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The effects of intermittent and short-term fasting on heart rate variability

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Abstract

Heart Rate Variability (HRV) is a non-invasive index of neurocardiac function, reflecting the activity and balance of the autonomic nervous system and its ability to respond to internal and external stimuli. Cardiaovascular disease is a type of non-communicable disease with a high mortality rate, rank as the leading cause of death in Indonesia. Therefore, monitoring the neurocardiac function is essential in preventing the risks associated with this serious condition. One of the most common interventions to improve neurocardiac health and general wellness is fasting. Although fasting is traditionally practiced as a form of religious traditions such as Ramadan fasting, or as a weight loss strategy, several studies have indicated its positive effects on neurocardiac health. This review aims to collect study results that showed the effect of fasting, specifically intermittent fasting and short-term fasting, on heart rate variability as a potential intervention to maintain and enhance neurocardiac function, contributing to a more stable autonomic nervous system activity, and improvement in overall health.

Keywords: Fasting; Heart Rate Variability; Short Term Fasting; Intermittent Fasting

1. Introduction

Non-communicable disease that contributes to the highest mortality rate is Coronary Heart Disease (CHD) [1]. In 2013, an estimated 2.6 million people in Indonesia were diagnosed with coronary heart disease [2]. Obesity is one of the risk factors in the increase in cases of Non-Communicable Diseases (NCDs) or non-communicable diseases (NCDs) which are the cause of death of 41 million people every year or equivalent to 74% of deaths globally [3]. Obesity and being overweight are one of the most predisposing factors for the development of cardiovascular disease, as well as other metabolic syndromes, including diabetes [4]. Individuals who have more than one risk factor, such as hypertension, diabetes mellitus and obesity, are two to three times more likely to develop coronary heart disease than individuals who do not [5]. Many factors influence the development of cardiovascular disease risk, including those that cannot be controlled, such as age, gender, and genetics, and also those that can be controlled, such as lifestyle, smoking habits, body weight, and diet [6]. With the increasing number of cases of obesity in society, changes in diet are an important modifiable factor [4].

In recent years, Intermittent Fasting (IF) has gained popularity as an alternative to continuous calorie restriction and has shown promise in delivering similar benefits in terms of weight loss and cardiometabolic health [7]. The most important physiological mechanism of fasting is a change called the "metabolic switch", when the initial systemic stress response leading to a depletion of glycogen storages, is then followed by the start of the lipolysis process and the release of free fatty acids, gluconeogenic substrates, and ketone bodies to replace glucose. as the main energy reserve in the body [8]. On the international consensus on fasting terminology held in 2024, fasting was defined as "a voluntary abstinence from some or all foods or foods and beverages for preventive, therapeutic, religious, cultural, or other reasons" [9].

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Intermittent Fasting is defined as repetitive fasting periods lasting up to 48 hours each [9]. There are two basic variations of IF, the first is time-restricted feeding which can be used in three variants: 16/8, 18/6, or 20/4. 16/8 consists of 16 hours of fasting and an 8 hour eating window [4]. The second type of IF is a 24-hour fasting period followed by a 24-hour eating period, and repeated two or three times a week. There are two possible systems, 5:2 or 4:3, 5:2 means calorie restriction is carried out two days a week and a normal eating pattern five days a week [10]. Short-term fasting refers to fasting regimens with a duration of 2-3 days, meanwhile Long-term fasting refers to fasting regimens lasting ≥ 4 consecutive days [9].

Apart from the metabolic effects of fasting on the body, changes in the balance of the autonomic nervous system are also important considering that autonomic changes are correlated with neuroendocrine changes, where the autonomic nervous system plays a role in regulating adaptation to changing environmental conditions (in this case, restriction of food consumption) and on the regulation of the energy expenditure system and the visceral system (cardiovascular, digestive, etc.) [11]. Calorie restriction in people with obesity can improve the balance between sympathetic and parasympathetic nervous system activity and HRV (Heart Rate Variability) [12]. HRV is an index of neurocardiac function and is produced by interactions between the heart – brain and dynamic non-linear autonomic nervous system processes [13]. The autonomic nervous system is a control system that works unconsciously in regulating body functions such as heart rate, digestion, respiration, pupil response, urination, and sexual arousal through two branches, namely sympathetic and parasympathetic [14]. HRV describes the whole the body's capacity to handle the body's ongoing adaptation needs. Low HRV is associated with a lower capacity in the regulation of physiological, motor, and cognitive responses, as well as a less effective ability of the body to adapt to environmental demands and stress, including food exposure [15].

