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CHARACTERIZATION OF BIOCHEMICAL AND IMMUNOLOGICAL RESPONSES TO VARIOUS TYPES OF EXERCISE LINKED TO MUSCLE INJURY*

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Abstract

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The purpose of this article is to present a brief overview of the changes of biochemical and inflammatory variables occurring at various modes of exercise, associated with exercise-induced muscle injury. Emphasis is placed on systemic changes of the neutrophils and their infiltration into muscle tissue. Possible relationship between the adaptation/overtraining and immune function is also discussed.

Key words: *exercise-induced muscle injury, neutrophils*

Introduction

It is very important to consider inflammatory events taking place during exercise associated with muscle damage. An inflammatory response represents a fundamental reaction in response to infection, tissue injury etc. For this reason there has been substantial interest in studying how exercise may affect the immune system and its association with the muscle injury. It is apparent that most of the characteristic features of a classical inflammatory reaction are noticeable in an exercising subject. Unlike sometimes uncontrollable inflammatory response in trauma patients, resulting in morbidity, strenuous and unaccustomed exercise draws an inflammatory response of a sub-clinical character. However, surprisingly comparable sequence of inflammatory reactions can be reproduced by different provocative events, such as trauma or infection, or exercise in the affected subject. Therefore, acute exercise and training represent excellent models for the study of inflammatory responses in humans and experimental animals. More, the immune system responding to exercise by coordinated activity of various types of cells. Further, immune cells do not all respond equally to the matching exercise stimulus. Thus, alterations of each components of the immune system should be discussed individually and systematically. Consequently, many variables, such as exercise mode, duration, and intensity and whether the subject was accustomed to the exercise being tested, should be taking into account in addressing this issue.

This article will discuss some biochemical and inflammatory events taking place during and after different types of exercise. Emphasis is placed on exercise, associated with exercise-induced muscle injury. The distinctive attention is devoted to the systemic changes of the neutrophils, as well as to neutrophils' infiltration into muscle tissue, following exercise-induced injury. Several types of skeletal muscle injuries may have different cause such as mechanical injury, muscular dystrophies, sport and exercise-induced injury. Exercise-induced injuries involving high-intensity, strenuous workload or eccentric contractions are associated with overloading of the contractile elements. To distinguish the exercise-induced injury process that will be discussed from the more traumatic forms of soft tissue injury, it is suitable to describe as a "muscle micro-injury".

Changes in muscle protein and intracellular enzymes release as a consequence of exercise-induced muscle injury

The structural damage to the muscle cell is accompanied by the leakage in muscle proteins and enzymes out of the cell into the bloodstream. Myoglobin and creatine kinase have been used repeatedly as markers of muscle damage in exercise studies in experimental animals and in humans. A significant increase in creatine kinase activity in blood serum in rats was found after downhill running on treadmill (-16% downhill grade) (1). Different mode of exercise (intensive

*Portions of this paper were presented by M. Kalinski in his keynote presentation at the 6th International Congress Medicina Sportiva in Krakow in November, 2006 swimming with an addition of 12% of total body mass) caused an increased myoglobin in blood serum of untrained rats. Concentration of myoglobin in blood of untrained rats was increased 3-fold immediately after physical exercises and 9-fold within 72 hrs of the rest (2). In humans, creatine kinase activity was not altered following level running (0% grade), but was increased at 12 h of recovery from trial of 60 min downhill running (-10% grade) (3). It was demonstrated that after extreme workout (300 maximal eccentric contractions) creatine kinase increased significantly throughout 95 hours post exercise (4). Plasma myoglobin and creatine kinase increased in well trained triathletes after treadmill eccentric exercise (at -10% grade) (5). Exercise is also characterized by change in intramuscular proteolytic pathway, in particular by an increased proteolytic enzyme activity (6-9). Changes in protein metabolism after exercise-induced ultrastructural damage would be necessary for a protein degradation and regeneration. It was also shown that adaptation to eccentric exercise was associated with attenuated serum creatine kinase activity and, potentially, an increase in the activity of the ubiquitin proteosome proteolityc pathway (10). The increase of muscle proteins and enzymes (creatine kinase, myoglobin, as well as tropomyosin) in the bloodstream from muscle may occur as a result of increase in the permeability of the myocellular membrane and the intramuscular vasculature.

