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Muscle power and strength performance in sport

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Abstract

Muscle power and strength performance in sport are known to be based on many factors. These respectively; exercise, resistance training, nutrient intake, beverages, etc. Although some factors cannot be controlled, two factors that we can control are exercise and nutrition habits. Therefore, exercise and nutrition habits need closer examination. The aim of the current study is to examine such factors influence muscle power and strength performance in detail.

Building strong muscles are developing body resistance. Developing body resistance depends on a specific outcome like as muscular endurance, maximal strength, or power. These include: muscle action; exercise selection; repetition velocity; and frequency. Resistance training is developing both strong muscles and body building. It can have favorable effects on bone mineralization and growth as well as lead to a decreased risk of osteoporotic fractures later on in life. Resistance training also provides psychological benefits for young participant.

For optimal athletic performance, recovery and body composition, athletes need to synchronize diet and physical activities. The composition of nutrient intake can significantly influence recovery from heavy exercise. Beverages are a significant influence on the exercise and muscle strength. Each of the beverages provides similar effects on recovery following heavy aerobic exercise, despite variations in the carbohydrate/protein compositions of the beverages. Caffeine-containing energy drink has become the most used caffeine-containing beverages in the sport setting. A dose of energy drink at least equivalent to 3 mg/kg of caffeine is necessary to significantly improve lower-body and upper-body muscle power and strength.

Keywords: Muscle power, strength performance, body resistance, resistance training, nutrient intake, energy drink

Introduction

Human muscle strength, which can be defined as the maximum force generation capacity of an individual, reaches its peak between the second and third decades, shows a slow or imperceptible decrease until about 50 years of age and then begins to decline thereafter at the rate of approximately 12% to 15% per decade, with more rapid losses above the age of 65 years (1). Various factors influence muscle size. Although some factors cannot be controlled, two factors that we can control are exercise and nutrition habits. Men generally have more muscle mass than women, mainly because men produce more testosterone than women. Strength training may increase muscle mass slightly in women; however, a common misconception is that strength training will cause women to “bulk up.” Importantly, strength training will greatly increase muscle strength and reduce the risks for injury. Moreover, women tend to have poor upper body strength and many military tasks require upper body strength (2).

Building strong muscles are developing body resistance. Developing body resistance depends on a specific outcome like as muscular endurance, maximal strength, or power. These include: muscle action; exercise selection; repetition velocity; and frequency (3). Resistance training is developing both strong muscles and body building. Resistance training is a special type of training that requires the use of resistance to train the large muscle groups. Today resistance training is multidimensional. Training consists of strength/power, speed, agility, plyometric, nutrition, and regeneration (4). Exercise is lately the focus of sport science. Auxiliary sciences are Anatomy, Biomechanics, Pedagogy, Psychology, History, Sport medicine, Physiology, Statistics, Nutrition, Motor learning, Sociology, Test and measurements. However training quality depends on few factors which are; athlete’s performance, Coach's knowledge and personality, facilities and equipment, heritage, athlete's abilities, motivation, competitions, findings from auxiliary sciences (5).

The Basis of Training

Strength training is exercising with the objective of increasing physical strength. There are two kinds of strength. Relative strength is building maximal force without increasing body-weight. Absolute Strength is the maximum force that exert irrespective of body size or muscle size. Absolute strength is about becoming strong regardless of body-weight. There are many benefits to Strength conditioning. The stronger could be defined as having more muscles that was exist. Strength conditioning is not bodybuilding however; building muscle is a by-product of strength conditioning and not necessarily its objective. Secondly, strength conditioning burns calories and keeps your metabolic rate high and lastly, it can sometimes help prevent conditions such as heart disease, diabetes, osteoporosis and arthritis (6).

Resistance training can have favorable effects on bone mineralization and growth as well as lead to a decreased risk of osteoporotic fractures later on in life. Resistance training also provides psychological benefits for young participant. It has been observed that the socialization and mental discipline exhibited by children and adolescents participating in a resistance training program are similar to the experiences of youths participating in team sports and other activities. Resistance training, as do most physical activities, has some risk for injury. Yet this risk is no greater than the one in other sports/recreational activities. The development of a youth resistance training program needs to follow the similar steps as that of an adult program, but it is important to remember that children and adolescents are not "miniature" adults. No matter how big and strong, they are still anatomically, physiologically, and psychologically immature. With proper and clear instruction and careful supervision, a youth resistance training program can be in aid of health and fitness improvement, and may develop a positive attitude towards strength training and a healthy lifestyle (7).

