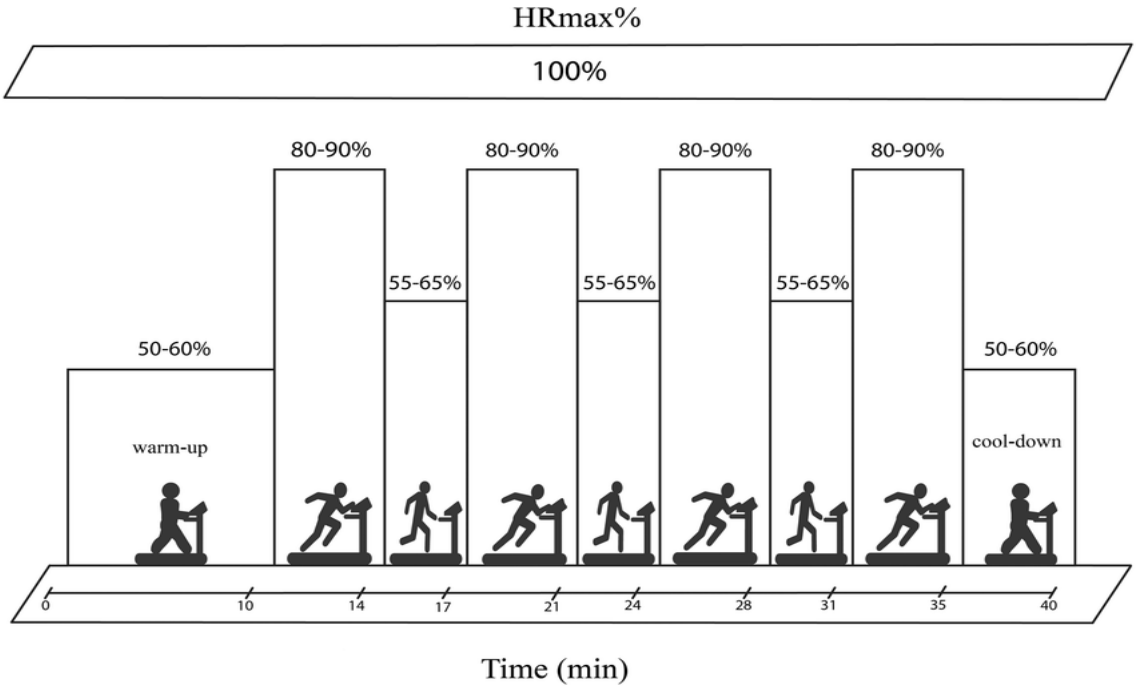

Fig. 2. Example of HIIT protocol (Lame et al. 2023).

Incorporating HIIT into a training program means that greater health-improving benefits can be achieved in less time, making HIIT a more efficient and attractive option (Weston et al. 2014; Muntaner-Mas & Palou, 2017).

Positive Effects of HIIT

There is robust evidence in the literature that HIIT may provide greater benefits over moderate-intensity continuous training models in terms of various health markers in both healthy and chronic disease populations, and this topic continues to be widely researched (Wewege et al. 2017; Batacan et al. 2017; Ai et al. 2021).

HIIT is highly effective in improving numerous health parameters, including blood pressure regulation, body composition, and important risk factors such as cardiovascular disease (Griffiths et al. 2024; Morcillo-Losa et al. 2024; Juránková et al. 2015). There is ample evidence that HIIT has various cardiovascular (cardiovascular

endurance) and metabolic benefits (Mabhout-Moghadam et al. 2020; Bilge et al. 2021; Liu et al. 2024). Recent academic reviews, meta-analyses, and research articles have reported that HIIT induces greater improvements in cardiorespiratory fitness than moderate-intensity continuous training patterns in healthy, young, and middle-aged adults and patients with coronary artery disease and cardio-metabolic disorders. HIIT also appears superior to moderate-intensity continuous training models in improving markers of vascular function in patients with metabolic or cardiovascular disorders (Wewege et al. 2017; Ai et al. 2021).

HIIT is an effective factor in people's nutrient intake (Aydemir & Yetkin, 2022). It is argued that HIIT applied to overweight or obese populations is an effective training strategy to improve fasting glucose levels and reduce blood pressure (Wewege et al. 2017; Ai et al. 2021). It is also argued that HIIT can be a cost-effective and more convenient method for body weight management in obese and overweight people, as it helps oxidize body fat. Therefore, HIIT is a very effective training strategy that can be used in the fight against obesity (Mabhout-Moghadam et al. 2020; Aydemir & Yetkin, 2022; Baynaz et al. 2017).

