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THE INFLUENCE OF THE REDUCTION DIETING ON RESTING METABOLIC RATE AND OXIDATIVE STRESS IN ATHLETES

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Abstract

Oxidative stress (OS) represents an imbalance between the production of reactive oxygen species (ROS) and the ability to detoxify the reactive intermediates, as well as the body's inability to provide adequate antioxidant defense. The aim of the study was to present the current data from the literature regarding influence of the reduction dieting on resting metabolic rate (RMR) and OS, in order to emphasize the need of dietary balance on sport performance and quality of life in athletes.

By using the current literature of the Systematic Reviews databases such as Medline, the Cochrane Library, Scopus, Pubmed and Web of Science, the data were selected and analyzed. The effect that regular exercising has on OS is different, depending on age, sex, workout intensity and its duration. Moderate physical activity has a positive impact on OS, improving health, while intensive physical activity may lead to excessive production of ROS. Although the physical activity can lead to increased OS, it gives a positive stimulus for the endogenous antioxidative defense, according to the theory of hormesis. Athletes compared to the sedentary subjects have a higher percentage of muscle mass due to their active lifestyle. Higher percentage of muscle mass contributes to higher energy requirement. Although athletes strive to maintain the energy balance, reduction diets are considered to have a positive effect on OS. Experimental studies show that prolonged caloric deficit increases the average lifespan of rodents and other animal species. One of the hypotheses explaining the effect of slowing down the ageing process by a reduction diet is the decreased energetic expenditure, leading to decreased ROS production. Focused on OS decreasing and improving the sport performance, athletes need balanced nutrition, including reduction diets. Reduction diets that decrease RMR by a combination with moderate physical activity show a positive impact on OS, slowing down the ageing process, prolonging the lifespan.

Keywords: oxidative stress, physical activity, reduction dieting, resting metabolic rate.

Introduction

Oxidative stress (OS) represents an imbalance between the production of reactive oxygen species (ROS) and the ability to detoxify reactive intermediates, as well as the body's inability to provide adequate antioxidant defense. This can lead to cell components damage, including the proteins, fats, carbohydrates, nucleic acids that may lead to chronically diseases such as cardiovascular, endocrine and neurodegenerative and malignant diseases. Also OS is linked with many physiological processes like ageing and exercising [1].

The effect of regular exercising on OS is different, depending on age, sex, workout intensity and its duration. Moderate physical activity has a positive impact on OS, improving health, preventing some diseases, while intensive physical activity may lead to excessive production of ROS. Although intense physical activity can lead to increased OS, it gives a positive stimulus to endogenous antioxidative defense, according to the theory of hormesis (Figure 1). This hypothesis suggests that the body response with increased production of ROS due to exercising causes an adaptive reaction which includes positive regulation of the antioxidants, contributing to better stress resistance and lifespan longevity [2].

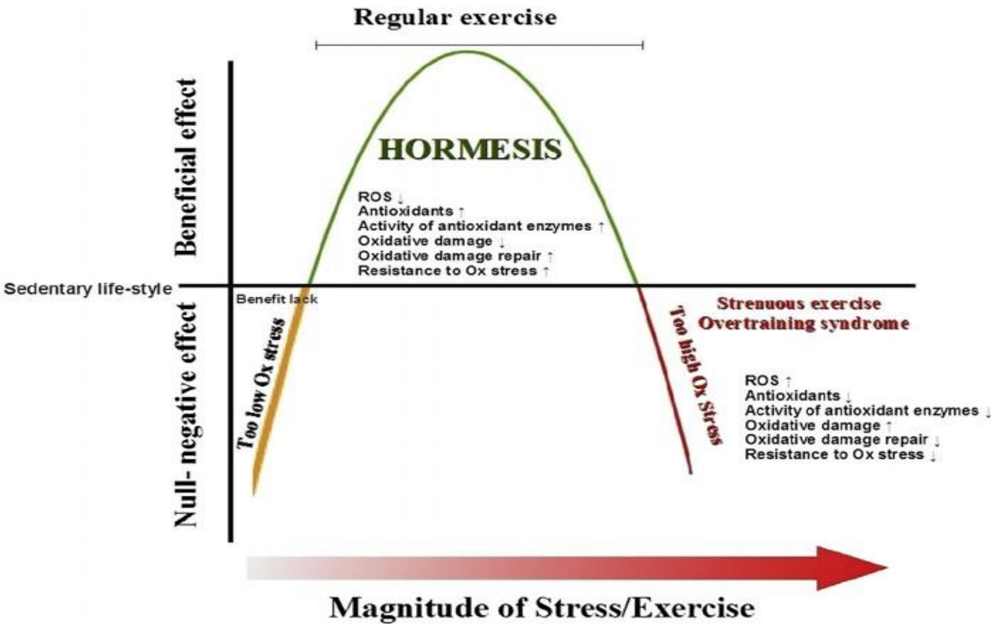

Figure 1. Theory of hormesis: mild OS caused by physical activity results with positive adaptation of the body which protects from OS damage [3].