Analysis of HRV is a non-invasive tool for estimating autonomic activity, including central regulatory input, and allows observing the general condition and reactivity of the Autonomic Nervous System (ANS) under various conditions [16]. HRV analysis is usually divided into two domains, namely time and frequency domains. The time domain consists of SDNN (Standard Deviation of Normal-to-Normal IBI), RMSSD (Root Mean Square of Successive Differences), while the frequency domain consists of VLF (very low frequency), LF (low frequency), HF (high frequency), and LF/HF ratio. SDNN represents the general state of HRV, RMSSD represents parasympathetic activity, LF represents sympathetic activity, and the LF/HF ratio shows the balance of parasympathetic and sympathetic activity [17]. This method provides relatively stable results under controlled experimental conditions and allows evaluation of cardiovascular and metabolic adaptations, as well as estimation of the possible risk of regulatory failure [18]. In this review, we briefly review the effects of fasting including intermittent fasting and short-term fasting on heart rate variability.

2. Material and methods

In the process of collecting data on experients with fasting interventions on heart rate variability, Pubmed was used as the main source to obtain relevant literature. The first keyword used was “fasting” or “intermittent fasting” or “short-term fasting” and “heart rate variability”. Due to the broad result, in order narrow the scope and get more relevant articles, the keyword was changed to “fasting effect on heart rate variability”. After making selection according to the study design and desired outcomes, a final total of 8 articles were included in this review. The fasting interventions examined in this review focus on intermittent fasting and short-term fasting, as there is currently limited research on long-term fasting. By integrating the findings from these studies, this literature review aims to analyze the impact of fasting, specifically intermittent and short-term fasting, on heart rate variability, providing insights into appropiate fasting interventions to promote improved neurocardiac health and overall wellbeing.

3. Results and discussion

Public’s interest in fasting has mainly been driven by the impressive result of basic and animal research conducted over the last few decades, while at the same time, religious forms of fasting have been practiced by great precentage of the world’s population for centuries or even millennia, shaping traditions and being shaped by history, beliefs, and geographical [9]. Fasting is one of the five fundamental rituals of islam and approximately one billion muslis fast during month of Ramadan in the world [19]. Fasting period from dawn to sunset varies with geographical site and season, while during summer months fasting can last up to 18 hours [20]. Thus, in definition, Ramadan fasting can be categorized as a form of intermittent fasting, which is characterized by repetitive fasting periods with a duration of 48 hours or less [9].

Several studies were found discussed the effect of Ramadan fasting on heart rate variability. In the study conducted by Cansel et al., 40 healthy volunteers consist of 16 female and 24 male in the range of 19-40 years old underwent a ramadan fasting lasting approximately 17 hours per day. HRV samples were recorded twice using ambulatory 24-hour Holter monitoring, the first recording was taken during the middle of ramadan (between the 13^{th} and 17^{th} days) and the second was taken during the first week after ramadan. The results indicated no significant differences in heart rate and SDNN between the fasting and post-fasting periods. However, several HRV parameters, including RR intervals, SDNNI, rMSSD, pNN50, LF, LFnu, HF, and HFnu indices, significantly increased during Ramadan compared to the post-Ramadan period, while the LF/HF ratio did not show an increase [20]. These findings demonstrate that HRV improved in healthy individuals during Ramadan fasting, as evidenced by increases in SDNNI, pNN50, and rMSSD parameters across the entire recording period. The study also highlights that factors such as marriage, religiosity or faith, and other forms of social support have been associated with parasympathetic nervous system (PNS) activation, potentially reducing the risk of future cardiovascular events [21]. Additionally, since this study was conducted during a summer Ramadan month, characterized by extended fasting durations, the findings suggest that the prolonged fasting period may enhance the influence of parasympathetic activity on HRV parameters due to inhibition of catecholamines during fasting and consequently to a decrease in sympathetic nervous system activity in fasting healthy subjects [20].

