RESEARCH PAPER

Effects of Phoenix dactylifera (Ajwa Date) Supplementation Combined with High Intensity Interval Training on Oxidative Stress and Cardiovascular Parameters in Overweight Hypertensive Individuals

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Abstract
Background: Hypertension and overweight/obesity are major modifiable cardiovascular risk factors associated with oxidative stress, endothelial dysfunction, chronic inflammation, and increased risk of coronary artery disease. High-Intensity Interval Training (HIIT) has been recognized as an effective non-pharmacological intervention for improving cardiovascular and metabolic health. However, intense exercise may transiently increase oxidative stress and inflammatory responses. Ajwa dates (Phoenix dactylifera L.), which are rich in antioxidants and anti-inflammatory compounds, may provide complementary protective effects against exercise-induced oxidative stress.
Objective: This literature review aimed to evaluate the potential synergistic effects of Ajwa date supplementation combined with HIIT on oxidative stress and cardiovascular parameters in overweight hypertensive individuals.
Methods: A narrative literature review was conducted using recent scientific articles published within the last five years from international databases related to hypertension, obesity, HIIT, oxidative stress, endothelial function, inflammation, and Ajwa dates. Relevant studies including clinical trials, systematic reviews, meta-analyses, and experimental studies were analyzed and synthesized.
Results: The reviewed literature demonstrated that HIIT significantly improves blood pressure, endothelial function, aerobic capacity, body composition, and lipid metabolism in overweight and hypertensive populations. However, HIIT may also increase reactive oxygen species (ROS), inflammatory cytokines, and oxidative stress biomarkers. Ajwa dates contain polyphenols, flavonoids, vitamins, minerals, and dietary fiber with potent antioxidant and anti-inflammatory properties that may reduce oxidative stress, improve vascular function, and support cardiovascular health. The combination of HIIT and Ajwa date supplementation may provide complementary cardiovascular and metabolic benefits while attenuating exercise-induced oxidative stress.
Conclusion: HIIT combined with Ajwa date supplementation represents a promising integrative approach for improving cardiovascular and metabolic health in overweight hypertensive individuals. Further randomized controlled trials are needed to confirm its long-term efficacy and safety.
Keywords: High-Intensity Interval Training, Ajwa Dates, Hypertension, Oxidative Stress, Cardiovascular Health
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Introduction

Coronary artery disease (CAD) remains one of the leading causes of mortality and disability worldwide. According to the American College of Cardiology/American Heart Association (ACC/AHA), approximately 9.44 million deaths were attributed to CAD in 2021 alone [1]. As a developing country, Indonesia also experiences a substantial burden of CAD, with an estimated 420,000 deaths annually attributed to cardiovascular disease [2]. Coronary artery disease develops as a long-term manifestation of multiple interacting cardiovascular risk factors. These risk factors synergistically increase the likelihood of adverse cardiovascular events when not managed comprehensively. Among the most significant modifiable risk factors are hypertension and overweight or obesity [3].

Hypertension is considered one of the most prevalent and important contributors to CAD. Globally, the prevalence of hypertension is estimated at approximately 32% in women and 34% in men [4]. Persistent elevation of blood pressure increases cardiac workload, leading to left ventricular hypertrophy, left atrial dilation, systolic and diastolic dysfunction, and ultimately clinical manifestations such as arrhythmia, myocardial ischemia, and heart failure [4], [5]. Another major cardiovascular risk factor is overweight and obesity, both of which are closely associated with increased visceral fat accumulation. Excess visceral adiposity contributes to insulin resistance, endothelial dysfunction, sympathetic nervous system activation, increased vascular resistance, and elevated pro-inflammatory and pro-thrombotic mediators, thereby accelerating the development of cardiovascular disease [6],[8].

Importantly, hypertension and overweight/obesity are classified as modifiable cardiovascular risk factors. Their management may involve lifestyle modification, pharmacological therapy, or interventional approaches, including surgical and minimally invasive procedures [2]. Physical exercise is widely recognized as an essential lifestyle intervention for the prevention and management of cardiovascular disease. Regular exercise improves mitochondrial function, promotes vascular repair and restoration, and stimulates the release of myokines from skeletal muscles that contribute to maintaining cardiac function. Furthermore, appropriate exercise programs may reduce visceral fat accumulation, improve myocardial perfusion, increase high-density lipoprotein (HDL) levels, and enhance insulin sensitivity, all of which positively influence cardiovascular health [9],[12].

High-Intensity Interval Training (HIIT) is a form of interval exercise characterized by alternating short bursts of high-intensity anaerobic activity with periods of lower-intensity recovery or rest. Typically, HIIT involves exercise intensities ranging from 85% to 250% of VO_2 max for durations of 6 seconds to 4 minutes, interspersed with recovery periods at 20%-40% of VO_2 max lasting 10 seconds to 5 minutes [13]. Numerous studies and meta-analyses have demonstrated the beneficial effects of HIIT on cardiovascular health, including reductions in blood pressure, body weight, and visceral fat percentage [13],[15]. Despite these benefits, HIIT is not without potential risks, particularly in individuals with cardiovascular risk factors or established coronary artery disease. Adverse effects associated with HIIT may include sudden increases in blood pressure and heart rate, elevated risk of myocardial infarction, arrhythmias, sudden cardiac arrest, exacerbation of heart failure, endothelial dysfunction, and abrupt increases in sympathetic nervous system activity [16]. At the cellular level, HIIT may transiently increase cardiac biomarkers such as cardiac troponin T, brain natriuretic peptide (BNP), and D-dimer, as well as inflammatory mediators including interleukin-6 (IL-6) and tumor necrosis factor-alpha (TNF-α) [10], [17].

