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ASSOCIATIONS BETWEEN NUTRIENT INTAKE AND CARDIOMETABOLIC BIOMARKERS IN JUNIOR ATHLETES- A NARRATIVE SYNTHESIS

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ABSTRACT
Junior athletes often struggle with nutritional challenges because of the increased demands of their physiological growth, cognitive development and athletic on field performance. The nutritional demands, therefore, changes, with the age progression, especially in context of junior athletes. They require additional nutrients in order to maintain their athletic performance. Cardiometabolic profiles are related to on-field sports performance as their impact is directly proportional to the athlete. Depletion or elevation of these markers may indicate the health-related risks associated which may hamper the athletic performance. This review paper highlights the association between dietary intake and cardiometabolic profile in junior athletes. This review synthesizes current evidence of the association between the cardiometabolic parameters such as blood pressure, pulse rate, and oxygen saturation along with the intake of optimal amount of nutrients. It will analysis the impact and importance of carbohydrate and protein timing on the cardiometabolic parameters.

KEYWORDS: macronutrients; ergogenic aids; blood pressure; pulse rate; hydration; athletes

1. INTRODUCTION

Adolescence is a stage of life which is characterized by extensive growth, development, and hormonal shifts. In this period, it becomes a necessity to properly fuel the body with essential macronutrients and micronutrients. Nutrition here plays a significant role in building up the physiological development but also to increase the capacity of athletic performance [1]. In females, menstrual cycle starts during adolescence period, which increases the requirements of nutrients in the body in order to carry on the metabolic and physiological processes. Lack or inadequate intake of these nutrients leaves the body to feel lethargic and deficient in energy ultimately leading to early fatigue, slow cognitive function, muscle tenderness, reduced bone mineral density (BMD), and micronutrient deficiencies.

Adolescence is a period in which diet choices are mostly conceived. Junior athletes are more open to factors which might be impacting their performance [2]. Prioritizing optimal nutrition in the early adulthood, might help the athletes to adapt healthy eating practices and body-positive habits that might help the athletes in their adulthood, if applicable, into elite and professional level competition [1].

For this narrative review synthesis, the term adolescent athletes describe the developmental stage between childhood to adulthood which represents girls and boys between 14-18 years.

Sports nutrition specifically becomes a necessity for the individuals engaged in athletic performance, weight training, combat sports, and powerlifting. Intake of adequate nutrition is necessary to support the physiological functions of the body and to aid in fueling, enhance performance, and recovery for better return-to-field.

The cardiometabolic indicators such as blood pressure, oxygen saturation, pulse and heart rate are important for assessing the nutritional status of an individual and monitor their physical activity levels.

This narrative review synthesizes and compiles the recent literature on sports nutrition for junior athletes, focusing on dietary intake and hydration with relation to the cardiometabolic parameters. It also examined the role of ergogenic aids and dietary supplements which are commonly used in sports. This review aims to provide practical and evidence-based approach for sports nutritionists working with such individuals.

2. METHODOLOGY

2.1 Literature Sources and Search Strategy

Google Scholar and PubMed Database were used for literature conduct using the following keywords (search terms: “cardiometabolic profiles, “dietary intake”, “macronutrients”, “blood pressure”, “oxygen saturation”, “athletic performance”, “adolescent athletes”). The sources which are added were English- language studies with no time restriction.

2.2 Data Analysis

Each author involved independently screened and analyzed the literature sources, compiling relevant information from the published works. The extracted data was verified by other authors for precision and thoroughness.

3. Effect of Macronutrient Intake on Cardiometabolic parameters

3.1 Carbohydrate intake and cardiometabolic responses

It is well known that carbohydrates and fats are the two primary sources of fuel which are oxidised by the skeletal muscles tissue especially in the field of prolonged exercise such as endurance exercise. The role of these fuels largely depends on the exercise intensity and duration of the sport played. Glucose is the predominant fuel required especially for the working muscle and to maintain the blood glucose levels. Daily carbohydrate consumption recommended for athletes depends on training volume and intensity. Optimal carbohydrate intake subsequently aids in recovery and for upcoming training sessions [4].

