Ovidius University Annals, Series Physical Education and Sport / SCIENCE, MOVEMENT AND HEALTH
Vol. XXIV, ISSUE 1, 2024, Romania
The journal is indexed in: ERIH PLUS, Ebsco, SPORTDiscus, INDEX COPERNICUS JOURNAL MASTER LIST, DOAJ DIRECTORY OF OPEN ACCES JOURNALS, Caby, Gale Cengage Learning, Cabell's Directories

Science, Movement and Health, Vol. XXIV, ISSUE 1, 2024
January 2024, 24 (1): 77-85
Original article

STUDY ON THE MANAGEMENT OF THE PHYSICAL EDUCATION AND SPORTS PROCESS REGARDING THE USE OF NATURAL SUPPLEMENTS TO MEET NUTRITIONAL AND ENERGY REQUIREMENTS.

STOICESCU DAN CRISTIAN[1], TUDOR VIRGIL[1]

Abstract

Aim. The aim of this study is to evaluate the levels of physical activity and nutrition, as well as the correlation between these two factors, in secondary school students who were administered natural supplements such as vegetable capsules containing Spirulina and Safflower Oil.

The discipline of physical education and sports management incorporates a range of measures and tools to guarantee a high-quality educational experience. The quality of physical education and sports may be assessed using various methods, one of which relates to the amount of time (hours) students spend engaging in physical activities both in structured classes and during their leisure time. Compared to the global or European mean, Romanian pupils devote around 10 times fewer hours to physical activity than their peers of the same age from other nations.

Conclusions. The systematic practice of physical education and sports in addition to the administration of natural supplements not only leads to improved performance, but also helps to reduce overweight in secondary school students. Several external and internal factors affect an athlete's diet, which may decrease or worsen food allergy/intolerance symptoms related to exercise. This review outlines various factors that impact food selection. It is essential to bear in mind that food choices are dynamic, and their efficacy differs depending on the time, location, and environmental factors in which the athlete selects the food. Consequently, athletes should adhere to the guidance of physicians and nutritionists before training and competitions. It is also crucial to explore and apprehend the nutritional trends and tactics practiced by athletes before and throughout training or competitions. This study aims to identify clinical trials for determining which foods athletes can consume to reduce harmful symptoms and enhance training outcomes.

Keywords: secondary school students, nutrition, natural supplements, physical activity, overweight.

Introduction

Physical education through movement involves the development of intellectual skills to structure and enhance motor activities, resulting in the refinement of both. Specifically, two aspects of physical education are important: the education of motor skills and the learning of movements (Marcu, D., Borz, C., Oprea, L., 2020).

Physical activity is crucial for maintaining good health, especially during childhood - considered the prime phase for physical and mental growth. Evidence suggests that physical activity positively correlates with both intelligence quotient and emotional quotient (Imamova, 2022).

Within physical education, development of creative capacity directed towards the motor component is heavily reliant on the teaching personnel during the instructional-educational process (Hayriye, Cihan, Bircan, 2023).

The students eagerly await the teacher's introduction of new practical concepts. It is vital for adolescents to maintain a balanced, nutritious diet while supplementing with non-toxic supplements to support healthy growth and development. Naturally, a well-balanced diet ought to supply the requisite nutrients, but in contemporary times, food contains fewer nutrients, and consequently, natural supplements are increasingly suggested. They represent the most convenient way to support the normal development of children/adolescents, simply by providing the daily requirement of nutrients (Burke et. al., 2019). Organic supplements are routinely prescribed for minors with an unbalanced or restrictive dietary regime. For the purpose of improving the performance and muscle mass, supplements are given to children who are involved in sports. Apart from that, children who play sports require vitamins and minerals, as well as proteins, healthy carbohydrates and antioxidants. The industry of natural supplements has progressed tremendously in recent times, with plenty of diverse and natural supplements, which come in various forms such as tablets, capsules, as well as solid and liquid powders, being available in the market. Recently, the Council for Responsible Nutrition in the US released a comprehensive report demonstrating that the judicious usage of multi-vitamin and mineral supplements can positively impact health and mitigate a range of conditions. For teenagers, natural supplements have considerable value, as they promote harmonious development and aid in coping with intense physical and intellectual stress. Given the desire of many young teenagers to engage in sports or performance activities, these supplements can be particularly advantageous. The market for so-called sports supplements is inundated with products that claim to enhance muscle mass and physical performance (Jalolov & Imamova, 2023).

[1] National University of Physical Education and Sports, Bucharest, Romania. Corresponding author: dan_bausu@yahoo.com.

However, most research on these supplements has focused on adults. The onset of adolescence occurs at different ages for boys and girls - 12-13 years and 10-11 years, respectively - and during this period, nutritional and energy requirements are higher than at any other stage of life due to the well-known growth spurt. During adolescence, there is a heightened requirement for specific vitamins and minerals to support physical and biochemical transformations and overall well-being (Miroslava P. & Miroslava A., 2021).

A teenager may require nutritional supplements during stressful periods or periods of recovery, when participating in complex physical activities and sports, when adhering to a vegetarian or restrictive diet, when following an irregular diet or a diet that doesn't use fresh ingredients, when not consuming enough dairy products, being underweight or undersized, having difficulty focusing at school, or when getting sick frequently.