Ajwa date (Phoenix dactylifera) is a variety of date fruit recognized for its potential cardiovascular health benefits. Ajwa dates are rich in dietary fiber, antioxidants, and essential nutrients, including vitamin B6, magnesium, potassium, and flavonoids [18], [19]. The fiber content may contribute to lowering blood cholesterol levels, thereby potentially reducing cardiovascular risk. In addition, the high antioxidant content, particularly flavonoids and carotenoids, may protect cells against oxidative stress and inflammation, two key mechanisms involved in the pathogenesis of hypertension and atherosclerosis. Moreover, the high potassium content may assist in blood pressure regulation, support healthy cardiac function, and reduce the risk of arrhythmias [20], [21].

Although previous studies have separately demonstrated the cardiovascular benefits of HIIT and the antioxidant properties of Ajwa dates, evidence regarding their combined effects in overweight hypertensive individuals remains limited. Therefore, this study aimed to evaluate the effectiveness of Ajwa date (Phoenix dactylifera) supplementation in overweight hypertensive subjects undergoing a High-Intensity Interval Training program, particularly regarding oxidative stress and cardiovascular parameters.

Methods

A narrative literature review was conducted using recent scientific articles published within the last five years from international databases related to hypertension, obesity, HIIT, oxidative stress, endothelial function, inflammation, and Ajwa dates. Relevant studies including clinical trials, systematic reviews, meta-analyses, and experimental studies were analyzed and synthesized.

Hypertension

Hypertension is one of the major risk factors for cardiovascular disease and remains a leading contributor to global morbidity and mortality. Over the past two decades, the prevalence of hypertension has increased substantially, affecting approximately 1.4 billion individuals worldwide [22]. In Indonesia, data from the 2018 National Basic Health Research (Riskesdas), as reported by Nurjanah et al., indicated that the prevalence of hypertension reached 31.4% of the population [23]. Hypertension is a chronic medical condition characterized by persistently elevated arterial blood pressure. According to the 2024 European Society of Cardiology (ESC) guidelines, hypertension is diagnosed when systolic blood pressure is ≥140 mmHg and/or diastolic blood pressure is ≥90 mmHg during measurements performed in healthcare facilities [24]. The ESC also introduced the category of Elevated Blood Pressure, defined as systolic blood pressure ranging from 120–139 mmHg and/or diastolic blood pressure ranging from 70–89 mmHg [24].

Several major risk factors contribute to the development of hypertension, including genetic predisposition, sedentary lifestyle, excessive salt intake, obesity, and smoking habits. Although hypertension is frequently asymptomatic, its long-term effects on the cardiovascular system are substantial, significantly increasing the risk of coronary artery disease, stroke, and heart failure [25]. The pathophysiology of hypertension involves a complex interaction among oxidative stress, inflammation, genetic factors, sodium homeostasis imbalance, and alterations in the gut microbiome [26], [27]. Over time, these mechanisms collectively elevate blood pressure and contribute to progressive damage to vital organs such as the heart, kidneys, and blood vessels [26], [27].

The kidneys play a central role in blood pressure regulation through the renin–angiotensin system (RAS) and sodium balance control. Impaired renal sodium homeostasis may lead to increased blood volume and persistent elevation of arterial pressure [26]. In addition, increased systemic vascular resistance and reduced vascular elasticity contribute to the development of hypertension. These alterations are associated with elevated vasoconstrictor activity and endothelial dysfunction, resulting in impaired physiological vasodilation [27]. Excessive activation of the sympathetic nervous system further exacerbates hypertension by promoting vasoconstriction and inflammatory responses [26], [27]. Recent studies have also highlighted emerging mechanisms involved in hypertension pathogenesis, particularly the roles of reactive oxygen species (ROS), immune system activation, and gut microbiota dysbiosis [26], [27]. Reactive oxygen species generated in response to stimuli such as angiotensin II can induce vascular injury and sodium retention, thereby worsening hypertension [26]. Furthermore, activated immune cells may contribute to vascular and renal damage through inflammatory pathways. Alterations in the gut microbiome have also been associated with systemic inflammation and impaired cardiovascular health, both of which influence blood pressure regulation [27].

From a cardiovascular perspective, hypertension contributes significantly to the development of coronary artery disease through several interconnected mechanisms. These include excessive neurohormonal activation, progression of atherosclerotic plaque formation, endothelial dysfunction, impaired intramyocardial coronary circulation, arterial stiffness, and reduced coronary perfusion [28]. Therefore, effective blood pressure control is essential in preventing coronary artery disease and other cardiovascular complications.