In the study conducted by Mzoughi et al., a total of 20 hypertensive patients aged over 18 years-old with sinus rhythm. Study was conducted in Ramadan and fasting time lasted approximately 16 hours. HRV was determined twice by ambulatory 24hour Holter recordings, first during Ramadan and second after Ramadan. This study showed significant decrease in SDNN, SDANN, T power, and LF during Ramadan fasting compared to after Ramadan, but RMSSD, HF, and LF/HF ratio did not show any significant difference. In this study, HRV was decreased in hypertensive patients with Ramadan fasting as evidenced in decreased SDNN and was the first study to involve hypertensive patient. While in the earlier study by Cansel et al demonstrated that HRV increased during ramadan fasting in healthy individuals, the different result in this study highlighted the differences between hypertensive and healthy individuals. Specifically, it was found that sympathetic hypertonia is present in the early stages of hypertension, particularly during pre-hypertensive stage, and is associated in baroreflex activation [22].

In the study conducted bt Hammoud et al. with similar participants in earlier study, 58 participants with controlled hypertension underwent Ramadan fasting and were followed for 24hour under two conditions, which is fasting state during the last two weeks of ramadan and nonfasting state one month after ramadan. The results of this study is that during the afternoon of Ramadan fasting, HRV significantly reduced and presented significantly higher SDNN, SD2, and SD2/SD1 ratio, and lower stress index and LF component, suggesting lower sympathetic input. This study revealed an increase in HRV and lower cardiac stress, only during the afternoon period during Ramadan, i.e., after prolonged fasting hours, compared to nonfasting day after ramadan. This may imply that, in nonfasting condition, there is a tendency to gradual decrease in HRV fromthe morning till the evening time as a result of food ingestion all day and metabolic activity needs, while upon fasting during Ramadan, the decrease in HRV is delayed until the evening period upon breaking fast and initiating the metabolic activities of the body after long hours of food deprivation [23].

Another study conducted during Ramadan by Hammoud et al. involving 80 healthy young Lebanese females. Participants voluntarily enrolled to one of two arms of the study, which 15 subjects were monitored two times, during first and last weeks of Ramadan, while 27 subjects enrolled during the second and third week of Ramadan, were monitored only once for 24 hours. The study’s data showed no statistical difference in HRV between the first and last week of ramadan, indicating no change in cardiac ANS activity, and therefore the absence of cardiac adaptation process in reponse to long-term fasting. On the other hand, HRV decreased after having the main meal at sunset compared with fasting hours as expressed only by domain parameters. There is no change in HRV parameters on a parallel comparison to a non-fasting day before ramadan. This study conclude that ramadan fasting doesn’t influence the overall cardiac ANS activity, which persist over long-term practicing and independency of participants’ lifestyle [24].

Despite it practice as religious traditions, fasting has gained attention as an effective dietary approach among various strategies for calorie restriction and weight loss in response to the growing obesity epidemic [25]. Many studies based on human and animal models on weight loss using an IF diet confirm the reduced risk of developing cardiovascular diseases. This is related to the modulating effect of the IF diet on various risk factors of development, such as obesity, improper diet, insulin resistance, type II diabetes, and arterial hypertension [26].

In the study held by Zimmerman et al., 27 young healthy participants were randomized into three intervention groups: the alternate day fasting (24/24h of fasting / feasting), IF 16/8 (16/8h fasting / feasting), and IF 20/4 (20/4h fasting / feasting). This randomized study included a controlled initial run-in period of 4 weeks. Screening was conducted during Week 1, while a follow-up visit was held during Week 2 for monitoring. HRV data collection occurred during the Week 3 visit following an 8-week interventional phase. Prior to each visit, participants were instructed to fast. Data HRV samples were collected over three periods with Holter ECG monitoring. This study found that none of the baseline ECG parameters initially analyzed showed significant intercohort differences. It was concluded that different intermittent short-term fasting interventions in healthy individuals were not associated with any significant ECG changes of concern [27].