The energy required by adolescents is higher than that needed by adults and varies based on factors such as sex, growth rate, body composition and physical activity levels. To maintain his weight, an active 16-year-old boy may require 2700 cal/day, while a sedentary girl of the same age may gain weight from consuming 1700 cal/day. (Reale, Burke, Cox & Slater, 2020). Physical development and health rely on the presence of essential micronutrients such as minerals and vitamins. Young individuals require significant quantities of calcium, iron, zinc, B-group vitamins, and vitamin A, which are generally not provided by their daily diet. Vitamins and minerals are critical for enhancing the immune system, promoting normal growth and development, and facilitating optimal function of cells and organs in the body. It is important to remember that teenagers face immense stress during exams and other assessments. Overwhelmed by stress, emotions, and restlessness, teenagers observe with astonishment the decline in their learning capabilities and concentration levels. Administering vitamins and mineral-based supplements can provide the necessary support for adolescents to manage this phase effectively. It is important to note that memory and concentration cannot be enhanced instantaneously. Certain vitamins and nutrients, when administered a few weeks before exams, have beneficial effect and support the proper functioning of the brain. Therefore, it is essential for teenagers to consume a healthy diet and supplement their nutrient needs, if required, to provide the body with the necessary nutrients for healthy growth and development (Reguant-Closa, Harris, Lohman & Meyer, 2019).

Regular exercise offers several benefits to adolescents, such as enhanced physical health, social interaction, and the development of self-esteem and self-identity. Furthermore, during the second decade of life, an individual's connection with food and the lifelong relationship between diet, exercise and body image are established (Reale et. al., 2020). A Narrative Review integrates knowledge from physiology, psychology, training science, and sociology to elucidate our present comprehension of the crucial nutritional principles for the advancement of adolescent athletes. Given the multifaceted and non-linear pathway to elite adult performance (i.e., success at junior levels infrequently predicts elite adult performance), the importance of sound nutrition supporting holistic athlete health during this period cannot be overstated. The responsibility for providing appropriate nutrition care to developing adolescent athletes is shared among sporting organisations, coaches, parents, teachers, and the athletes themselves (Abbott et. al., 2020).

Adolescence is a period of significant physical development, encompassing changes in body composition, metabolic and hormonal fluctuations, the maturation of organ systems, and the establishment of nutrient deposits, all of which may have an impact on future health (Reale, Roberts, Lee, Bonsignore & Anderson, 2020). Participating in sports undoubtedly benefits the psychological well-being of adolescents, promoting a positive self-image. Yet, for several years now, it has become increasingly apparent that athletic disciplines that place a high emphasis on leanness have led to higher rates of disturbed eating attitudes/ behaviors and body dissatisfaction. While athletes may possess inherent traits (e.g. perfectionism, high pain thresholds, and motivation) that are sought after in competitive sport, such qualities may also be linked to the emergence of disordered eating. Additionally, external pressures from coaches, peers, parents, and social media can also impact behaviour. For instance, previous research has indicated that coaches' thoughtless remarks regarding weight or physical appearance may trigger or maintain disordered eating or eating disorders among athletes. This evidence, accompanied by influential advocacy from former athletes and a heightened understanding of the lasting health effects of mishandling diet and exercise in young athletes, has prompted recent demands for a fundamental revision of how sports organizations manage aspiring athletes.

These changes could include refraining from discussing nutrition/food without sufficient justification, ceasing to assess body composition/weight, promoting awareness of the harmful consequences of enduring low energy availability (LEA), and dismantling harmful training environments that involve abusive body shaming or strategies aimed at altering an athlete's appearance regardless of their performance. In response, certain sporting organisations have endeavoured to protect their custodianship of adolescent athletes by issuing anticipated stakeholder conduct. In 2019, for instance, Gymnastics Australia published Body Positive Guidelines, prescribing exact recommendations on suitable language, the frequency and provision of nutrition education, and body composition evaluation within gymnastics surroundings (Kawther & Nagla, 2019). The guidelines stipulate that body composition assessments, such as weight, height, skinfolds or physique assessments, must be carried out solely by an experienced and certified anthropometrist. Prior to the assessments, the anthropometrist must obtain written consent from the gymnasts as well as their parents or guardians, and provide them with relevant education. The extent to which such strategies moderate the conduct of coaches, parents, and support staff, and ultimately reduce the occurrence of harmful health outcomes in developing athletes, remains unclear. However, it seems sensible to recommend that individuals involved in adolescent sports receive the necessary knowledge and support to provide suitable, evidence-based nutritional care for young athletes (Stoyel, Delderfeld, Shanmuganathan-

Felton, Stoyel & Serpell,2021) Throughout adolescence, it is essential to consume enough energy to fulfil the needs of growth and development, as well as the substrate demands linked with physical activity, training and competition.