HIIT training leads to metabolic adaptations such as increased mitochondrial density and glucose utilization. Both of these are crucial for strength development (Liu et al. 2024). HIIT has positive effects on muscle thickness, muscle strength, and muscle function (Juránková et al. 2015; Morcillo-Losa et al. 2024). Therefore, HIIT protocols are an effective way to prevent and treat sarcopenia (Morcillo-Losa et al. 2024). Current research on HIIT confirms its effectiveness in increasing strength and promoting muscle hypertrophy in athletes. HIIT activates fast-twitch muscle fibers that are responsible for producing high levels of power. This promotes muscle adaptation and muscle strength increase (Liu et al. 2024; Morcillo-Losa et al. 2024; Callahan et al. 2021). Similarly, HIIT activates both aerobic and anaerobic energy systems, allowing athletes to increase the speed and strength of high-strength muscle fibers. However, HIIT not only improves anaerobic capacity but also mimics the speed and duration of activities specific to various sports, helping athletes develop energy systems and muscle adaptations tailored to their needs (Liu et al. 2024).

HIIT has become a highly popular training method for athletic performance improvement due to its enhancing effect on elements such as flexibility, speed, and endurance (Liu et al. 2024; Köse and Atlı, 2020; Baynaz et al. 2017).

Compared to traditional training models, HIIT workouts are quite short (Liu et al. 2024). In this respect, HIIT training protocols provide significant time savings for individuals (Blackwell et al. 2018; Akgül et al. 2016). Therefore, HIIT is a highly time-efficient training strategy (Juránková et al. 2015; Ai et al. 2021).

Recently, HIIT training methods have been shown to improve both aerobic and anaerobic performance (Akgül et al. 2016). Because, HIIT has an effective potential to improve aerobic conditioning and aerobic fitness (Bilge et al. 2021; Selmi et al. 2018), aerobic capacity (Morcillo-Losa et al. 2024), aerobic endurance and anaerobic power (Baynaz et al. 2017; Karayiğit et al. 2020) (Selmi et al. 2018; Akgül et al. 2016; Tetik, 2016; Köse and Atlı, 2020). Higher VO2 max levels are indicative of better aerobic capacity and endurance, which allows for continuous training at sub-maximal intensity over long periods (Liu et al. 2024). HIIT is more effective in improving VO2 max, which represents maximum oxygen utilization during exercise, than moderate-intensity continuous training models (Griffiths et al. 2024; Liu et al. 2024; Batacan et al. 2017).

HIIT has beneficial effects on mental health, stress levels, anxiety, and quality of life (Griffiths et al. 2024; Caliskan et al., 2024; Wilczyńska et al. 2024). Recovery intervals between intense loading sets in HIIT contribute to a more positive emotional response (Oliveira et al. 2018).

HIIT is highly effective on hormone parameters due to its high-intensity nature (Mabhout Moghadam et al. 2020). HIIT training patterns stimulate the production of anabolic hormones such as testosterone and growth hormone, which are effective in muscle protein synthesis and thus muscle growth and hypertrophy (Liu et al. 2024).

HIIT affects metabolic syndrome, metabolic functions, and metabolic variables (Durgut & Eskici, 2023; Bilge et al. 2021; Akgül et al. 2016). Remarkably, HIIT training can improve metabolic control mechanisms and the activity of important mitochondrial enzymes such as citrate synthase and cytochrome oxidase (Morcillo-Losa et al., 2024).

HIIT affects inflammation, oxidative stress, apoptosis, and histopathological changes in the lung (Rajizadeh et al., 2024). In the context of high exercise intensities specific to HIIT, there is an increase in both respiratory rate and tidal volume (Morcillo-Losa et al., 2024). On the other hand, HIIT is highly beneficial in the aging process (Morcillo-Losa et al. 2024).

The Negative Effects of HIIT

HIIT is known to have several health benefits, but this inherently high-intensity type of training can also carry some risks if overdone or not performed properly. Below, the potential harms of HIIT are presented in detail.