Focus should be given to carbohydrate rich foods which shows the glycemic index from low to moderate, including complex carbohydrates as well [5]. High intensity activities such as endurance athletes, are dominantly depended on carbohydrates as their main source of fuel. Balancing an optimal level of glycogen in the liver should be 80-100 grams along with in the skeletal muscle which is 300-400 grams [5]. Few studies have demonstrated that frequent episodes of hypo and hyper glycemia are majorly seen in athletes [7] [8]. Athletes are engaged in high demand exercises, which results in the depletion and reduction of glucose tolerance post exercise, also day after the exercise [7].

Intake of single meal rich in carbohydrate before or during intensive exercise or practice sessions tends to improve the fatigue and can regulate the heart rate responses by regulating the substrate energy availability and dodging the onset of fatigue. In young athletes, it is seen that carbohydrate intake has improved the level of exertion and diminishes heart rate drift in the course of prolonged exercise [9].

3.2 Protein intake and hemodynamics

Protein is meant to support the tissue synthesis and repair, muscle functionality, recovery, regulating the metabolism and growth of lean mass, which will affect in better body composition, on-field performance and stable cardiometabolic parameters [11].

Current evidence of umbrella review and meta-analysis shown that intake of higher amount of protein leads to decline in hypertension and reduction in systolic/ diastolic blood pressure [10]. There is still no evidence on evidence of the intake of protein on resting heart rate in junior athletes. Randomised Control Trials (RCTs) on some populations have showed a neutral effect on heart rate [12].

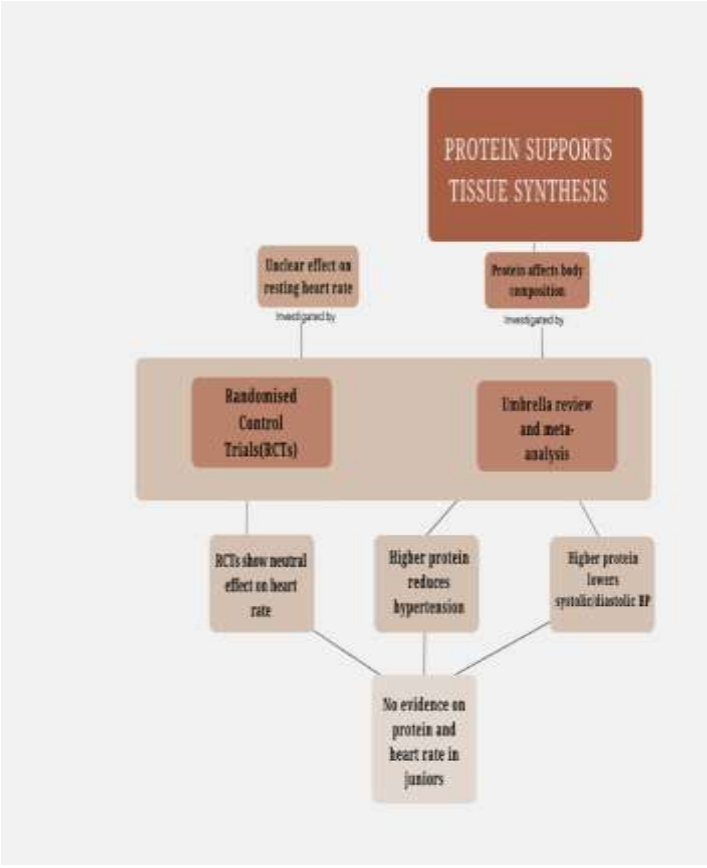

Figure 1: Conceptual summary of evidence on dietary protein intake and cardiovascular outcomes. Randomized controlled trials have shown a neutral effect of protein intake on resting heart rate, while umbrella reviews and meta-analyses suggested a higher protein intake is associated with improved body composition and reductions in systolic and diastolic blood pressure, potentially lowering hypertension risk. However, evidence linking protein intake to resting heart rate in junior populations remains insufficient.

3.3 Dietary fat and cardiometabolic markers

Dietary fat plays a pivotal role in regulating the blood pressure, heart rate, lipid metabolism, endothelial function, and inflammation in athletes. Adequate intake of Saturated Monounsaturated and Polyunsaturated Fatty Acids, they all are essential in recommended amounts for reducing inflammation, improving lipid profiles and regulate cardiac electro pathophysiology.