Group estimates of energy expenditure in adolescent athletes are available (males ~ 3640±830, females ~ 3100±720 kcal/day). However, the energy expenditure of individual adolescent athletes may significantly vary. This is because factors such as changes in training and competition loads, participation in multiple competitive sports, part-time employment, and concurrent compensatory sedentary behaviours could all impact energy requirements. Determining the energy needs of adolescent athletes presents additional challenges due to the variability in metabolic and hormonal processes between individuals, as well as difficulties in accurately estimating both energy intake and expenditure. Pubertal growth is linked to hormonal changes coinciding with sexual development and can be categorised into three stages: (1) minimal height velocity before the growth spurt (prepubertal growth lag); (2) peak height velocity (PHV); and (3) decreasing height velocity (fusion of the epiphyses and attainment of final height). While girls typically experience their growth spurt and reach PHV two years earlier than boys (around 12 years old for girls compared to 14 years old for boys), additional factors, including ethnicity (for example, individuals with European ancestry demonstrate a skeletal age approximately six months younger than chronologically matched individuals with Asian and African heritage), may also have an impact on growth timing. The energy requirements for adolescent athletes include energy needs for growth, which consists of two parts: the energy expended to synthesize new tissues and the energy deposited in growing tissues. The energy expended to synthesize new tissues can be measured directly using the doubly labelled water (DLW) method or indirectly estimated through measures of resting metabolic rate (RMR), which is commonly utilised. Using adult-based equations to predict resting metabolic rate (RMR) in adolescent athletes is ill-advised as they tend to underestimate energy expenditure (up to 300 kcal/day) when compared with indirect calorimetry measures. There are now newly developed predictive RMR equations based on a cohort of 126 male and female junior athletes, each of whom underwent an indirect calorimetry assessment of RMR under standardised conditions. The study recruited athletes from a variety of sports, with an average age of 16.5 years (range 13.1–19.7). An equation, which can predict the resting metabolic rate (RMR) of developing athletes, was formulated (Eq. 1): RMR (kcal⁄day) = 11.1 × Body Mass (kg) + 8.4 × Height (cm) − (340 male or 537 female) (Ergin, Lok, N. & Lok S., 2020).

Measuring the energy deposited in growing tissues is challenging. However, it is deemed small and is typically estimated at approximately 2.0 kcal/g of daily weight gain. For instance, a 15-year-old male gaining 6 kg per year equates to roughly 33 kcal/day. Thus, although two energy components of growth may modify total caloric requirements, the evidence shows that changes linked to physical activity and/or athletic training are likely to exert a far greater impact on the total energy demands of adolescent athletes (Stoyel, Slee, Meyer & Serpell, 2020). General energy requirements for adolescent populations with different levels of physical activity and/or training have been published. Individual energy expenditure can be accurately measured via indirect calorimetry or similar methods. However, considering the costs and complexity of such techniques, it is worth considering the use of widely available methods for estimating individual energy expenditures. It is important to note that these estimates should be approached with caution given their potential limitations. Estimates of the specific energy cost of various exercises undertaken by adolescent athletes are not currently available. As a result, the energy expenditure of exercise in adolescents is calculated by recording the type, intensity, and duration of exercise. Then, using the individual's body weight, the energy cost is calculated by employing published adult values of metabolic equivalents for specific activities. Wearable technologies that incorporate accelerometers are a cost-effective method to estimate energy expenditure in younger demographics. Recent reviews have assessed the accuracy of various 'wearables' to calculate total energy expenditure and the energy expenditure of physical activity against DLW and indirect calorimetry in younger (general) populations. The reviews indicate that at present, there is no optimal device available (1). Additionally, accelerometers have a tendency to underestimate energy expenditure during activities such as incline walking, cycling, and carrying items (2). Finally, greater accuracy can be achieved by placing the accelerometer nearer to the individual's centre of mass, such as at the hip rather than the wrist or ankle (3). Accurately determining energy intake and expenditure is crucial. Young individuals undertaking intense exercise are prone to experiencing relative energy deficiency in sports. This condition may lead to various severe health issues when developing athletes, such as delayed puberty, menstrual irregularities, poor bone health, short stature, disordered eating behaviours, and an increased risk of injury. Furthermore, the effects may be more pronounced in females with a gynaecological age of 14 years or younger. On the other hand, some developing athletes, such as those in throwing events, exhibit anthropometric characteristics that are consistent with a higher risk of chronic disease. Therefore, severe and prolonged energy restriction is not advisable in this context, and weight maintenance is a more appropriate management strategy for developing individuals, rather than weight loss.

Methods

The study was conducted on adolescent students aged 11-14 years residing in rural regions. The students engaged in physical activity and incorporated natural supplements into their dietary routine. Both their physical activity and nutritional habits were assessed (Firmansyah & Reza, 2021).

Nutrition refers to the uptake and consumption of nutrients that are essential for safeguarding the growth and wellbeing of individuals. It also plays a pivotal role in growth, development, and academic performance. Irrespective of age, youngsters undergo a continual process of growth and development (Jagim & Kerksick, 2021).

The appropriate employment of specific dietary supplements and nutritional ergogenic aids could enhance athletic performance in adults. Nevertheless, the effectiveness of most (but not all) products in young populations, is yet to be thoroughly explored concerning their long-term safety, typically due to the ethical principle of beneficence (i.e. cost versus benefit). Commonly, supplement usage with the aim of improving athletic performance is reported among young athletes, despite the paucity of scientific evidence. The usage of dietary supplements among children and adolescents in the US is prevalent. Adolescent athletes consume 'performance-enhancing' (PE) supplements for various reasons including the desire to obtain results, pursuing physical ideals, and facing peer, social, and marketing pressure. Some elite adolescent athletes opine that supplements are not mandatory to excel in their sport but still acknowledge their importance in training adaptations, particularly for building strength. In general, it is widely viewed as inappropriate to promote the use of dietary supplements for performance enhancement among young athletes (Ekeland, Heian & Hagen, 2005). This opinion is in agreement with prominent sporting organisations and expert groups. It is important to note, however, that this recommendation does not apply to the clinical use of dietary supplements such as calcium, iron and vitamin D, when taken under the suitable guidance of qualified health professionals, such as medical practitioners and sports dietitians. Developing athletes can achieve significant performance improvements through maturation, experience in their sport, and by following proper training, nutrition, and rest guidelines. However, it is important to note that the use of legal supplements in developing athletes should not be overemphasized as it typically results in only a 2-5% increase in performance, and safety considerations must also be taken into account. Emphasis has been placed on prioritising cautious training and nutrition practices based on whole foods for adolescent athletes, even when contemplating safe supplements.