Because HIIT is a high-intensity workout, if a person is not used to training at this level, HIIT can be very difficult and heavy for their body. Because HIIT puts a lot of strain on the muscles and joints. Therefore, it is important to start HIIT slowly and not try to do too much in too short a time. For example, if there is not enough warm-up at the beginning of HIIT, joint problems and muscle contractions can often occur (WEB 1, 2024).

Another disadvantage of HIIT is that it can be hard on the heart. This is because HIIT is a very intense and strenuous type of exercise and can raise the heart rate to levels that are unsafe for people with certain heart conditions. Therefore, HIIT protocol follow-up should be performed by a physician (WEB 1, 2024; WEB 5, 2024). HIIT is not considered a safe and appropriate form of training for people with heart disease or at risk of heart disease (WEB 1, 2024).

For some people, it can be difficult to stick to HIIT. This is because a training regimen that constantly pushes the limits can accelerate exhaustion (WEB 1, 2024; WEB 2, 2024). HIIT sessions can push the body to the limits of elevated cortisol levels. Cortisol is the primary stress hormone in the body and is responsible for the functioning of a "fight or flight" state in the body. While short-term spikes in cortisol can help to strengthen the body, very high spikes over long periods can cause several unwanted side effects such as bloating, digestive problems, and weight gain. It is also known that such intense exercise and the stress associated with it can cause persistent anxiety in individuals (WEB 2, 2024; WEB 5, 2024). In fact, in one study, negative conditions such as increased anxiety, excessive fatigue, mood disturbance, and loss of strength were observed in participants after HIIT training. In this study, it was argued that as the intensity of training increased, mood disturbance increased in parallel (Selmi et al. 2018).

The explosive force and repetitive movements applied during HIIT sessions can create extreme stress situations on joints, tendons, and muscles.

Therefore, without adequate recovery time, participants become prone to sprains and even muscle tears (WEB 4, 2024; WEB 5, 2024).

Related Literature Review

The literature studies presented in Table 1 assess various aspects of HIIT. These studies evaluate the effects of HIIT on physical fitness, muscle strength and hypertrophy, general health and fitness, potential benefits on energy expenditure, metabolic adaptations, ability to increase endurance, as well as potential risk factors that may occur with HIIT. The current study also examined the effects of HIIT on different populations and its implementation methods. By summarizing the findings and results of some of the studies in the existing literature, this study provides more information about the potential advantages and disadvantages of HIIT.

Table1. *Published literature studies investigating the pros and cons of HIIT.*

Reference	Participant(n)	Title	Training Mode	Training Duration	The factor in which the effect of HIIT was investigated	Effect of HIIT
(Griffiths et al., 2024)	Review (22 academic studies)	The effects of high intensity interval training on quality of life: a systematic review and meta-analysis	Review	Review	Quality of life	+
(Wilczyńska etal., 2012)	38female Experimental group: 22female Control group: 16 hamile kadın	Stress is not so bad cortisol level and psychological functioning after 8-week HIIT program during pregnancy: a randomized controlled trial	Surveys and cortisol hormone measurement	8 Weeks (3 days a week)	Stress level Mental health	+ +
(Rajizadeh etal., 2024)	48 male diabetic Wistar rats	Lung molecular and histological changes in type 2 diabetic rats and its improvement by high-intensity interval training	Motorized treadmill	8 Weeks	Inflammation, oxidative stress, apoptosis, and histopathologic changes in the lung	+
Morcillo-Losa etal.,2024)	Review (5 academic studies)	Effects of High-Intensity Interval Training on Muscle Strength for the Prevention and Treatment of Sarcopenia in Older Adults: A Systematic Review of the Literature	Review	Review	Muscle Strength Prevention and Treatment of Sarcopenia	+
(Liu et al., 2024)	Review (10 academic studies)	Effects of high-intensity interval training on strength, speed, and endurance performance among racket sports players: A systematic review	Review	Review	Strength, speed, and endurance performance	+
(Akgületal., 2016)	10female (ön test – son test)	The Influence of 2 Weeks of Low- Volume High-Intensity Interval Training on Aerobic Indices in Women	Wingate Cycle Ergometer	2 Weeks (3 days a week)	Aerobic indicators ($MaxVO_2$, $PeakVO_2$, and time to exhaustion)	+
(Tetik., 2019)	70 male and female (45 male/25 female)	The Effect of High Intensive Interval Trainings (HIIT) on VO_{2max}	Sprint Test	8 Weeks (2 days a week)	VO_{2max}	+
(Köse & Atlı, 2020)	20 male (10 control / 10 experimental)	Investigation of the Effect of High Intensity Interval Training on Agility, Speed and Aerobic Performance in Young Football Players	Sprint Test	7 Weeks (3 days a week)	Agility, Speed and Aerobic Performance	+
(Karayiğit etal., 2020)	Review (15 academic studies)	The Effects of High-Intensity Interval Training (HIIT) on Aerobic Endurance and Body Fat Burnıing	Review	Review	Aerobic endurance and body fat-burning	+