Some meta-analyses shows that consumption of long chain omega-3 supplementation results in diminished effects of both systolic and diastolic blood pressure, mainly in hypertensive and endurance engaged athletes [13]. Omega 3 exerts its effects but the mechanism of endothelial nitric oxide synthesis, decreased vascular resistance, and reduced arterial stiffness.

Omega-3 PUFA has shown that to elevate the effects of improve heart rate variability (HRV) and it is directly proportional to reduction in resting heart rate. Intake of increased amount of MUFA tends to give a supportive effect of lower resting heart rate which is a good indicator of autonomic control in trained individuals [14] [15].

3.4 Hydration

Junior athletes who are actively engaged in intensive training face a common consequence of lack of hydration which occurs through sweat losses, stress from external and internal heat dissipation mechanism, and episodes of high intensity workout [16]. Hypohydration along with heat and stress, results in an elevation of sympathetic outflow and vasoconstrictor tone. This condition can increase the rate of heart rate and blood pressure during and after the exercise [17].

Some cross-sectional studies have shown that junior athletes who have started their training in a hypohydrated state which leads to early fatigue and lack of sports performance [18]. Reviews and few experimental studies have shown that when the body mass losses are more than 2 % significantly increases the heart rate. Thermogenesis and impaired endurance performance. In the study, it is shown that field adolescent athletes their body mass losses are more and it exceeds the optimal range 1-2%, which is associated with increased heart rate and cortisol post-match [19].

Current evidences of reviews have shown that if there is an appropriate intake of fluid in the course of and post exercise and training, there would be a significant reduction of heart rate elevation, aids in recovery and depletion in the cardiovascular stress [20].

4. Ergogenic Aids

4.1 Caffeine (including coffee, energy and sports drinks, and supplements)

Caffeine is the broadly sold and consumed stimulant with the purpose of enhancing the performance highlighting the benefits of muscle endurance and strength, velocity in movement, jumping, sprinting, and a broad range of all the aerobic and non-aerobic sports actions [21].

In reviews when caffeine was administered to a group of junior individuals, acute increases in blood pressure by following a moderate dose which is commonly used ergogenic dose 3–6 mg/kg. Heart rate varies in individuals. Some ;stimulation and baroreflex responses [22] [23]. Thus, it is advised to follow a recommended dosage of <3 mg/kg for junior athletes [22].

4.2 Beet Juice

Beet juice, which is an extraction of root vegetable, beetroot. It has gained considerable attention its advancement in sports field majorly because of its ability to elevate the levels of Nitric Oxide (NO), which has a lot of functions such as enhanced blood flow, improved vascular function, mitochondrial activity elevation, and more effective muscle contraction. The nitric oxide supplementation could have some ergogenic effects on cardiorespiratory endurance which is beneficial for improved athletic performance [24].

Some reviews when synthesized together, it was evidenced that beetroot juice significantly reduces systolic/diastolic blood pressure. In athletes, it is seen that it is involved in lower oxygen cost of submaximal exercise. Evidence in adolescents is limited but it is advised to consume under supervision [25].

4.3 Creatine Monohydrate

Some systematic reviews indicate that intake of recommended levels of creatine monohydrate i.e. 3-5 g/day to 0.1 g/kg of body mass/day is well tolerated by athletes [26]. Cardiovascular studies suggest that consumption of creatine monohydrate significantly stalls the drop in resting blood pressure and heart rate [26]. Appropriate dosing is advised under supervision.

4.4 Pre-workouts and energy drinks

Junior athletes are often engaged in consumption of pre workout energy drinks, which has a composition of caffeine and other stimulants such as synephrine, taurine, and B complex vitamins. Researches have reported that there is a sudden increase in blood pressure and consecutively the heart rate [29].