During childhood, the body requires a greater amount of energy and natural supplements compared to adulthood. In France, 20% of adults utilize natural supplements.

A survey conducted by the union of natural supplement manufacturers (Synadiet) found that the majority of natural supplement consumers (68%) are women who use the product regularly or very regularly (70% of consumers), and this frequency of consumption increases with age (70% are over 65 years old). However, it should be noted that 11% of children also consume natural supplements. Natural supplements are considered a form of alternative medicine that can cure or even prevent diseases. It is noteworthy that the primary consumers of natural supplements were individuals between the ages of 35 and 50 a few years ago. Between 2000 and 2010, a series of national surveys conducted by NHANES, the official health bodies in the United States, reveal that over 106 million Americans (currently over 114 million, equating to over half of the adult population) consume vitamins and trace elements every day. In their book, "All About Dietary Supplements," Prof. Cynober and Dr. Jacques Fricker distinguish four categories of dietary supplements:

- Essential nutrients are those that the human body is unable to synthesize but are essential for survival. Therefore, they must be acquired through food or supplements.
- Non-essential nutrients are also derived from food and have a physiological effect on the body. However, they are considered "non-essential" because the body can either produce them or they are not required for sustaining life.
- Additionally, plant extracts or natural products can also provide nutrients. The use of herbal remedies is often rooted in ancient traditions, with one or more active ingredients whose identities are not always known. Through scientific research, various molecules have been extracted from certain natural products, forming the basis of many modern medications such as aspirin, taxotere, and digitatin. Depending on the dosage and composition, these compounds can have beneficial or harmful effects on the body, or no effects at all (Walsh, 2019).

Table 1. Examples of food supplements based on essential nutrients

Gamma-linoleic acid Calcium Beta-carotene Chromium	Iron Folate (vitamin B9) Magnesium Omega 3 Selenium Tryptophan Vitamin A Vitamin B6	Vitamine B12 C vitamine Vitamine D Vitamin E Zinc

Table 2. Examples of food supplements based on non-essential nutrients

Arginine Carnitine Carotenoids CIA Coenzyme Q10 Creatinine	Cysteine Glucosamine Glutamine	Inositol Phosphatidylserine S- adenosilmetionina Taurine

Table 3. Examples of dietary supplements based on plant extracts or natural products

Garlic	Phytoestrogens	Spirulina
Algae	Phytosterols	Borage
Argan	Fucus	Cranberry
Caffeine	Garcinia cambogia	Papaya
Catechins	Ginger	Polyphenols
Green tea	Ginkgo biloba	Prebiotics
Chitosan	Ginseng	Probiotic
Citrulline	Guarena	Resveratrol
Knoll	Isoflavones	Spirulina
Curcumin	Royal jelly and beehive products	Vine
Pumpkin		Lycopene

Discussions

Spirulina and Safflower Oil were selected for administration to secondary school students. Spirulina has a longstanding track record of success and serves as an effective complement to weight loss programs, decreasing hunger pangs (Ghanbarzadeh, Moazami, Hassan & Mirdamadi, 2022). Additionally, this natural supplement is a tonic that restores energy and vitality, benefits convalescents and athletes by supporting physical exertion. Spirulina is a valuable protein source, as it has been shown to reduce total cholesterol, LDL (harmful) cholesterol, and triglycerides, while increasing HDL (beneficial) cholesterol levels when consumed. Additionally, it is rich in DNA and should be consumed daily at a dosage of 5-10g. It is worth noting that spirulina is considered a safe product by the American Food and Drug Administration. On the other hand, safflower oil capsules are natural supplements based on conjugated linoleic acid and marketed to reduce adipose tissue in children.

A study conducted by Kumar et al. (2022) showed that Spirulina platensis exhibited significant antioxidant and phytonutrient potential. The aqueous extract displayed high antioxidant activity, while all other enzyme activities and phytonutrients were higher in the aqueous extract. Vitamins can serve as a reliable indicator of organismal health. The study's findings reveal significantly higher levels of vitamin C and vitamin E in the ethanolic extract. Vitamins aid in prostaglandin synthesis, blood pressure regulation, cholesterol synthesis, inflammation, and cell proliferation. Spirulina products, widely available commercially, boast high levels of antioxidants and phytonutrients, making them ideal for regular consumption. Leading health organisations have extolled the virtues of Spirulina as a formidable supplement. Numerous herbal cosmetics, including face creams, hair lotions, and biolistics, have been developed using the phycocyanin pigment present in Spirulina. The substantial concentrations of antioxidants and phytonutrients detected in Spirulina extracts may promote its utilisation in the pharmaceutical, food additive, and cosmetic industries. It may also aid in discovering innovative pharmaceutical compounds for the management of diverse illnesses in the future.