(Çalışkan etal., 2024)	16 Wistar Albino male rats (8 control /8 experimental)	Effect of high-intensity interval training on self-care and anxiety-like behaviors in naive rats	Sprint Test	8 Weeks (5 days a week)	Self-care and anxiety-like behaviors	+
(Bölükbaş et al. 2023)	Review (17 academic studies)	The Effects of High-Intensity Interval Training on Body Composition, Cardiorespiratory Fitness, and Metabolic Parameters in Patients with Type 2 Diabetes: A Systematic Review	Review	Review	Body Composition, Cardiorespiratory Fitness, and Metabolic Parameters	+
(Aydemir & Yetkin, 2022)	Review (8 academic studies)	Effects of High-Intensity Interval Training (HIIT) Model on Food Intake in Individuals with Obesity: A Systematic Review	Review	Review	Food Intake	-
(Baynaz et al. 2017)	20 female (10 control / 10 experimental)	The effect of high intensity interval training on flexibility and anaerobic power	Tabata Protocol	6 Weeks (3 days a week)	Flexibility and anaerobic power	+

Table1 (Devamı). *Published literature studies investigating the pros and cons of HIIT.*

Reference	Participant(n)	Title	Training Mode	Training Duration	The factor in which the effect of HIIT was investigated	Effect of HIIT
(Juránková et al. 2015)	7 female (10 control / 10 experimental)	Effects of high-intensity strength interval training program on body composition	Strength interval training	10 Weeks (3 days a week)	Body composition Reduction of body fat Increased muscle mass	+
(Arazi et al. 2017)	16 female (8 speed-based HIIT/ 8 heart rate-based HIIT)	Effects of Heart Rate vs. Speed-Based High Intensity Interval Training on Aerobic and Anaerobic Capacity of Female Soccer Players	Run and walk	6 Weeks (3 days a week)	Aerobic and Anaerobic Capacity	+
(Selmi et al. 2018)	20 male (pre- and post-training)	High intensity interval training negatively affects mood state in professional athletes	Sprint Test	5 days HIIT	Mood state	-
(Batacan et al. 2017)	Review (65 academic studies)	Effects of high-intensity interval training on cardiometabolic health: a systematic review and meta-analysis of intervention studies	Review	Review	Cardiometabolic health	+
(Ai et al. 2021)	Review (24 academic studies)	The Effect of Acute High-Intensity Interval Training on Executive Function: A Systematic Review	Review	Review	Executive Function	+
(Callahan et al. 2021)	Review (13 academic studies)	Can High-Intensity Interval Training Promote Skeletal Muscle Anabolism?	Review	Review	Skeletal Muscle Anabolism	+
(Mabhout Moghadam et al. 2020)	Review (Compilation of academic studies)	Review the Effect of High Intensity Interval Training on Obesity- Related Hormones	Review	Review	Obesity and Obesity- Related Hormones	+

(de Araujo et al. 2016)	50 Wistar male rats	Short and Long Term Effects of High-Intensity Interval Training on Hormones, Metabolites, Antioxidant System, Glycogen Concentration, and Aerobic Performance Adaptations in Rats	Swim bouts	12 Weeks long term HIIT / 6 Weeks short term HIIT (6 days a week)	Hormones, Metabolites, Antioxidant System, Glycogen Concentration, and Aerobic Performance	+
(Wewege et al. 2017)	Review (13 academic studies)	The effects of high-intensity interval training vs. moderate-intensity continuous training on body composition in overweight and obese adults: a systematic review and meta-analysis	Review	Review 10 Weeks (Studies involving 3 days a week were included)	Body composition	+
(Weston et al. 2014)	Review (10 studies with 273 patients)	High-intensity interval training in patients with lifestyle-induced cardiometabolic disease: a systematic review and meta-analysis	Review	Review	Chronic diseases	-
(Sabag et al. 2018)	Review (13 academic studies)	The compatibility of concurrent high intensity interval training and resistance training for muscular strength and hypertrophy: a systematic review and meta-analysis	Review	Review	Muscular strength and hypertrophy	+
(Oliveira et al. 2018)	Review (8 academic studies)	Affective and enjoyment responses in high intensity interval training and continuous training: A systematic review and meta-analysis	Review	Review	Affective and enjoyment responses	+