Overweight and Obesity

Overweight and obesity have reached epidemic proportions globally and are recognized as major risk factors for cardiovascular disease (CVD). Obesity is defined as a Body Mass Index (BMI) ≥30 kg/m², whereas overweight is classified as a BMI ≥25 kg/m² and <30 kg/m² [8], [29]. Obesity is influenced not only by genetic predisposition and lifestyle factors, but also by environmental and psychosocial determinants. Worldwide, obesity affects millions of individuals, and its prevalence continues to increase, contributing to a higher incidence of cardiovascular disease, type 2 diabetes mellitus, dyslipidemia, and hypertension [6], [29].

The pathophysiological relationship between obesity and cardiovascular disease is highly complex. Excess adipose tissue accumulation, particularly visceral adiposity, plays a critical role in promoting metabolic dysfunction and chronic inflammation. Visceral fat produces various bioactive molecules, including adipokines, which contribute to inflammation, insulin resistance, and endothelial dysfunction [28], [30], [31]. Increased visceral fat accumulation is also associated with accelerated atherosclerosis, reduced arterial elasticity, and elevated risk of hypertension. Furthermore, obesity enhances sympathetic nervous system activity and activates the renin–angiotensin system, both of which contribute to elevated blood pressure and cardiovascular complications [8], [28], [29].

At the cellular and biomolecular levels, obesity significantly contributes to the progression of cardiovascular disease. Adipose tissue, particularly visceral fat, functions not only as passive energy storage but also as an active endocrine organ that secretes adipokines and pro-inflammatory mediators.

Adipokines such as leptin, adiponectin, resistin, visfatin, and apelin are involved in the regulation of lipid metabolism, glucose homeostasis, and inflammatory responses [30], [31].

Leptin, a hormone secreted by adipocytes, normally regulates appetite and energy metabolism. However, obesity is commonly associated with leptin resistance, a condition in which elevated leptin levels fail to adequately suppress appetite, thereby promoting excessive food intake. In addition, leptin stimulates sympathetic nervous system activity and contributes to hypertension and inflammation [30], [31]. Conversely, adiponectin, an adipokine with anti-inflammatory and insulin-sensitizing properties, is typically reduced in obesity. Lower adiponectin levels are associated with insulin resistance, endothelial dysfunction, and increased cardiovascular risk [30], [31].

Inflammation is a central mechanism in obesity-related cardiovascular disease through increased oxidative stress and the production of pro-inflammatory cytokines such as tumor necrosis factor-alpha (TNF-α), interleukin-6 (IL-6), and monocyte chemoattractant protein-1 (MCP-1). Enlarged adipocytes in obese individuals often experience hypoxia, which triggers inflammatory responses through macrophage activation within adipose tissue. These activated macrophages release inflammatory cytokines that promote insulin resistance and endothelial dysfunction, thereby worsening cardiovascular risk [6], [28], [30]. Mitochondrial dysfunction in obese adipose tissue also contributes to increased production of reactive oxygen species (ROS). Elevated ROS levels induce oxidative stress, leading to endothelial cell injury and acceleration of atherosclerotic processes. Impaired mitochondrial function additionally disrupts glucose and lipid metabolism, further aggravating metabolic abnormalities associated with obesity [6], [30].

From a preventive and therapeutic perspective, weight reduction through lifestyle modification, including healthy dietary patterns and regular physical activity, as well as medical and surgical interventions, may significantly reduce obesity-related cardiovascular risk. Substantial weight loss achieved through pharmacological therapy or bariatric surgery has been shown to reduce the incidence of coronary artery disease, heart failure, and metabolic disorders [28], [29]. Nevertheless, effective obesity management requires a multidisciplinary approach and long-term commitment from both individuals and healthcare professionals [6], [28].

High-Intensity Interval Training (HIIT)

High-Intensity Interval Training (HIIT) is a form of physical exercise characterized by short periods of high-intensity activity alternated with recovery periods consisting of low-intensity exercise or rest. HIIT is commonly performed at near-maximal intensity, often exceeding 90% of maximal oxygen uptake (VO_2 max). High-intensity exercise intervals generally last from 10 seconds to 4 minutes and are followed by longer recovery periods ranging from 1 to 5 minutes [15], [16]. HIIT can be performed using various exercise modalities, including sprint running, cycling, and aerobic training exercises [15], [16].

A common HIIT protocol consists of four repetitions of 4-minute high-intensity exercise performed at 85%-90% of maximal heart rate, followed by 3-minute recovery periods at 50%-60% of maximal heart rate. The total training duration usually ranges from 20 to 30 minutes, including warm-up and cool-down sessions [32], [33]. HIIT may be implemented through aerobic activities such as sprinting, cycling, or treadmill-based exercise programs.

Benefits of HIIT in Individuals with Hypertension and Obesity

Numerous studies have demonstrated that HIIT provides substantial benefits for individuals with hypertension and obesity. Previous investigations reported that HIIT significantly reduces both systolic and diastolic blood pressure while simultaneously improving endothelial function, which is essential for maintaining vascular elasticity [15]. Other studies have shown that HIIT produces greater improvements in VO_2 max compared with Moderate-Intensity Continuous Training (MICT), an important finding considering that higher aerobic capacity is associated with reduced cardiovascular risk [32], [34].