Sources of Energy

ATP is the basic source of energy. Energy obtains from converting nutriments at the muscle cell level into a high-energy compound known as ATP (adenosine triphosphate). The energy for all physical activity comes from the conversion of high-energy phosphates (adenosine *tri*phosphate—ATP) to lower-energy phosphates, adenosine *di*phosphate—ADP; adenosinemonophos- phate—AMP; and inorganic phosphate, P_i (8). Three energy systems function to replenish ATP in muscle: (1) Phosphagen, (2) Glycolytic, and (3) Mitochondrial Respiration. The three systems differ in the substrates used, products, maximal rate of ATP regeneration, capacity of ATP regeneration, and their associated contributions to fatigue. In this exercise context, fatigue is best defined as a decreasing force production during muscle contraction despite constant or increasing effort. The replenishment of ATP during intense exercise is the result of a coordinated metabolic response in which all energy systems contribute to different degrees based on an interaction between the intensity and duration of the exercise, and consequently the proportional contribution of the different skeletal muscle motor units (9). ATP is the principal immediate donor of free energy. Turnover is very high: an ATP molecule is typically consumed within a minute of its formation. The reactions of ATP production and consumption can be centred around the proton-motive force (Δp) and divided into substrate oxidation (all reactions between the oxidizable substrates and the mitochondrial redox proton pumps) and the phosphorylating system (all reactions of ATP synthesis and utilization). Alternatively, the reactions can be centred around ATP and divided into ATP-producers and ATP-consumers. Oxidative phosphorylation is never fully coupled;

even in their natural intracellular environment mitochondria show a significant passive permeability to protons not coupled to ATP synthesis (termed ‘proton leak’). Possible functions of the leak are production of heat to maintain body temperature, the endowment of increased sensitivity of metabolic reactions to effectors, reduction of harmful free radical production and regulation of carbon flux (10).

Energy is extracted from foods in the body by converting the chemical energy stored in chemical bonds to high energy phosphate bonds in **ATP** (adenosine triphosphate). This high-energy bond can be used in a number of biochemical reactions as a fuel with the conversion of ATP to ADP (adenosine diphosphate). If ADP begins to accumulate in muscle, then an enzyme is activated in muscle to break down phosphocreatine (**PCr**) in order to restore ATP levels ($\text{PCr} + \text{ADP} \rightarrow \text{ATP} + \text{Cr}$). The creatine released from this reaction is converted to creatinine and excreted in the urine. The stores of PCr are extremely limited and can only support muscle ATP levels for about 10 seconds if there were no other sources of ATP. Because ATP is provided from other sources, PCr ends up being a major energy source in the first minute of strenuous exercise. PCr is localized in the muscle so that it can rapidly restore and maintain ATP levels for intense exercises such as sprinting, jumping, lifting and throwing (11).

The activity patterns of many sports (e.g. badminton, basketball, soccer and squash) are intermittent in nature, consisting of repeated bouts of brief (≤6-second) maximal/near-maximal work interspersed with relatively short (≤60-second) moderate/low-intensity recovery periods. Although this is a general description of the complex activity patterns experienced in such events, it currently provides the best means of directly assessing the physiological response to this type of exercise. During a single short (5- to 6-second) sprint, adenosine triphosphate (ATP) is resynthesised predominantly from anaerobic sources (phosphocreatine [PCr] degradation and glycolysis), with a small (<10%) contribution from aerobic metabolism (12).

Muscle contraction and, therefore, all exercise are dependent on the breakdown of adenosine triphosphate (ATP) and the concomitant release of free energy. This free energy release is coupled to the energy requirements of cell work, of which muscle contraction is just one example;

$$\boxed{\text{ATP} \xrightarrow{\text{ATPase}} \text{ADP} + \text{Pi} + \text{energy} \rightarrow \text{muscle contraction}}$$

One would think that muscle, like all cells, would benefit from a large store of ATP from which to fuel cell work. However, this is not the case. The total quantity of ATP stored within the cells of the body is very small (approximately 8mmol/kg wet weight of muscle). Thus, cells rely on other mechanisms to supply ATP to support cell work, which involves the store of energy in more complex molecules such as glycogen and triacylglycerols, and more importantly, having a sensitive control system to rapidly increase metabolism during times of energy (ATP) demand. Muscle tissue is unique in that it can vary its metabolic rate to a greater extent than any other tissue depending on the demands placed upon it. The study of bioenergetics provides a rationale explanation for this scenario, where the concentrations of muscle ATP, ADP, AMP, and Pi during rest conditions are optimal for supporting free energy transfer to and from ATP (12,13).