"+": HIIT has a positive effect. "-": HIIT has a negative effect.

MATERIALS AND METHODS

This review includes a systematic analysis of scientific studies related to the research data, and the research topic was obtained through a literature review. In this framework, 25 academic studies were compiled. In this study, a review of current literature examining the positive and negative effects of HIIT on athletic performance was conducted. This study was structured to include studies and meta-analyses in various scientific databases such as "*Web of Science*", "*PubMed*", "*Google Scholar*" and "*TR Index*". "*High-Intensity Interval Training*", "*HIIT*", "*Sporty Performance*", "*Athletic Performance*", and "*HIIT and Athletic Performance/HIIT and Sports Performance*" in these databases for the analysis of the studies, A literature review of keywords such as "*Effects of HIIT*", "*Sports Injuries*" and "*Injury Risks in Sports*" was conducted both in Turkish and English and the conclusion section of the current study was formed according to the results of these studies. The findings and results of the 25 selected articles were analyzed in detail and common points were identified and solution suggestions were presented.

The schematic of the literature review process is shown in Figure 3.

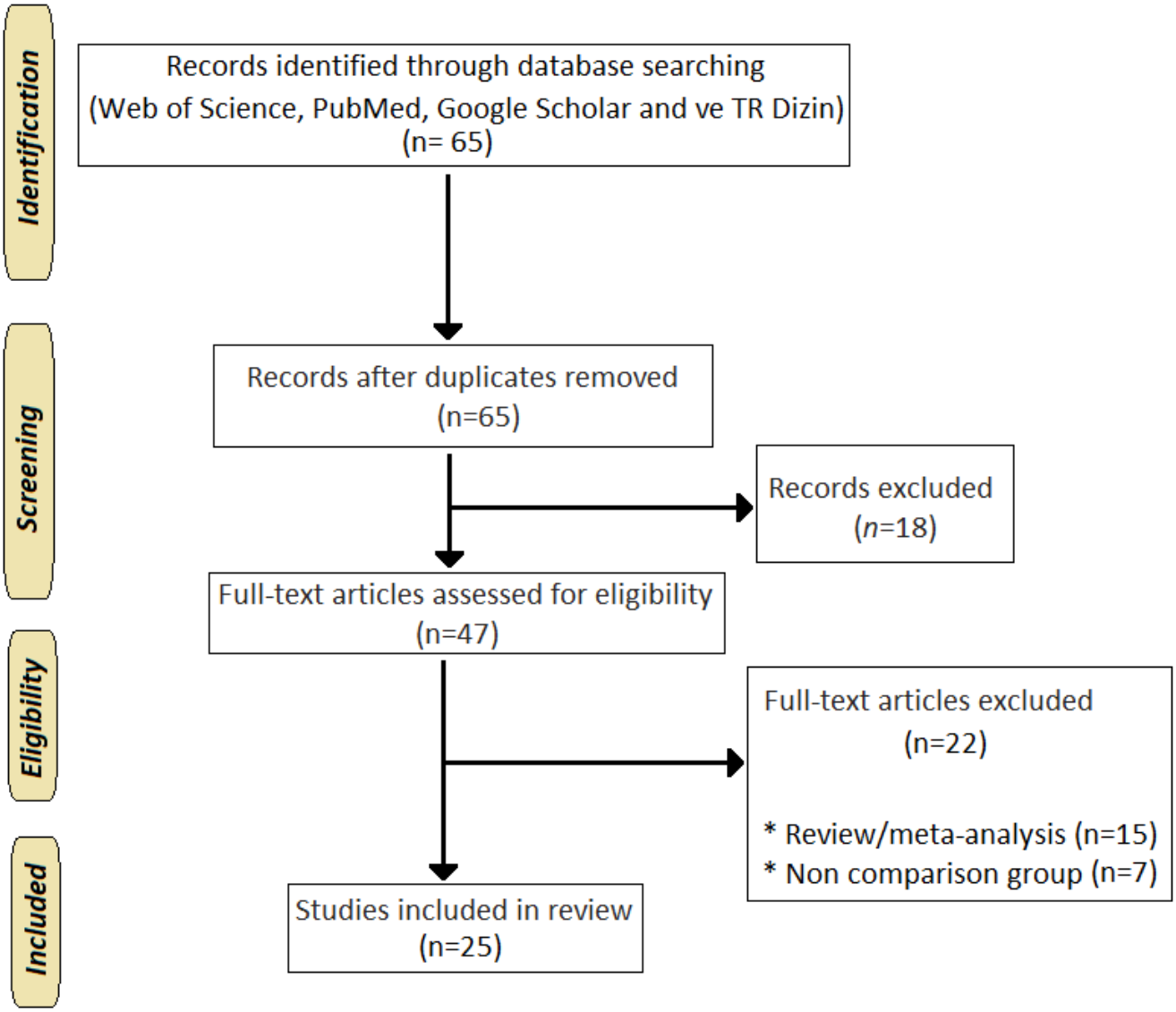

Fig. 3. Flow diagram of the literature screening process.

DISCUSSION

In this study, "Positive and Negative Effects of High Intensity Interval Training on Athletic Performance" was investigated. The conclusion section of our research was formed in light of the findings obtained from the academic studies compiled by examining the research subject in the literature in depth. According to the findings obtained from these studies, HIIT has the potential to improve performance in many sports. When the results of the studies included in the present research are examined, it is seen that although significant improvements and developments are recorded in performance measures such as strength, endurance, speed, and aerobic and anaerobic capacity with HIIT protocols, there are also negative effects of HIIT such as the risks of overtraining, muscular injuries and excessive fatigue. A detailed discussion section is presented below, comparing the results of the scientific studies included in the current research. In recent years, HIIT protocols have become a popular training method among athletes. Studies have reported significant improvements and improvements in performance measures such