Shahavi & Mirdamadi's study from 2022 investigated the impact of various concentrations of iron, zinc, and manganese on the growth of Arthrospira platensis MGH-1 and its ability to accumulate these micronutrients. The cyanobacterium was found to possess the capability to accumulate all three micronutrients in its cells. For optimal enrichment of A. platensis MGH-1 and potential development of functional foods, the appropriate concentrations were 0.1 g L− 1 iron and 25 mg L− 1 manganese. This may be a viable approach to combat micronutrient malnutrition. Based on the daily intake of Arthrospira sp. and the necessary daily dose of zinc, A. platensis MGH-1 appears unsuitable for zinc enrichment. Nevertheless, an increase in carotenoid, chlorophyll, soluble sugar content, and antioxidant enzyme activity was recorded in A. platensis MGH-1 treated with 4.0 mg L− 1 zinc compared to the respective control. This study suggests that A. platensis MGH-1, which has been fortified with 0.1 g L− 1 iron, holds high potential as a multi-functional nutritious food due to its abundance of bioactive compounds.

Furthermore, Safflower oil caused a noteworthy decrease in waist circumference (-2.42 ± 3.24 vs. 0.97 ± 2.53, $p<0.001$), systolic blood pressure (-8.80 ± 9.77 vs. -2.26 ± 8.56, $p = 0.021$), and diastolic blood pressure (-3.53 ± 7.52 vs. -0.70 ± 6.21, $p = 0.$). 041) The treatment group had significantly lower levels of fasting blood sugar (-5.03 ± 10.62 vs. 2.94 ± 7.57, $p = 0.003$) and insulin resistance (-0.59 ± 1.43 vs. 0.50 ± 1, $p = 0.012$), along with a significant increase in adiponectin levels (0.38 ± 0.99 vs. -0.09 ± 0.81, $p = 0.042$), compared to the placebo group. The results indicate a direct relationship between leptin levels and Body Mass Index (BMI) in both groups ($p<0.001$), whilst an increase in BMI resulted in a non-significant decrease in adiponectin levels in both groups. Furthermore, no notable divergence was detected between the two groups in terms of lipid profiles, leptin serum level, serum creatinine concentration, and other consequences. Consumption of safflower oil without changes in lifestyle enhanced abdominal obesity, blood pressure, and insulin resistance in patients with Metabolic Syndrome (Ruyvaran, Zamani, Mohamadian & Mohammad, 2022).

Adequate dietary fat intake is necessary to meet requirements for fat-soluble vitamins and essential fatty acids, and to provide energy to support growth and development. Additionally, it has been indicated that adolescent athletes under 18 years of age exhibit slightly higher maximal fat oxidation rates (in relation to lean mass). Presently, there is a lack of research on dietary interventions aimed at enhancing the role of intramuscular triacylglycerols on performance, as well as the effect of training in a state of depleted carbohydrates (CHO) on endurance in adolescent athletes. Since chronically high fat intakes are associated with increased chronic disease risk, the advice for the type and total fat consumption by

adolescent athletes remains consistent with public health guidelines. These guidelines typically advise on a dietary fat intake ranging between 20-35% of total energy, with saturated and trans fatty acids not exceeding over 10% of total energy intake. When energy demands alter, sports nutrition recommendations urge athletes to adjust their dietary intake to enhance daily performance and optimize training adaptations, commonly known as 'fuel for the work required'. Young athletes may need assistance in adopting a 'food first' strategy to align their energy intake with the intensifying training regime and can benefit from practical resources that explain how to select the right macronutrients (Iraki, Fitschen, Espinar & Helms, 2019).

The cornerstone of athletic performance is the combination of training and the athlete's diet, with nutritional strategies playing a supportive role in enhancing the athlete's adaptation to training. As training prescriptions continue to evolve, so do nutrition strategies for athletes. Current nutritional consensus statements advocate for the periodisation of nutritional intake to optimise the adaptation of the athlete to the prescribed training programme. Nutritional periodisation theory involves planned energetic and macronutrient strategies, tailored to individual exercise sessions and the overall training programme, to facilitate long-term performance gains in athletes. Nutritional periodisation strategies involve manipulating carbohydrate and fat intake to upregulate essential signalling pathways in skeletal muscle, promoting mitochondrial biogenesis, angiogenesis, and increased lipid oxidation. Alternatively, optimising protein intake can support hypertrophic responses in skeletal muscle. However, various metabolic processes and reactions necessary for energy extraction from macronutrients, oxygen delivery and transfer, tissue repair, and growth and development rely on crucial vitamins and minerals.