Sports performance and energy expenditure

Sports performance is the result of interactions among a host of genes and environmental constraints. There are important implications for advising clinicians, teachers, coaches, administra and athletes on the seductive, but highly simplistic, myths surrounding ‘single-gene-as-magic bullet’ approaches, which have become more prevalent in sports medicine. These implications relate to the uncritical acceptance of general models for talent identification and development programmes across the world (14).

Training programs play an important role to improve the performance of athletes. Increasing sustainable power output requires that the athlete undergo a carefully designed training program that will improve the athlete's abilities to: 1) produce metabolic energy by both aerobic and anaerobic means, 2) sustain aerobic energy production at high levels before lactic acid accumulates excessively in the blood, 3) recruit more of the efficient slow–twitch muscle fibers at exercise intensities used in competition, and 4) become more skillful by recruiting fewer non– essential muscle fibers during competition. Careful attention to maintaining a sufficient intake of fluids and carbohydrate before, during, and after strenuous competition and training sessions is also important (15).

For optimal athletic performance, recovery and body composition, athletes need to synchronize diet and physical activities. Sprinters are strength athletes who need to achieve a high power to weight ratio by maximizing muscle mass and maintaining low body fat. For this reason many training programs were compared to find the balance of diet and physical activities (16-18). Energy expenditure changes by the field of sport and calculated with different sport branch. For example estimation of energy expenditure in judo athletes is complex. Energy expenditure during training in judo athletes is not well described. Energy expenditure during randori as estimated with the Sensewear armband (SWA) is rather low when compared to the reference values. The combination of different methods such as activity diaries and SWA may improve the estimate of the energy expenditure in judo athletes (19,20).

Total energy expenditure is the energy required by the organism daily and it is determined by the sum of tree components: basal energy expenditure, diet induced thermogenesis and physical activity. The determination of energy expenditure, considering the physical activity level and health status, is very important to adjust the individuals' nutritional supply. Energy expenditure can be determined by using indirect calorimetry, bioelectrical impedance, doubly labeled water, predictive equations, among others. All these methods have been used in clinical and research areas. However, considering the inconsistence in several research results, there is no consensus yet about the applicability of many of these methods. Indirect calorimetry and doubly labeled water are considered more accurate methods, but expensive. On the other hand, even though other methods present limitations, they are convenient and less expensive, and can be used with some caution (21).

Sports performance and energy intake

All athletes can benefit from making good food choices that will support consistent training, maximise performance in competition and help maintain good health. Food choices will be very different in different countries and different cultures, but the basics of good nutrition remain the same: a wide variety of healthy and wholesome foods eaten in appropriate amounts should be the primary elements of every athlete's diet (22).

Getting the right amount of energy to stay healthy and to perform well is key. Consuming too much energy increases body fat: too little, and performance falls, injuries are more likely to occur, and illness results. Carbohydrate supplies the muscles and brain with the fuels they need to meet the stress of training and competition. Athletes must be aware of what foods they should choose to meet their carbohydrate needs, how much should be eaten, and when these foods should be eaten. Foods rich in protein are important for building and repairing muscles, but a varied diet containing everyday foods will generally supply more than enough protein. With protein also, the timing of intake in relation to training and competition may be important and taking a small amount of protein- containing foods soon after training may help to promote adaptations taking place in the muscles. Well-chosen vegetarian diets can easily meet protein needs (23).

Oxidative stress plays a vital role in a number of physiological processes. Increased aerobic metabolism during exercise is a potential source of oxidative stress. Exercise can create an imbalance between oxidant and antioxidant levels, a situation known as oxidative stress. Indeed, oxidative stress resulting from acute exercise in unadapted and adapted subjects has been proposed to damage enzymes, protein receptors, lipid membranes, and DNA (24-27).

An appropriate nutritional intake improves the antioxidant capacity of soccer players and influences the activity of the principal antioxidant enzymes (such as superoxide dismutase and glutathione peroxidase) that protect against the potentially damaging effects of oxidative stress. Furthermore, some specific macronutrients and micronutrients diminish the negative physiological impact of playing a soccer match, since changes in some markers related to cell damage, inflammation and immunity were found. Nutrition intake should be taken into account by nutritionists and coaches during training sessions and championships, in order to enhance players physiological response to the stress associated with playing a soccer match and eventually, their performance (28).