as speed, strength, endurance, and anaerobic capacity with the application of protocols. For example, Akgül et al. applied 2-week HIIT to female participants in their study and aimed to examine the effects of HIIT on the aerobic indicators of the participants. As a result of the study, significant improvements were observed in the participants' aerobic indicators such as *maxVO2, peakVO2,* and time to exhaustion at the end of 2 weeks (Akgület al. 2016). Similarly, in another study whose aim was to examine the effect of HIIT on agility, speed, and aerobic performance in young soccer players, 20 young soccer players were included in the HIIT protocol. The results of this study showed that HIIT improved both running distance and speed in young soccer players. (Köse & Atlı, 2020). Arazi et al. compared the effects of two types of HIIT programs on the aerobic and anaerobic capacity of female soccer players. Sixteen young female athletes participated in this study. The athletes performed HIIT training three days a week for 6 weeks. As a result, statistically significant improvements in strength, *VO2 max,* and fatigue index were reported in female soccer players in both HIIT groups. (Araziet al. 2017). A meta-analysis compared the results of the reviewed articles on the topic. This systematic review aimed to quantify the effect of HIIT in improving VO2 max in patients with lifestyle-induced chronic diseases. The results showed that HIIT improved cardiorespiratory fitness in patients with lifestyle-induced chronic diseases almost twice as much as a moderate-intensity continuous training model (Weston et al. 2014). In a similar study, the effects of HIIT on the strength, speed, and endurance performance of athletes were evaluated. As a result of the study, it is emphasized that HIIT has a higher potential to improve overall athletic performance compared to other training methods. (Liu et al. 2024). Although it is common knowledge that HIIT training has so many beneficial aspects, it is also important to consider the negative consequences of overuse and misuse of HIIT. For example, in a study by Selmi

et al., it was argued that HIIT causes negative health problems. In the study, they aimed to describe the effects of HIIT on psychological responses. 20 male soccer players participated in the study. According to the findings of the study, it was concluded that the HIIT protocol led to negative health conditions such as increased anxiety, fatigue, mood disturbance, and decreased strength (Selmi et al. 2018).