Nutrition is regarded as a fundament of athletic performance, and post-exercise nutritional recommendations are crucial for recovery and adaptive processes (Capling et. al., 2019). As such, an optimal recovery strategy, be it during competition or between workouts, can considerably increase the adaptive response to various mechanisms of fatigue, boosting muscle function and endurance. An efficient intervention to enhance an athlete's physical fitness involves monitoring their daily routines and diet, admitting food components in a timely and specified manner (Desbrow et. al., 2014). The quality and quantity of food components are considered fundamental factors in restoring an athlete's physical fitness. The creation of personalized diets is a focus of new developments in dietetics (Desbrow, 2021). These comprise genetic studies that are likely to ascertain people's predisposition to specific types of food and the degree of risk of food-related diseases (1); studies on the diversity of the human microbiota, the characteristics of digestion, and the state of the intestinal barrier (2); and studies of individual responses of the immune system to food antigens that induce changes in food tolerance and the reactivity of the adaptive immune response (3). The acquired immunity-mediated lymphocyte functions provide the adaptive immune response, playing a crucial part in defending against infections and eliminating exogenous pathogens in vivo. Food allergy is characterised as an unwanted immunological reaction occurring upon exposure to a food agent, with symptoms subsiding after its removal. Non-allergic food reactions, on the other hand, are classified as intolerant and have no impact on the immune system. Adverse food reactions may arise from toxins, manifestations of congenital metabolic disorders, and functional disorders of the gastrointestinal tract. Food allergy represents a health issue that affects 3% to 10% of adults worldwide and up to 8% of children. Similarly, approximately 2% to 20% of the global population experience food intolerances.

Micronutrients are vital for maintaining life and include vitamins, which are organic compounds supporting health, growth, and reproduction. These essential vitamins must be obtained through dietary intake in small amounts to prevent clinical deficiencies and declines in health since the human body cannot synthesise them. Vitamins are classified according to their in vivo solubility, with A, D, E, and K being fat-soluble and vitamins B and C being water-soluble. Minerals are vital inorganic substances that aid physiological functioning (Fogelholm, 2015). The daily requirements establish the mineral classifications, whereby healthy individuals require approximately 100mg•day−1 of macrominerals (sodium, potassium, calcium, phosphorus and magnesium) and 20mg•day−1 of trace elements (iron, zinc, copper, chromium and selenium). A balanced diet can typically provide all the recommended micronutrients in appropriate doses for normal bodily functions in a healthy individual (Commonwealth Department of Health and Ageing in Australia, Ministry of Health in New Zealand, National Health and Medical Research Council, 2006). However, the suitability of these recommendations for athletes remains debatable among researchers and clinical practitioners (Tarbeeva, Lymtseva, Lisitsa, Kozlova, Ponomarenko & Ilgisonis, 2021).

Athletes have unique physical activity and energy requirements that vary from those of the general population. Fueling the demands of exercise necessitates ingestion of appropriate nutrition. Adequate nutrition supports energy levels during physical activity, aids in maintaining healthy blood glucose levels, curbs hunger, sustains muscle mass, and facilitates recuperation. Despite the increased energy demands, the recommended dietary choices for teenage athletes remain largely in line with the general guidelines for promoting overall well-being (Firmansyah & Prasetya, 2021).

Micronutrient supplementation is prevalent among athletes, with a meta-analysis indicating that roughly 50% of athletes are consuming vitamin or mineral supplements. It is essential to consider both aspects when devising a diet plan for athletes. Research implies that the athlete's macronutrient needs are dependent on the intensity, duration and mode of exercise, and this also applies to their micronutrient requirements. Athletes participating in high-energy sports may require more micronutrients, although exact levels are not yet determined. Adequate intake of both macronutrients and micronutrients should reflect the athlete's overall energy needs, which are influenced by their training load. Most athletes require high levels of energy to support their training. If they obtain this extra energy intake from a balanced diet, then

the dietary reference intakes for minerals and vitamins may be adequate. However, certain circumstances, occurring regularly, may increase the requirement for essential minerals and vitamins. Athletes who experience high sweat and urine losses, such as electrolytes and zinc, as well as those with low energy intakes, such as iron, or specific dietary preferences, such as a vegetarian or vegan dietary pattern and haem iron, may require exogenous supplementation with vitamins and minerals to promote health and performance. Alternatively, athletes may consider taking supplements to support their adaptation to training. For instance, when adapting to altitude training, iron supplements may be necessary. Certain micronutrients present a greater cause of concern in specific sports. For instance, athletes who train and compete in Winter sports or spend most of their time indoors may have low vitamin D concentrations, while athletes or physically active individuals engaging in high-intensity and endurance-based exercise may experience greater depletion of their iron stores. Although obtaining sufficient vitamins and minerals is crucial for individual health, the impact of supplementation on exercise performance, whether it is direct or indirect, necessitates a recent review.

Therefore, this paper aims to review the recent literature on the effects of the key micronutrients, iron, antioxidants (vitamins C and E), vitamin D and calcium, on exercise performance. Our search was focused on publications from the past decade using the Pubmed database. We located several review papers and searched for citations from relevant sources. Iron, antioxidant, oxidative stress, vitamin C, vitamin E, vitamin D, calcium, exercise, athlete, sport, and performance were the search terms used. Only full manuscripts published in English were included; abstracts, theses, and conference proceedings were excluded.

Conclusions

The study's results revealed a correlation between the evaluated students' physical activity and nutritional habits and their likelihood of being overweight. It is crucial to enhance students' awareness of regular exercise and reduce their screen time, as well as encourage the consumption of healthy foods and natural supplements. Parents should be aware that their eating habits are likely to be copied by their children, including the types of foods they enjoy. Thus, it is important for parents to model healthy eating behaviours and to encourage their children to develop good dietary habits from an early age.