Well balanced nutrition and evaluating the basal metabolism of athletes is of great importance in order to reach better sport performance and also better health results, respectively. While basal metabolic rate (BMR) is harder to obtain, resting metabolic rate (RMR) is more often used as an appropriate parameter to assess the metabolic state.

The aim of the study

The aim of the study was to present the current data of the influence of the reduced diet on RMR and OS to emphasize the need of well balanced diet on sport performance and quality of life in athletes.

Material and methods

By using the current literature of the Systematic Reviews databases such as Medline, the Cochrane Library, Scopus, Pubmed and Web of Science, the data were selected and analyzed. Keywords for this search were: oxidative stress, resting metabolic rate, physical activity and reduction dieting.

Athletes specific issues and metabolic state

Athletes compared to the sedentary subjects have a higher muscle mass percentage due to the active lifestyle. Higher percentage of muscle mass contributes to higher energy requirement. Athletes aim to maintain adequate body mass with a well balanced nutritional regimen. Their active lifestyle contributes to higher total daily energy expenditure (TDEE), which is the total energy that body daily burns. It is a combination of BMR, thermal effect of the food (TEF), non-exercise activity thermo-genesis (NEAT) and thermal effect of activity (TEA). The BMR, as a minimal energy requirement the body needs to function, is 60-80% of TDEE [4]. More often used and reliable measurement for minimal energy expenditure is RMR, while BMR is 10-15% lower than RMR. TEF is the energy that our body uses for digestion, absorption and utilization of the nutrients. TEF is 5-15% for carbohydrates, 0-5% for fats and 20-35% for proteins of the caloric intake. TEA is the number of calories burned as a result of exercise (i.e. steady-state cardio, resistance training, HIIT, sprints, Cross Fit, etc.). Similar to NEAT, the thermal effect of exercise is highly variable from one person to another or even from one day to another for the same person, as the intensity of training, length of the workout and training frequency all impacts your weekly thermal effect of activity. Athletes tend to have higher TDEE which have an impact on increasing RMR. Although athletes make efforts to maintain the energy balance, reduction diets are considered to have a positive effect on oxidative stress. Nutritional practitioners in order to make nutritional regimens for athletes in optimal caloric deficit should have evaluation of the TDEE. This nutritional regimen should be made according to individual requirements of the athlete in order to maintain the muscle mass but prevent relative energetic deficit syndrome (RED-S). RED-S may have negative effects on the musculoskeletal system and reproductive and psychological health [5].

Methods for measuring BMR / RMR

Aiming that the nutritional practitioner should calculate or measure athlete's RMR and TEA, RMR can be measured by indirect calorimetry (IC) which is a method that measures oxygen consumption and carbon dioxide production and is a valid method for calculating RMR. IC is harmless, fast, available, inexpensive and practical to use on a field. Dating from the 1970s, gas-exchanging portable devices for IC were available for clinical use. These are accurate devices with a 5% margin of error but they require a protocol (participants should be rested, calm, fasted in the last 8 hours and physically inactive in the last 24 hours) and the device should be calibrated [6].

Mathematical equations were developed from the measurements of direct and indirect calorimetric method and are accepted as the main method for determining the individual energy requirements. Predicted equations are based on available parameters like age, sex, height and weight [7].

Among the first widely spread and used equations is Harris and Benedict (HB) from 1918 year, and FAO/WHO/UNU equation which is based on the Schofield database from 1985 year [8, 9].

Many of the equations used today are derived from older and overweight population and less from physically active and young subjects, that makes these equations unsuitable for the athletic population. Lean body mass has a high impact on energetic requirements. Webb has found a strong relationship between 24 hour energetic expenditure in rest and lean body mass in males and females [10].

Cunningham et al. [11] found that lean body mass is the main factor that can give 70% variations between the equations. The Cunningham equation is derived from cohort groups who were classified as more active compared to the participants in the Harris-Benedict equation [9].

Studies showed that the Cunningham equation is the most relevant for athletes because it considers fat free mass [12, 13, 14].

In order to have exact value of the TDEE, RMR should be multiplied by factor of physical activity, for sedentary subjects - 1.53, recreational athletes -1.76 and professional athletes 2.25 (Energy Requirements of Adults, Report of a Joint FAO/WHO/UNU Expert Consultation). This way the nutritional practitioners will have the exact value of energy metabolism of the athlete and can be able to perform nutritional regimens with an optimal caloric deficit.