Karayiğit et al. aimed to examine the effects of HIIT on aerobic endurance and body fat burning. With the meta-analysis prepared for this purpose, 15 academic studies were compiled and a conclusion was obtained by comparing the results of these studies. As a result of the study, it was concluded that HIIT is a highly effective method for increasing body fat-burning rate, decreasing body fat mass, and improving aerobic endurance (Karayiğit et al. 2016). Griffiths et al. conducted a comprehensive systematic review of the effect of HIIT on physical, mental, and overall quality of life in a meta-analysis. According to the results of this study, participating in HIIT, which is a more time-efficient training strategy, provides statistically significant improvements in physical, mental, and overall quality of life with small to moderate effect sizes in clinical and non-clinical populations (Griffiths et al. 2024). Similarly, another study argued that HIIT is a valid strategy for increasing muscle strength and preventing sarcopenia in older adults (Morcillo-Losa et al. 2024). In another study in which 70 students (female n: 25, male n: 45) studying in the field of physical education and sports participated voluntarily, it was concluded that HIIT improved aerobic performance and increased aerobic capacity (Tetik, 2016). De Araujo et al. aimed to investigate the effects of short and long-term HIIT on anaerobic and aerobic performance, creatinine, uric acid, urea, creatine kinase, lactate dehydrogenase, catalase, superoxide dismutase, testosterone, corticosterone, and glycogen concentration. In the study, HIIT was applied to one of the two groups for 12 weeks and the other for 6 weeks. According to the findings of the study, it was concluded that HIIT was effective on corticosterone, glycogen stores, white blood cells, and aerobic performance (De Araujo et al. 2016). Alongside these beneficial effects of HIIT, it has also been argued that HIIT is highly detrimental to some populations. For example, a Web page on sports performance information discusses the disadvantages of HIIT. One important disadvantage is that HIIT, which is a very intense and exhausting type of exercise, can be hard on the heart. On this webpage, HIIT is not seen as a suitable training model for cardiac patients (WEB 1, 2024). Although HIIT is not recommended in populations with heart disease, some studies mention the benefits of HIIT in overweight/obese populations. For example, Batacan et al. (2017) argue that HIIT can increase VO_{2max} and improve some cardiometabolic risk factors (body fat percentage, fasting glucose, etc.) (Batacanet al. 2017). Similarly, Wewege et al. (2017) aimed to investigate the effect of HIIT on body composition in overweight or obese adults. In the study, it was concluded that HIIT has an improving effect on the body composition of overweight and obese individuals and that HIIT is also a time-efficient type of training for this population, given that this population spends ~40% less time for HIIT each week (Wewege et al. 2017). In another study investigating the effect of HIIT on adults with obesity, the effects of HIIT on food intake in obese adults were analyzed by reviewing

articles published in the literature. According to the results of this study, it was revealed that HIIT was not effective in reducing food intake but was effective in increasing energy expenditure in general. It was also argued that HIIT may be an effective exercise model in the treatment of obesity by contributing to the reduction of body fat mass by suppressing appetite through anorexigenic hormones and changing food preferences (Aydemir & Yetkin, 2022). Oliveira et al. (2018) also applied HIIT to obese individuals in their study. This study aimed to conduct a systematic review and meta-analysis of the literature on the acute effects of HIIT on emotional and pleasure responses. In this meta-analysis, 6 out of 10 studies showed an enhancing effect of HIIT in both normal-weight and obese individuals. Based on the results of this study, it is possible to conclude that HIIT exercise can be a valid strategy for health improvement as shown in previous studies, evoking psychological responses that are in line with those expected for exercise adherence, including in overweight and unfit individuals (Oliveira et al. 2018). A review study of HIIT in type 2 diabetic patients reported that HIIT improved body composition, cardiorespiratory fitness, and metabolic parameters (Bölükbaş et al. 2023).