HIIT has also been proven effective in promoting weight loss, particularly by reducing visceral adiposity. Compared with prolonged moderate-intensity exercise, HIIT increases energy expenditure within a shorter duration. Moreover, HIIT induces a greater Excess Post-Exercise Oxygen Consumption (EPOC) effect, resulting in increased calorie burning even after exercise completion [33]. This phenomenon makes HIIT an attractive exercise strategy for individuals seeking efficient body weight reduction.

The metabolic effects of HIIT are largely attributed to the EPOC mechanism, whereby the body continues to consume oxygen and expend energy during the recovery phase to restore physiological homeostasis. During post-exercise recovery, energy is required for muscle tissue repair, replenishment of energy stores, and restoration of oxygen balance, all of which contribute to prolonged calorie expenditure [32], [33].

Additionally, HIIT enhances lipid oxidation during both exercise and recovery periods. Studies have shown that HIIT improves the body's ability to mobilize and utilize fat more efficiently compared with MICT [32], [34]. Several intervention studies demonstrated significant reductions in body fat percentage following HIIT programs. In an 8-week study involving obese university students, the HIIT group exhibited substantially greater reductions in body fat percentage compared with the MICT group. Male participants experienced a 23.71% reduction in body fat, whereas female participants demonstrated a 26.76% reduction. In contrast, the MICT group only showed reductions of 9.81% in males and 7.16% in females [32], [34].

HIIT has also been associated with reductions in waist circumference and visceral fat composition, both of which are important predictors of cardiovascular and metabolic disease risk. Previous studies demonstrated that HIIT reduced visceral fat more rapidly than MICT, thereby contributing to a lower risk of metabolic disorders such as type 2 diabetes mellitus and cardiovascular disease [34]. Furthermore, HIIT improves overall body composition and lipid profiles by reducing total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), and triglyceride (TG) levels, all of which are important indicators of cardiovascular health [32], [33].

Because of its shorter duration and efficient physiological outcomes, HIIT has emerged as an effective strategy for reducing body weight, decreasing adiposity, and improving cardiovascular fitness, particularly among overweight and obese populations [32], [34].

HIIT and Inflammatory Responses

Although HIIT substantially improves cardiorespiratory fitness and metabolic function, it may also induce inflammatory and oxidative stress responses. Interleukin-6 (IL-6) and Tumor Necrosis Factor-alpha (TNF-α) are among the primary inflammatory biomarkers elevated following HIIT sessions. Sarkar et al. demonstrated that after an 8-week HIIT program, IL-6 levels increased by 18.2% and TNF-α levels increased by 14.4% among athletes participating in high-intensity training [17].

The increase in IL-6 is believed to occur as a response to metabolic stress induced by high-intensity exercise. Acute inflammation following exercise is generally considered a temporary adaptive response that facilitates tissue repair and physiological adaptation. However, in certain individuals, excessive inflammatory responses may lead to greater cellular injury and increase the risk of long-term adverse effects [17].

HIIT may also elevate oxidative stress through increased production of Reactive Oxygen Species (ROS) during exercise. Long-term HIIT interventions have been associated with increased lipid peroxidation and reduced antioxidant enzyme activity, including Superoxide Dismutase (SOD) and Glutathione Peroxidase (GPx), indicating redox imbalance [11], [17]. If inadequately controlled, oxidative stress may contribute to muscle injury, endothelial dysfunction, and worsening cardiovascular disease risk [17].

Ajwa Dates, Nutritional and Bioactive Components of Ajwa Dates

Ajwa dates (Phoenix dactylifera L.) are a date fruit variety originating from Medina, Saudi Arabia. Ajwa dates possess significant historical and religious importance, particularly within Islamic tradition, where they are believed to provide numerous health benefits. Beyond their nutritional value, Ajwa dates have traditionally been used in herbal medicine for the treatment of various diseases. In recent years, scientific investigations have increasingly explored the therapeutic potential of Ajwa dates, particularly in cardiovascular disease, diabetes mellitus, and metabolic disorders [18], [20], [38], [39].

Table 1. Summary of Recent Literature on Hypertension, Obesity, HIIT, and Ajwa Date Supplementation in Cardiovascular Health (2020–2025)

No.	Author(s) & Year	Study Design	Population/Subjects	Main Variables	Key Findings	Cardiovascular Relevance
1	Unger et al., 2020 [22]	International guideline review	Global adult population	Hypertension prevalence and management	Hypertension affects more than 1.4 billion individuals worldwide and remains a major contributor to	Confirms hypertension as a major global cardiovascular risk factor