Reduction diet and RMR in athletes

Over time, prolonged reduction diet can lead to a phenomenon called adaptive thermal genesis, where the body lowers the BMR to conserve energy. This is a survival mechanism designed to combat perceived starvation. If the diet is too restrictive or lacks adequate protein, the body may break down muscle tissue for energy, reducing lean muscle mass. Since muscle is metabolically active, losing muscle can decrease BMR. Caloric restriction can lower levels of thyroid hormones (like T3), which regulate metabolism, thereby reducing BMR. Leptin (which signals satiety) levels drop during calorie deficits, while ghrelin (which stimulates hunger) levels rise. These hormonal shifts can indirectly influence metabolic rate by signaling energy conservation. Prolonged caloric deficit is extending lifetime in rodents and other species [15].

Whether it happens in humans, it is still unknown, thus the effects of prolonged calorie deficit continue to be investigated mostly in experimental studies.

OS and aging process

One of the hypotheses explaining the effect of slowing down the ageing process with caloric deficit diets is lowering energy expenditure, thus reducing the production of ROS [16, 17]. Other metabolic effects linked to calorie deficit diets include changes in insulin signalization and sensitivity, neuroendocrine function and stress response which contribute to slow down the ageing process [18].

Leibel et al. discovered that decreasing the body weight up to 10% at obese patients may decrease the TDEE, indicating metabolic adaptation in humans [19]. Leibel et al. also discovered that decreasing the body weight with liquid diet and prolonged caloric deficit has no effect on TDEE in the subjects with normal weight. In one study, examining the rhesus monkeys on a calorie deficit diet for 11 years showed that their RMR was decreased [20]. Although athletes have higher calorie needs because of their active lifestyle and large muscle mass, reduction diets have a positive impact on OS recovery, caused by vigorous and prolonged exercise.

Discussion

One of the theories about accelerating ageing and unhealthy state is the OS influence, explaining that oxidative damage from accumulation of ROS may cause chronic diseases like cardiovascular, neuro-endocrine and malignant diseases, with even fatal outcome [21].

The ROS are side products of the energetic metabolism, app. 0,2 - 2% by oxygen consumption [22, 23]. ROS may damage lipids, proteins and DNA molecules, affecting the cell physiology (24). In some studies with experimental subjects, caloric deficit diet in rodents causes 30% decrease of 8 oxo-7,8 di-hydroxyguanine (8 oxo G) in the brain, skeletal muscle and heart and similar reduction of the concentration of carbonyl in brain and in muscles which indicate OS decrease [25, 26, 27, 28, 29].

Caloric deficit diet in rhesus monkeys causes different outcomes in expressions of the genes involved in OS [30]. Body temperature and level of dehydroepiandrosterone sulphate (DHEAS) and insulin are biomarkers for caloric deficit and prolonged life in rodents and monkeys [31].

Some results from Baltimore longitudinal study for ageing support the connection between longevity, body temperature, insulin levels and DHEAS of low levels in male subjects. In a study of Fontana et al. [33] which compared subjects on a reduction diet and a control group with normal body weight, is shown that the group who were on the reduction diet had lower levels of serum glucose, insulin and atherosclerosis markers. In rest OS is lower in athletes compared to sedentary group [34, 35]. Several studies have shown lower oxidative response in athletes compared to sedentary group, during and after exercise. The OS markers such as malondialdehyde, protein carbonyl and 8 hydroxyguanosine had lower values in athletes compared to sedentary subjects, and also the antioxidative enzymes such as superoxide dismutase (SOD) activity was higher in athletes compared to sedentary group [36, 37]. Furthermore, antioxidative enzymes like catalase and glutathione-peroxidase show higher activity in athletes compared to sedentary subjects. However, the sport type and intensity of the exercise may modify these changes [38].

Well trained athletes can be resistant to unexpected OS caused by vigorous exercise [39]. Acute and vigorous exercise increased erythrocyte malondialdehyde (lipid peroxidation marker) at sedentary rats, but not in trained ones, and decreased erythrocyte superoxide dismutase activity at untrained rats [40].

Some recent studies showed that OS is decreased after the Ironman race [41].

Concerning the hormesis theory of OS and physical activity, these results can give explanation that elite athletes have longer life span, compared to the sedentary subjects. This gives an inversely proportional linear correlation between intensity of physical activity and mortality in some studies [42, 43, 44].

Conclusion

Reduction diets in combination with moderate exercise have positive impact on healthy life style in general. It may contribute for decreased OS, slowing down the ageing process, prolonging the lifespan, and improving the quality of life, respectively. In athletes, appropriate sport intensity, well balanced nutrition and reduction dieting may also contribute for better sport performance, improving their sport achievements.

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