Juránková et al. (2015) conducted a 10-week HIIT program for 7 female participants in their study. This study aimed to examine the effects of a 10-week HIIT program on body composition. The results of the study showed that 10 weeks of HIIT had a non-significant positive effect on the reduction of body fat but a significant positive effect on the increase of muscle mass. (Juránková et al. 2015). In another study, it was aimed to examine the self-care and possible anxiolytic effects of 8-week HIIT. This study shows that HIIT has beneficial effects on different aspects of behavior such as exploratory behavior, enhancement of anxiolytic behavior, and reduction of anxiogenic behavior. In this study, 16 8-week-old male Wistar albino rats were used as the research group. To clarify the results of the study, the application of a similar HIIT protocol on human participants may help to further clarify the issue (Çalışkan et al. 2024). Baynaz et al., (2017) aimed to examine the effect of HIIT with own body weight on flexibility and anaerobic capacity for 6 weeks. Twenty volunteer young sedentary women participated in the study. According to the results of the study, it was determined that 6 weeks of HIIT applied with the Tabata Method had a positive effect on body weight, flexibility, and anaerobic power parameters of sedentary women (Baynaz et al. 2017). Ai et al. (2021) argued in their study that HIIT has an improving effect on executive function (Ai et al. 2021). In another study, it was argued that HIIT delays hunger by inducing a transient state of anorexia for a short time after exercise and plays an enhancing role by changing hunger and appetite signals and regulatory peptides from short-term to long-term signaling levels (Mabhout Moghadam et al. 2020). Sabag et al (2018) aimed to evaluate the effect of HIIT on strength and hypertrophy in their meta-analysis study. The findings of this review suggest that HIIT has an enhancing effect on strength and hypertrophy (Sabag et al. 2018). However, it is also argued that HIIT, being high-intensity in nature, carries great risks, especially in terms of muscle strength and hypertrophy. For example, a Web page on the harmful effects of HIIT discusses the disadvantages of HIIT on muscles, joints, and tendons. This webpage emphasizes that the explosive force and repetitive movements applied in HIIT sessions can create extreme stress situations on joints, tendons, and muscles, and therefore HIIT protocols used incorrectly or without adequate recovery time can cause sprains and even muscle tears in participants (WEB 4, 2024; WEB 5, 2024).

In conclusion, HIIT has the potential to improve performance in many sports. In fact, in the studies included in the present research, significant improvements and developments were recorded in performance measures such as speed, strength, endurance, aerobic and anaerobic capacity with HIIT protocols. It should be noted that HIIT is also a very time-efficient training method. However, it is necessary to take into account the negative situations that may arise with excessive and improper use of HIIT. Therefore, although HIIT has many benefits, it is very important to design a personalized HIIT program, taking into account individual health status, fitness level, and training history. Consulting an expert, such as a doctor or sports trainer, before starting HIIT training and making sure that the training program is implemented correctly will help to avoid or minimize the harmful effects of HIIT.

CONCLUSIONS

According to the results of the present study, HIIT has the potential to improve athletic performance in many sports. It was noted in the literature review that HIIT provides significant improvements and enhancements in performance measures such as strength, endurance, speed, and aerobic and anaerobic capacity. However, since HIIT is a high-intensity training type and HIIT sets are performed at full strength, it can lead to the development of various risk factors. Therefore, HIIT training protocols are also associated with negative effects such as overtraining risks, muscular injuries, and excessive fatigue, and more research is needed to better understand the harms of HIIT. Recommendations based on the results of our research are presented below.

Recommendations

- HIIT training protocols should be individualized considering the athletes' physical abilities, goals, and health status. Appropriate intensity, duration, recovery and rest periods should be determined for each athlete. Because athletes having adequate recovery and rest periods can reduce the risk of overtraining.
- Using the correct training techniques in HIIT training programs can reduce the risk of injury. For this reason, athletes should be given the necessary training to perform their training in the right way and it should be ensured that they train under the supervision of a coach or specialist.
- If athletes show signs of excessive fatigue during training, revisions should be made to the training protocol, and rest periods should be increased if necessary. Because prevention of excessive fatigue is important for the sustainability of athletic performance.
- Keeping the motivation of athletes high in training is important for adherence to training and sustainability of performance. Therefore, the motivation of athletes should be supported by providing variety in training and using motivational strategies for the goals of the athlete. Motivation is a very important factor in the prevention of sports injuries.

Author Contributions

Conceptualization, M.Ö. methodology, M.Ö. and İ.G; formal analysis, İ.G. and M.Ö; investigation, İ.G. and M.Ö; data curation, İ.G. and M.Ö; writing-original draft preparation, İ.G. and M.Ö; writing-review and editing, M.Ö.

Informed Consent Statement:

The research was conducted in line with the Declaration of Helsinki.

Acknowledgments:

We would like to thank all participants who took part in the research.

Funding:

This research was not funded by any institution or organization.

Conflicts of Interest:

The authors declare that no conflicts interest.

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