No.	Author(s) & Year	Study Design	Population/Subjects	Main Variables	Key Findings	Cardiovascular Relevance
					cardiovascular mortality	
2	Nurjanah et al., 2021 [23]	National epidemiological analysis	Indonesian population	Hypertension prevalence	Prevalence of hypertension in Indonesia reached 31.4%	Demonstrates increasing cardiovascular burden in Indonesia
3	ESC Guidelines, 2024 [24]	Clinical guideline	Adult cardiovascular patients	Blood pressure classification	Hypertension defined as SBP ≥140 mmHg and/or DBP ≥90 mmHg	Provides updated diagnostic criteria for cardiovascular risk assessment
4	Hall et al., 2021 [26]	Review article	Obese and hypertensive subjects	Oxidative stress and inflammation	Oxidative stress and inflammation contribute significantly to hypertension pathogenesis	Supports antioxidant-based cardiovascular interventions
5	Schiffrin et al., 2020 [27]	Mechanistic review	Hypertensive patients	Endothelial dysfunction and ROS	ROS and endothelial dysfunction worsen vascular stiffness and hypertension	Explains vascular mechanisms leading to coronary artery disease
6	Powell-Wiley et al., 2021 [29]	Scientific statement	Obese population	Obesity and cardiovascular disease	Obesity strongly associated with hypertension, dyslipidemia, and coronary artery disease	Highlights obesity as a modifiable cardiovascular risk factor
7	Piché et al., 2020 [30]	Narrative review	Obese adults	Adipokines and inflammation	Visceral fat promotes inflammatory cytokine production and insulin resistance	Explains obesity-related cardiovascular inflammation
8	Frühbeck et al., 2021 [31]	Molecular review	Patients with obesity	Adipose tissue dysfunction	Adipose tissue acts as an endocrine organ influencing metabolic and cardiovascular pathways	Supports link between obesity and endothelial dysfunction
9	Weston et al., 2020	Meta-analysis	Adults with cardiometabolic	HIIT vs MICT	HIIT significantly improv	Demonstrates superior

No.	Author(s) & Year	Study Design	Population/Subjects	Main Variables	Key Findings	Cardiovascular Relevance
	[13]		disease		es VO_2 max and blood pressure	cardiovascular adaptation with HIIT
10	Batacan et al., 2021 [15]	Systematic review	Hypertensive adults	HIIT and blood pressure	HIIT reduced systolic and diastolic blood pressure significantly	Supports HIIT as non-pharmacological hypertension therapy
11	Martland et al., 2020 [34]	Meta-analysis	Obese and overweight adults	Body composition after HIIT	HIIT reduced visceral fat and body fat percentage more effectively than MICT	Reduces obesity-related cardiovascular risk
12	Ramos et al., 2021 [35]	Clinical intervention study	Physically inactive adults	HRV and resting heart rate	HIIT improved autonomic cardiac function and HRV	Indicates improved cardiac autonomic regulation
13	Way et al., 2022 [36]	Meta-analysis	Adults with cardiovascular risk factors	Flow-Mediated Dilation (FMD)	HIIT significantly improved endothelial function	Suggests vascular protection and reduced atherosclerotic risk
14	Qiu et al.,	Systematic	Cardiometabolic	Endothelial	HIIT increas	Supports

No.	Author(s) & Year	Study Design	Population/Subjects	Main Variables	Key Findings	Cardiovascular Relevance
	2021 [37]	review	patients	response to HIIT	ed nitric oxide bioavailability and vascular elasticity	vascular adaptation and coronary protection
15	Sarkar et al., 2022 [17]	Experimental study	Athletes undergoing HIIT	IL-6, TNF-α, CK, LDH	HIIT increased inflammatory and muscle injury biomarkers transiently	Indicates exercise-induced oxidative stress
16	Khalid et al., 2021 [18]	Phytochemical review	Ajwa dates (*Phoenix dactylifera*)	Antioxidant compounds	Ajwa dates contain flavonoids, polyphenols, and carotenoids with strong antioxidant activity	Supports antioxidant cardioprotective effects
17	Alalwan et al., 2020 [20]	Nutritional analysis	Ajwa date samples	Mineral and nutrient composition	Ajwa dates are rich in potassium and magnesium	Important for blood pressure regulation and cardiac function
18	Rahmani	Review article	Functional food	Cardiovascul	Ajwa dates	Supports

No.	Author(s) & Year	Study Design	Population/Subjects	Main Variables	Key Findings	Cardiovascular Relevance
	et al., 2021 [21]		studies	ar benefits of Ajwa dates	demonstrated anti-inflammatory and antihypertensive potential	therapeutic role in cardiovascular prevention
19	Ali et al., 2022 [40]	Experimental antioxidant study	Date fruit extracts	Polyphenol activity	Ajwa date extracts significantly reduced oxidative stress markers	Suggests protection against endothelial injury
20	Hassan et al., 2023 [42]	Laboratory study	Phenolic compounds in Ajwa	Flavonoid bioactivity	High flavonoid concentrations improved antioxidant defense systems	Reinforces role of Ajwa dates in oxidative stress reduction