Adolescent athletes have specific nutritional needs resulting from their daily training and competitions while also undergoing the developmental stage (Sawyer et. al., 2012). Dietary suggestions and education aimed at this group of athletes should promote long-term health by emphasising the importance of proper eating habits. Specifically, it is advisable to urge young athletes to regulate their eating habits in accordance with their everyday physical exertions. They ought to consume high-quality carbohydrates and protein at regular intervals throughout the day, particularly in the period right after training. Furthermore, it is crucial to consider the potential risk of Low Energy Availability (LEA) as well as the dietary intake of calcium, vitamin D, and iron for youth athletes due to the prospect of deficiency and higher demands. The nutritional requirements of adolescent athletes should be fulfilled through a healthy diet rather than relying on dietary supplements. The overemphasis on dietary supplements by young athletes tends to exaggerate their potential to improve performance compared to other training and dietary methods.

Athletes may take micronutrient supplements to enhance recovery, boost immune function, and improve performance. Evidence from reviewed literature suggests that overall, micronutrient supplementation does not tend to improve performance in the absence of mineral deficiency. Supramaximal doses may have negative effects, including blunting the body's natural defence system.

This report outlines the factors that affect the dietary habits of athletes, the evolution of the market, service provision in this area and the efficacy of recommended interventions. While health and weight management are crucial for athletes, it is challenging to determine their impact on athletic performance (Pizzuto, Bonato, Vernillo, La Torre & Piacentini, 2017). The athlete's condition, sport, stage of training, and level of competition are also significant factors that determine their food selection. Further research is necessary to determine the optimal macronutrient balance for athletes' nutrition as their dietary requirements change. Non-homeostatic factors linked to the food environment, including food advertising and restricted dietary practices, can stifle intrinsic signals related to appetite and hunger.

Athletes adopt specific diets for various reasons, including health, ethical, religious, and industrial purposes. Vegetarian and lean diets have become popular choices, with a significant increase in their prevalence (Munekata, Pérez-Álvarez, Pateiro, Viuda-Matos, Fernández-López & Lorenzo, 2021). A rigorous diet plan tailored to an athlete's needs can improve their overall health and potentially enhance their performance. However, despite the numerous advantages of low diets, these dietary regimes are also linked with disrupted gut microbiota, reduced production of short-chain fatty acids, eating disorders, heightened psychosocial anxiety, and lowered energy and nutrient consumption. Research into a new approach to immune health in athletes is currently concentrating on tolerogenic nutritional supplements, which have been found to decrease the risk of infection in athletes. These supplements include probiotics, vitamin C, and vitamin D. It is necessary to further investigate the advantages of tolerogenic supplementation to reduce infection in athletes without impeding their training adaptation and without any adverse effects. Athletes train and compete in a variety of settings, and a thorough comprehension of this field can support nutritionists in managing nutrition and planning meals for athletes attending training facilities. It is vital to remember that food choices are ever-changing, and their significance may differ with time, location, and situations in which athletes are selecting their food.

References

Abbott, A., Mackenzie L., Bird, Wild E., Brown S.M., Stewart G., Mulkahey M.K. (2020). Part I: Epidemiology and risk factors for stress fractures in female athletes. *Physician Sportsmed*.

Burke, L.M., Castell, L.M., Casa, D.J., Close, G.L., Costa, R.J.S., Desbrow, B., Halson, L.S., Lis, M.D., Melin A.K., Peeling P., Sauders P.U., Slater, G.J., Sygo, J., Witard, O.C., Bermon, S., Stellingwerff, T. (2019). International Association of Athletics Federations Consensus Statement 2019: nutrition for athletics. *Int J Sport Nutr Exerc Metab*.; 29(2):73–84. https://doi.org/10.1123/ijsnem. 2019-0065.

Capling, L., Gifford, J.A., Beck, K.L., Flood, V.M., Slater, G.J., Denyer, G.S., O'Connor, H.T. (2019). Development of an Athlete Diet Index for Rapid Dietary Assessment of Athletes. *Int. J. Sport Nutr. Exerc. Metab*., 29, 643–650.

Desbrow, B., McCormack, J., Burke, L.M., Cox, G.R., Fallon, K., Hislop, M., Logan, R.,Marino, N, Sawyer, M.S., Vidgen, H., Leveritt, M. (2014). Sports Dietitians Australia position statement: sports nutrition for the adolescent athlete. *Int J Sport Nutr Exerc Metab*., 24(5):570–84. https://doi.org/10.1123/ijsnem. 2014-0031.

Desbrow, B. (2021). Youth Athlete Development and Nutrition. *Sport Medicine*, (53-59).

Department of Agriculture, Department of Health and Human Services. Dietary Guidelines for Americans. (2020–2025). 9th ed. Washington, DC; 2020. p. 75–88. https://DietaryGuidelines.gov. Accessed 18 Aug 2021.

Ergin, E., Lok, N., Lok, S. (2020). The relationship between physical activity and nutrition levels of secondary school students with obesity. (222-225).

Ekeland, E., Heian, F., Hagen, K.B. (2005). Can exercise improve self-esteem in children and young people? A systematic review of randomised controlled trials. *Br J Sports Med*. 2005; 39(11):792–8. https://doi. org/10.1136/bjsm.2004.017707 (discussion 792–8). Gymnastics, Australia. Body Positive Guidelines.

Firmansyah, A., Reza, M. A.P. (2021). The nutrition needs of adolescent athletes: A systematic review. *Jurnal Sportif Penelitian Pembelarajan*, Vol.7 No.3.