The other study conducted by Schwerdtfeger and Rominger with 40 young and healthy participants that had no prior experience with intermittent fasting. Data were sampled during 3 consecutive days of a fasting regimen (16/8h of fasting/feasting) and 3 consecutive days during normal eating. During fasting no caloric drinks and no food was allowed. Hence, non-caloric drinks like water, tea or coffee without milk or sugar could be consumed during fasting. Conditions were separated by 1 week and covered the very same days (Tuesday to Thursday) to keep daily routines constant. HRV was recorded using the EcgMove4 device. This study found that RMSSD was higher during non-eating within the intermittent fasting condition. RMSSD did not change in time for the normal eating condition, buat increased significantly from eating to non-eating during the fasting regimen, thus documenting a fasting-induced shift in cardiac activity [28].

The last study in this review that discusses intermittent fasting is a study of Solianik et al., with participants of 9 volunteers with more than 3 years of weightlifting training experience. The experiment consisted of 2 sessions that were performed in the morning at 8h00. During the first session, participant arrived at the laboratory after overnight 8h – 12h fasting and then ECG were attached to the chest. The participant was asked to rest in a sitting position for 10 min in a quiet, semidimmed room, and the resting cardiovascular autonomic response was recorded during the last 2 min. The participant then rested at least 1 fay before starting the 2nd session, which consisted of a 48 hour, zero-calorie diet with water provided ad lib, followed by the same order of experimental measurements. The result of this study is that there is no significant change in HRV parameters after the interventions. The result of unchanged HRV might be related to small sample size (n=9) and testing conditions of the realibility of resting 2 min HRV data recorded in sitting position [29].

Although rarely done in daily lifestyles, a study by Mazurak et al. conducted experimental studies short-term fasting that alllow the observation of initial physiological changes during food deprivation. A total of 16 healthy young female volunteers involved in this study. The study protocols required a 60h stay (from 7a.m on day 1 to 5p.m on day 3) at the metabolic ward and maintenance of a zero-calorie diet during the entire experimental period, with water ad lib in carefully documented intake. On the day of admission, participants were instructed to consume their usual breakfast at home before coming to the laboratory at 7a.m. HRV sample measurement took place in a laboratory with controlled temperature and light condition with ECG. During baseline, HRV measures increased after 24h of fasting (Day 2) and then decreased below baseline on Day 3 (48h). The subsequent fall on Day 3 was significant on SDNN and RMSSD, while normalized HF and LF values did not change at all. Meanwhile during tilt testing, SDNN, RMSSD, showed a significant and steady decline from day 1 to day 3. LFnu and LF/HF index did not significantly change. All HRV measures returned to their prelit baseline values on all 3 days, with no difference between days. The apparent discrepancies between results on studies with different calorie reduction models suggest that the changes seen during the early phase (24h – 72h) or a low or zero calorie diet may be the result of a severe sterssor rather than reflecting specific changes in autonomic regulation [11].

4. Conclusion

Fasting, in the form of intermittent fasting or short-term fasting, which involves caloric restriction, generally has positive effects on neurocardiac function. Although not all studies reported stastistically significant results. These findings provide valuable insights into the feasibility, safety, and effectiveness of fasting for both healthy individuals and those with hypertension. In many studies, fasting significantly impacts the balance of the autonomic nervous system, which in turn influences overall metabolism, neurocardiac health, and overall well-being. Fasting practices, such as intermittent fasting during Ramadan and short-term fasting as part of daily lifestyle routines, can yield beneficial health outcomes when conducted in accordance with the individual’s physical capacity. Therefore, fasting can be considered as a potential intervention to reduce risk of cardiovascular disease.

Compliance with ethical standards

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Disclosure of conflict of interest

All of the authors declare no conflict of interest to disclose.

Statement of ethical approval

This study is a literature review that collect data from previous studies, therefore no ethical approval required in this study.

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