Table 1 present recent scientific evidence published within the last five years regarding hypertension, obesity, High-Intensity Interval Training (HIIT), and Ajwa date supplementation in relation to cardiovascular health. The table demonstrates that hypertension and obesity remain major global health burdens strongly associated with increased cardiovascular morbidity and mortality. Several studies consistently reported that oxidative stress, endothelial dysfunction, inflammation, and metabolic dysregulation are central mechanisms linking these conditions to cardiovascular disease development. Furthermore, recent international guidelines and epidemiological studies emphasize the importance of early identification and comprehensive management of cardiovascular risk factors to reduce long-term complications. The table also highlights growing evidence supporting HIIT as an effective non-pharmacological intervention for improving cardiovascular fitness, endothelial function, blood pressure regulation, and body composition. In addition, studies investigating Ajwa dates indicate that their rich antioxidant and anti-inflammatory compounds, particularly flavonoids and polyphenols, may provide cardioprotective benefits by reducing oxidative stress and improving vascular health. Overall, the evidence presented in Table 1 supports the hypothesis that combining HIIT with antioxidant-rich nutritional interventions such as Ajwa date supplementation may offer synergistic benefits for overweight hypertensive individuals.

Table 2. Mechanisms Linking Hypertension, Obesity, HIIT, and Ajwa Dates to Cardiovascular Outcomes

Factor	Main Mechanism	Biological Effect	Cardiovascular Impact	Supporting References
Hypertension	Increased vascular resistance	Endothelial dysfunction	Coronary artery disease and heart failure	[24], [26], [27]
Obesity	Visceral fat accumulation	Chronic inflammation and insulin resistance	Atherosclerosis and hypertension	[28]–[31]
Oxidative Stress	ROS overproduction	Cellular and endothelial injury	Vascular stiffness and plaque formation	[26], [30]
HIIT	Increased VO_2 max and nitric oxide	Improved endothelial function	Reduced cardiovascular risk	[13], [15], [36]
HIIT-induced stress	Increased IL-6 and TNF-α	Acute inflammatory response	Temporary oxidative imbalance	[17]
Ajwa dates	Polyphenol and flavonoid activity	Antioxidant and anti-inflammatory effects	Reduced oxidative stress and improved vascular function	[18], [20], [40]–[42]
Potassium in	Electrolyte	Blood pressure	Improved cardiac	[20], [21]

Factor	Main Mechanism	Biological Effect	Cardiovascular Impact	Supporting References
Ajwa	regulation	stabilization	electrophysiology	
Magnesium in Ajwa	Vascular smooth muscle relaxation	Vasodilation	Reduced hypertension risk	[20]

Table 2 presents the major biological and physiological mechanisms linking hypertension, obesity, oxidative stress, HIIT, and Ajwa dates to cardiovascular outcomes. Hypertension and obesity contribute to cardiovascular disease development through multiple interconnected pathways, including increased vascular resistance, endothelial dysfunction, chronic inflammation, insulin resistance, and excessive production of reactive oxygen species (ROS). These pathological mechanisms collectively promote vascular stiffness, atherosclerosis progression, impaired coronary perfusion, and increased cardiovascular risk.

The table further demonstrates that HIIT exerts beneficial cardiovascular effects primarily by improving aerobic capacity, nitric oxide bioavailability, endothelial responsiveness, and metabolic efficiency. However, intense exercise may also transiently elevate oxidative stress and inflammatory mediators such as IL-6 and TNF-α. Ajwa dates may help counterbalance these adverse effects through their antioxidant compounds, including flavonoids and polyphenols, which neutralize free radicals and reduce inflammation. The potassium and magnesium content in Ajwa dates also contributes to blood pressure regulation and vascular relaxation, supporting cardiovascular protection.

Table 3. Potential Synergistic Effects of HIIT and Ajwa Date Supplementation

Intervention Component	Physiological Effect	Oxidative Stress Impact	Cardiovascular Benefit
HIIT	Increased aerobic capacity and fat oxidation	May transiently increase ROS	Improved endothelial function and blood pressure
Ajwa dates	Antioxidant and anti-inflammatory effects	Neutralizes free radicals	Protects vascular endothelium
HIIT + Ajwa dates	Combined metabolic and antioxidant adaptation	Reduces exercise-induced oxidative imbalance	Potential synergistic cardiovascular protection
HIIT + Ajwa dates	Improved body composition	Reduced visceral adiposity-associated inflammation	Lower cardiometabolic risk
HIIT + Ajwa dates	Enhanced nitric oxide bioavailability	Improved redox homeostasis	Better vascular elasticity and coronary perfusion

Table 3 describes the potential synergistic effects of combining HIIT and Ajwa date supplementation on oxidative stress and cardiovascular health. HIIT improves cardiovascular fitness through enhanced oxygen utilization, increased fat oxidation, improved endothelial function, and reductions in visceral adiposity. Nevertheless, high-intensity exercise may temporarily increase oxidative stress due to elevated ROS production during intense metabolic activity. Without adequate antioxidant defense, this physiological stress may contribute to endothelial injury and inflammation.

Ajwa dates may serve as a complementary nutritional intervention because of their strong antioxidant and anti-inflammatory properties. The polyphenols, flavonoids, vitamins, and minerals contained in Ajwa dates may reduce oxidative damage induced by intense exercise while simultaneously supporting vascular health and blood pressure regulation. Therefore, combining HIIT with Ajwa date supplementation may provide complementary physiological adaptations, improving cardiovascular outcomes while minimizing exercise-induced oxidative imbalance and inflammation in overweight hypertensive individuals.