Ghanbarzadeh, M., Moazami, N., Hassan, M., Mirdamadi, S. (2022). Study of bioactive compounds in Arthrospira platensis MGH-1 fortifed with micronutrients of iron, zinc, and manganese, *Journal of Applied Phycology*.

Hayriye, C-A., Cihan A., Bircan, D. (2023). Comparison of body composition, bone mineral content and muscle strength variables between elite taekwondo and swimming. *Science, Movement and Health*, Vol.XXIII, issue 1.

Imamova, A. (2022). Ways to optimize the formation of the principles of a healthy lifestyle of children, *American Journal of Medicine and Medical Sciences*, 12(6) :606-608.

Iraki, J., Fitschen, P., Espinar, S., Helms, E. (2019). Nutrition Recommendations for Bodybuilders in the Off-Season: A Narrative Review. *Sports*, 7, 154.

Kumar, A., Ramamoorthy, D., Kumar, D., Kumar, N., Kumar, N., Kanak Raj Kanak, Mary Marwein B., Mohan, K. (2022). Antioxidant and phytonutrient activities of Spirulina platensis, *Elsevier*, Energy Nexus 6(2022) 1000070.

Jalolov, N.N., Imamova, A.O. (2023). The role of nutrition the management of chronic hepatitis. *European International Journal of multidisciplinary research and management studies*, 3(02), 28-34.

Jagim, A.R, Kerksick, C.M. (2021). Creatine supplementation in children and adolescents. *Nutrients*. 13(2):664. https://doi.org/10. 3390/nu13020664.

Kawther, K., Nagla, E. (2019). Use of total contact and its effectiveness in improving the results of educational content and emotional intelligence for deaf-mute children in the eastern province (Dammam), *Series Physical Education and Sport/Science, Movement and Health*,Vol XIX,ISSUE 1.

Miroslava, P., Miroslava, A. (2021). Retrospective analysis of physical inability to 9-year-old students, (177-183), *Series Physical Education and Sport/Science, Movement and Health*, Vol. XXI, ISSUE 2.

Marcu, D., Borz, C., Oprea, L. (2020). Study on quality management for the physical education and sport subject, *Series Physical Education and Sport/Science, Movement and Health*. Vol. XX, ISSUE 2.

Munekata, P.E., Pérez-Álvarez, J., Pateiro, M., Viuda-Matos, M., Fernández-López, J., Lorenzo, J.M. (2021). Satiety from healthier and functional foods. *Trends Food Sci. Technol*., 113, 397–410.

Pizzuto, F., Bonato, M., Vernillo, G., La Torre, A., Piacentini, M.F. (2017). Are the World Junior Championship fnalists for middle and long-distance events currently competing at international level? *Int J Sports Physiol Perform*. 12(3):316– 21. https://doi. org/10.1123/ijspp.2015-0717.

Reale, R., Burke, L.M., Cox, G.R.., Slater, G. (2020). Body composition of elite Olympic combat sport athletes. *European journal of sport science*. 20(2), 147-156.

Reale, R.J., Roberts, T.J., Lee, K.A., Bonsignore, J.L., Anderson, M.L. (2020). Metabolic rate in adolescent athletes: The development and validation of new equations, and comparison to previous models. *Int J Sport Nutr Exerc Metab*. 30(4):249–57. https://doi.org/10. 1123/ijsnem.2019-0323.

Reguant-Closa, A., Harris, M.M., Lohman, T.G., Meyer, N.L. (2019). Validation of the Athlete's Plate nutrition educational tool: phase I. *Int J Sport Nutr Exerc Metab*.; 29(6):628–35. https://doi.org/10. 1123/ijsnem.2018-0346.

Ruyvaran, M., Zamani, Mohamadian, A., Mohammad. (2022). Safflower (*Carthamus tinctorius* L.) oil could improve abdominal obesity, blood pressure, and insulin resistance in patients with metabolic syndrome: A randomized, double-blind, placebo-controlled clinical trial, *Journal of Ethnopharmalogy*, volume 282.

Sawyer, S.M., Aff, R.A., Bearinger, L.H., Blakemore, S.J., Dick, B., Ezeh, A.C, Patton, C.G., (2012). Adolescence: a foundation for future health. *Lancet*. 2; 379(9826):1630–40. https://doi.org/10.1016/ S0140-6736(12)60072-5.

Stoyel, H., Delderfeld, R., Shanmuganathan-Felton, V., Stoyel, A, Serpell, L. (2021). A qualitative exploration of sport and social pressures on elite athletes in relation to disordered eating. *Front Psychol*.

Stoyel, H., Slee, A., Meyer, C., Serpell, L. (2020). Systematic review of risk factors for eating psychopathology in athletes: a critique of an etiological model. *Eur Eat Disord Rev*., 28(1):3–25. https:// doi.org/10.1002/erv.2711.

Tarbeeva, S., Lyamtseva, E., Lisitsa, A., Kozlova, A., Ponomarenko, E., Ilgisonis, E. (2021). ScanBious: Survey for Obesity Genes Using PubMed Abstracts and DisGeNET. *J. Pers. Med*., 11, 246.

Walsh, N.P. (2019). Nutrition and Athlete Immune Health: New Perspectives on an Old Paradigm. *Sports Med*., 49, 153–168. https://www.gymnastics.org.au/Ga/Athletes/Body_ Positive.aspx. Accessed 18 Aug 2021.