Athletes have no influence over their heredity, but they can control their training and diet. Athletes are constantly looking for a competitive edge. Though the appropriate diet won't guarantee athletic success, a poor diet can undermine training efforts. In many events, especially among elite athletes, the margin between victory and defeat is very small. Attention to nutrition can make that critical difference. The foods an athlete chooses will influence performance in both training and competition. Diet may actually have its biggest impact on training. A healthful diet supports regular, intensive training and decreases the risk of illness and/or injury. Appropriate food choices can also enhance adaptations to the training stimulus (29).

Two main reports reccomended valnurable advise on the current subject. The first has been printed by International Olympic Committee (30). The second is a report that athletes do not need a diet substantially different than that recommended in the 2010 Dietary Guidelines for Americans (31).

During high-intensity training, particularly of long duration, athletes should aim to achieve carbohydrate intakes that meet the needs of their training programs and also adequately replace carbohydrate stores during recovery between training sessions and competitions. Dietary protein should be consumed in daily amounts greater than those recommended for the general population, but a varied diet that meets energy needs will generally provide protein in excess of requirements. Foods or snacks that contain high-quality proteins should be consumed regularly throughout the day as part of the day's total protein intake, and in particular soon after exercise, in quantities sufficient to maximise the synthesis of proteins, to aid in long-term maintenance or gain of muscle and bone and in the repair of damaged tissues. Ingestion of foods or drinks providing 15-25 g of such protein after each training session will maximise the synthesis of proteins that underpins these goals. The use of supplements does not compensate for poor food choices and an inadequate diet, but supplements that provide essential nutrients may be a short-term option when food intake or food choices are restricted due to travel or other factors. Vitamin D may be needed in supplemental form when sun exposure is inadequate (30).

American Dietetic Association, Dietitians of Canada, and the American College of Sports Medicine that physical activity, athletic performance, and recovery from exercise are enhanced by optimal nutrition. These organizations recommend appropriate selection of foods and fluids, timing of intake, and supplement choices for optimal health and exercise performance. This updated position paper couples a rigorous, systematic, evidencebased analysis of nutrition and performance-specific literature with current scientific data related to energy needs, assessment of body composition, strategies for weight change, nutrient and fluid needs, special nutrient needs during training and competition, the use of supplements and ergogenic aids, nutrition recommendations for vegetarian athletes, and the roles and responsibilities of sports dietitians. Energy and macronutrient needs, especially carbohydrate and protein, must be met during times of high physical activity to maintain body weight, replenish glycogen stores, and provide adequate protein to build and repair tissue (31).

Many other studies in the literature have shown that composition of nutrient intake can significantly influence recovery from heavy exercise (32 – 38). Beverages are a significant influence on the exercise and muscle strength. According to the outcomes of Goh Q et al. beverages containing similar caloric content but different proportions of carbohydrate/protein provided similar effects on muscle recovery and subsequent exercise performance in well-trained cyclists. Each of the beverages (CHO, HCLP, LCHP) provides similar effects on recovery following heavy aerobic exercise, despite variations in the carbohydrate/protein compositions of the beverages. Thus, following heavy aerobic exercise of approximately 1 h duration, short-term exercise recovery of well- conditioned male cyclists does not appear to be significantly influenced by the macronutrient content of recovery beverages, provided that the caloric content of the beverages is similar (*i.e.*, 285–300 kcal in each serving). These findings may be limited to well-trained endurance cyclists, as it is possible that populations that incur larger disruptions in muscle recovery may obtain different results from the treatment beverages. Therefore it is recommended that future investigations examine the effects of CHO + Pro beverages under differing exercise conditions, and with participants of varying training status (39).

Caffeine-containing energy drink has become the most used caffeine-containing beverages in the sport setting. In addition, the caffeinated energy drink increased jump height which may represent a meaningful improvement for headers or when players are competing for a ball. The ingestion of a caffeine-containing energy drink equivalent to 1 mg/kg of caffeine does not produce significant ergogenic effects on muscle performance. A dose of energy drink at least equivalent to 3 mg/kg of caffeine is necessary to significantly improve lower-body and upper-body muscle power and strength. The ingestion of this second energy drink dose also increases heart rate, blood pressure, and tended to increase the frequency of some minor side-effects in the subsequent hours to the ingestion (40,41).

Conclusions

Increase muscle power and strength performance are known to be based on many factors. These respectively; exercise, resistance training, nutrient intake, beverages, etc. Although some factors cannot be controlled, two factors that we can control are exercise and nutrition habits. Therefore, exercise and nutrition habits need closer examination. In addition, it needs not neglect other factors. In the current study such factors influence muscle power and strength performance were examined in detail.

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