Table 4. Research Gaps and Future Directions

Research Area	Current Limitation	Future Recommendation
Combined HIIT and Ajwa intervention	Limited human clinical trials	Conduct randomized controlled trials

Research Area	Current Limitation	Future Recommendation
Oxidative stress biomarkers	Variability in biomarker assessment	Standardize oxidative stress measurements
HIIT protocol	Different exercise intensities and durations	Develop standardized cardiovascular HIIT protocols
Ajwa supplementation dosage	No consensus on optimal dosage	Determine effective therapeutic dose
Long-term outcomes	Mostly short-duration studies	Evaluate long-term cardiovascular effects
Cardiovascular biomarkers	Limited molecular assessment	Explore endothelial and inflammatory biomarkers
Obese hypertensive population	Limited subgroup analysis	Stratify participants by obesity and hypertension severity

Table 4 highlights the major research gaps and future directions related to the combined effects of HIIT and Ajwa date supplementation in cardiovascular health. Although substantial evidence supports the individual benefits of HIIT and Ajwa dates, studies evaluating their combined effects remain very limited. Variations in HIIT protocols, antioxidant dosages, intervention duration, and biomarker assessment methods also make it difficult to compare findings across studies. Additionally, most available studies are short-term interventions, limiting understanding of long-term cardiovascular and metabolic outcomes. The table emphasizes the need for well-designed randomized controlled trials using standardized exercise protocols and antioxidant supplementation strategies. Future studies should focus on identifying optimal Ajwa date dosages, evaluating long-term safety and efficacy, and exploring molecular biomarkers related to oxidative stress, endothelial function, inflammation, and cardiovascular adaptation. Stratification of participants based on obesity severity, hypertension stage, and cardiovascular risk profile may also improve understanding of individualized therapeutic responses to combined HIIT and Ajwa date interventions.

Discussion

This literature review highlights the complex interrelationship between hypertension, overweight/obesity, oxidative stress, inflammation, and cardiovascular dysfunction, while also emphasizing the potential role of High-Intensity Interval Training (HIIT) combined with Ajwa date (Phoenix dactylifera) supplementation as a complementary strategy for cardiovascular risk reduction. The findings from the reviewed studies suggest that both HIIT and Ajwa dates exert beneficial physiological effects through mechanisms involving endothelial improvement, metabolic regulation, antioxidant activity, and modulation of inflammatory pathways.

Hypertension and obesity remain among the most important modifiable cardiovascular risk factors worldwide. The coexistence of these conditions substantially accelerates the progression of cardiovascular disease through interconnected mechanisms such as endothelial dysfunction, sympathetic nervous system overactivation, oxidative stress, chronic inflammation, and dysregulation of the renin angiotensin system [26],[31]. Excess visceral adiposity further aggravates cardiovascular risk by increasing inflammatory adipokine secretion and impairing insulin sensitivity. Consequently, interventions targeting both metabolic and cardiovascular dysfunction are critically needed in overweight hypertensive populations.

The reviewed evidence demonstrates that HIIT provides substantial cardiovascular and metabolic benefits. Compared with Moderate-Intensity Continuous Training (MICT), HIIT appears to produce greater improvements in VO_2 max, endothelial function, body composition, and blood pressure regulation [13], [15], [32], [34]. Improved endothelial function, particularly through increased Flow-Mediated Dilation (FMD), indicates enhanced nitric oxide bioavailability and vascular responsiveness, both of which are essential for maintaining cardiovascular homeostasis [36], [37]. Furthermore, HIIT-induced reductions in visceral adiposity may indirectly decrease systemic inflammation and improve cardiometabolic outcomes.

Despite these benefits, HIIT also induces transient inflammatory and oxidative stress responses. Increased levels of IL-6, TNF-α, cardiac biomarkers, and reactive oxygen species (ROS) following intense exercise indicate that HIIT may acutely increase physiological stress, particularly among individuals with pre-existing cardiovascular risk factors [10], [17]. Although these responses are generally adaptive and temporary, excessive oxidative stress may potentially worsen endothelial dysfunction and contribute to adverse cardiovascular effects when exercise intensity or frequency is not appropriately managed. Therefore, strategies aimed at attenuating exercise-induced oxidative stress may further optimize the safety and effectiveness of HIIT interventions.

In this context, Ajwa dates emerge as a promising nutritional adjunct because of their rich antioxidant and anti-inflammatory properties. Ajwa dates contain abundant polyphenols, flavonoids, vitamins, minerals, and dietary fiber, all of which contribute to cardiovascular protection [18], [20], [40]. Polyphenols and flavonoids are known to neutralize ROS, reduce lipid peroxidation, and improve endothelial function. Additionally, potassium and magnesium contained in Ajwa dates may assist in blood pressure regulation and maintenance of normal cardiac electrophysiological activity. These mechanisms suggest that Ajwa date supplementation may counterbalance the transient oxidative and inflammatory responses induced by HIIT.