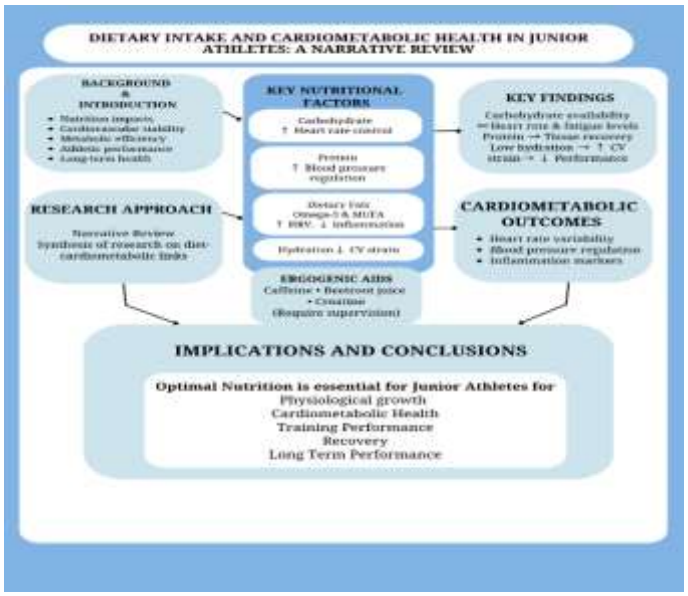

Figure 2: Conceptual framework illustrating the relationship between dietary intake, key nutritional factors, and cardiometabolic health in junior athletes based on evidence synthesized in the narrative review.

5. RESULTS

This Review summarized findings from published work which explored the relationship between dietary intake and cardiometabolic profiles in junior athletes. Published work has shown that balanced macronutrient intake, plays a crucial role in maintaining the cardiometabolic indicators focusing on blood pressure, heart rate and oxygen saturation.

It is seen that adequate intake of carbohydrate before and during exercise improved fatigue levels, regulation of heart rate drift, and maintenance of glucose levels, primarily in high-intensity and intermittent sports. In the case of protein, it was seen that it significantly improved the blood pressure. Dietary fats have improved the heart rate, reduction in inflammation, and better blood pressure control. Hydration was linked to increased heart rate, cardiovascular strain and reduced exercise tolerance.

6. CONCLUSION

This narrative review synthesized findings which are taken from research papers highlighting the strong interconnection between dietary intake and cardiometabolic profiles in junior athletes. It is seen that adequate and sufficient intake of major nutrients including carbohydrates, protein end essential fats played a significant role in stability of cardiovascular, efficiency of metabolism, and improved athletic performance. It is evidenced that carbohydrate availability in the body is directly proportional to heart rate responses and fatigue levels, meanwhile protein intake has shown a positive correlation effect on healthy blood pressure regulation and increased rate of tissue recovery. Coming to dietary fats, Omega 3 and MUFA contributed to increased heart rate variability and simultaneously reduction in the inflammation, bracing up their importance in adolescent athletes' diet.

Hydration is a key component of cardiometabolic stability, with low fluid intake resulted in increased levels of cardiovascular strain which resulted in low performance on field. Meanwhile, ergogenic aids such as caffeine, beetroot juice, and creatine have shown performance benefits, parental and coach supervision is instructed due to their variable effects on blood pressure and heart rate.

Overall, optimal nutrition in junior athletes is not only important for the physiological growth and development but it is also mandatory for maintaining internal cardiometabolic profiles that directly impacts their training performance, recovery and long-term health

7. Limitations

Several limitations emerged in this narrative review:

1.There is a limited junior athletes focused research with few high-quality studies specifically targeting junior athletes 14-18 years of age.

2.In this review, it is mainly composed of cross-sectional studies, observational designs and randomized controlled trials (RCT) which reduces its comparability and strength.

3.Most studies examine acute or short-term responses (e.g., single-meal carbohydrate ingestion, 1–2-week supplementation), with insufficient data on chronic effects of dietary patterns on cardiometabolic health.

4.Despite sex-based physiological differences and menstrual-related variation in nutrient needs, female adolescent athletes remain underrepresented.

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9. Declaration of Interest Statement

The authors declare that there are no conflicts of interest regarding the publication of this manuscript. The research was conducted independently, and no external funding, sponsorship, or financial support influenced the findings or conclusions.

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