The combination of HIIT and Ajwa date supplementation may therefore provide synergistic cardiovascular benefits. HIIT primarily improves cardiovascular fitness, body composition, and vascular function, whereas Ajwa dates may enhance antioxidant defense and reduce exercise-induced oxidative damage. This combination may be particularly beneficial for overweight hypertensive individuals, who often exhibit increased oxidative stress, endothelial dysfunction, and chronic low-grade inflammation. The integration of structured exercise with functional nutritional supplementation represents a potentially effective non-pharmacological approach for cardiovascular risk reduction.

Another important aspect identified in this review is the role of oxidative stress in both hypertension and obesity. Increased ROS production contributes to endothelial dysfunction, vascular stiffness, inflammation, and atherosclerosis progression [26], [30]. Since both HIIT and obesity-related metabolic dysfunction can influence oxidative balance, antioxidant support through nutritional interventions may play an essential role in maintaining redox homeostasis. Ajwa dates may therefore provide additional therapeutic value by improving endogenous antioxidant capacity and reducing inflammatory responses associated with intense physical activity.

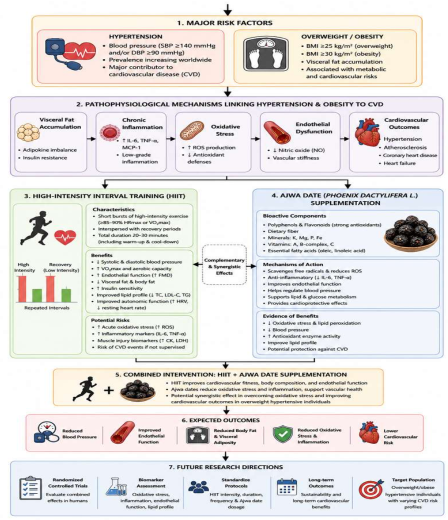

Figure 1. Conceptual Flowchart of the Potential Synergistic Effects of High-Intensity Interval Training (HIIT) and Ajwa Date (Phoenix dactylifera L.) Supplementation on Oxidative Stress and Cardiovascular Health in Overweight Hypertensive Individuals

The Figure 1. illustrates the pathophysiological relationship between hypertension, overweight/obesity, oxidative stress, inflammation, and cardiovascular dysfunction, as well as the proposed role of High-Intensity Interval Training (HIIT) and Ajwa date supplementation as complementary interventions. Hypertension and obesity contribute to cardiovascular disease development through several interconnected mechanisms, including visceral fat accumulation, endothelial dysfunction, chronic inflammation, increased production of reactive oxygen species (ROS), and impaired vascular function. These pathological processes collectively increase the risk of atherosclerosis, coronary artery disease, and heart failure. The flowchart also demonstrates how HIIT improves aerobic capacity, endothelial function, lipid metabolism, and body composition, although intense exercise may transiently increase oxidative stress and inflammatory biomarkers [41],[42].

In contrast, Ajwa dates (Phoenix dactylifera L.) contain various antioxidant and anti-inflammatory compounds such as polyphenols, flavonoids, vitamins, minerals, and dietary fiber that may help reduce oxidative stress and improve vascular health. The diagram highlights the potential synergistic interaction between HIIT and Ajwa date supplementation, where HIIT induces beneficial cardiovascular adaptations while Ajwa dates provide antioxidant protection against exercise-induced oxidative stress. Together, these interventions may contribute to improved endothelial function, reduced blood pressure, decreased visceral adiposity, lower inflammatory activity, and overall reduction in cardiovascular risk among overweight hypertensive individuals.

Conclusion

Hypertension and overweight/obesity are major modifiable cardiovascular risk factors closely associated with oxidative stress, endothelial dysfunction, chronic inflammation, and metabolic disturbances that contribute to the development of cardiovascular disease. The literature reviewed in this study demonstrates that High-Intensity Interval Training (HIIT) provides significant benefits in improving cardiovascular fitness, reducing blood pressure, decreasing visceral fat accumulation, and enhancing endothelial function in overweight hypertensive individuals. However, HIIT may also induce transient inflammatory and oxidative stress responses, particularly in individuals with pre-existing cardiovascular risk factors. Ajwa dates (Phoenix dactylifera L.) contain various bioactive compounds with potent antioxidant and anti-inflammatory properties, including polyphenols, flavonoids, vitamins, minerals, and dietary fiber, which may help reduce oxidative stress and support cardiovascular health. Therefore, the combination of HIIT and Ajwa date supplementation may represent a promising complementary strategy for improving cardiovascular and metabolic outcomes in overweight hypertensive individuals. Nevertheless, further randomized controlled studies are needed to confirm the synergistic effects, optimal intervention protocols, and long-term clinical benefits of this combined approach.

Competing interests

The authors declare no competing interest.

Authors' contributions

W contributed to conceptualization, literature review, data interpretation, manuscript drafting, and final manuscript preparation. I.M., M.A., and M.S.R. contributed to study supervision, critical revision of the manuscript, and scientific validation of the cardiovascular and metabolic aspects discussed in the review. I.I. contributed to data interpretation, methodological guidance, and manuscript revision. N.A.M. contributed to conceptual development, overall supervision, and final approval of the manuscript. All authors read and approved the final version of the manuscript.

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