Systemic and local neutrophils' responses to strenuous exercise and exercise-induced muscle injury

There is no doubt that exercise causes significant changes in the distribution and function of a number of immune factors. The further considerations in this article are devoted primarily to neutrophils. Neutrophils comprise the majority of circulating leukocytes pool. The inclusion into discussion the alterations in the neutrophils function during exercise is essential, because neutrophils represent one of the key nonspecific host defense cell populations responsible for the phagocytosis of many microbial, bacterial and viral pathogens. The broad prospective that appears from existing research is that neutrophils (and macrophages) control fundamental inflammatory reactions in injured muscle. The sequence of events that occurs in the neutrophil response to exercise includes several steps, including their elevation in circulation.

Exercise-induced changes in circulating neuthrophils and their interpretations

It is well established that exercise activate defense mechanisms similar to the acute phase response to infection. In general, during and immediately after exercise the number of leucocytes in circulation increases. The increase in the number of circulating neutrophils as part of the inflammatory response to exercise was recognized for some time (11). Neutrophil invasion follows a fairly rapid time course, hitting the highest point quite early in the post-exercise period (12). The effect of downhill and level running on circulating leukocyte, was determined in runners completed two trials of 60 min of level running (0% grade) and downhill running (-10% grade) at 70% of level $\dot{V}O_2max$. Leukocyte and neutrophils counts were significantly higher at 1.5 and 12 h of recovery from downhill running compared with level running. Summing up, downhill running relative to level running resulted in a greater mobilization of neutrophils (1.5-12 h of recovery) (3). It is of interest, that circulating numbers of leukocytes, neutrophils in the subjects completed a 60-min ride at 75% maximal O_2 uptake, were significantly greater in the low-CHO diet (0.5 g CHO/kg) vs. the high-CHO diet (8.0 g CHO/kg) at the post-exercise and 2 h post-exercise time points (13).The increased number of circulating neutrophils was demonstrated in a number of studies using eccentric contractions of the quadriceps and elbow flexors. After subjects performed 2 bouts of one-arm eccentric exercise, anti-inflammatory doses of ibuprofen reduced creatine kinase activity but not the neutrophil response or other indirect markers of muscle injury during recovery from eccentric arm exercise (14). Blood concentration of leucocytes and neutrophils granulocytes was also increased after high-force eccentric exercise (4). A positive correlation was seen between acute reductions in force and percent increase in blood leukocytes post exercise (4). Total count of leukocyte and neutrophil was increased in well trained triathletes after treadmill eccentric exercise (at -10% grade) (5). It is important to point out that even light none-eccentric exercise, such as moderate level walking can prompt neutrophilia. In healthy subjects 30-min level walking caused modest increase in immune parameters, most notably in neutrophil counts (15). Exercise sessions (swimming in rats) resulted in stimulation of neutrophil degranulation in the experiments with animal. A significant increase of the myeloperoxidase (MPO) (+67%) and lysozyme (+51%) contents was found in plasma of rats immediately after exercise (16). Some studies suggested positive immune response to viral infection during moderate exercise in mice adapted to running on a treadmill for 8 weeks at a moderate pace (17) In contrast to moderate exercise, heavy exertion causes larger acute and chronic influences on systemic immunity, in particular on blood leucocytes and neutrophils counts. Smith and Pyne affirmed that intense exercise is potentially immunosuppressive and that endurance training also suppresses most neutrophil functions chronically (18). Many components of the immune system exhibit adverse change after prolonged, heavy exertion, interpreted as immunosuppressive (15,19-21). According to the "open window theory", after each bout of prolonged exercise immunity is altered ("open window"), and viruses and bacteria may gain a grip, escalating the risk of infection (22). However, this theory remains unproven as the challenge to link potentially immunosuppressive endurance training with an augment infection risk was not solved successfully. In addition, some investigators called into questions the assumption that acute exercise has any genuine immunosuppressive effect and whether the level of the circulating population is a crucial clinical factor (23). A greater understanding of some fundamental aspects of neutrophil function underlines potential applications in sports medicine. However, the practical value of this knowledge for monitoring the health and training programs of exercising subjects, in particular elite athletes requires further clarification.

Local inflammatory responses and muscle injury

Numerous studies have investigated the effect of exercise on circulating blood leukocytes regarding absolute number, percentage distribution and *in vitro* function. Those studies are important for understanding the systemic function of the immune system but give merely limited information about local immunological events in peripheral tissue. The cellular pathways affected in the adaptation to eccentric exercise-induced muscle damage have not been well characterized in humans. Strenuous and eccentric exercises induce local muscle damage resulting in the release of various substances such as intracellular proteins, cytokines and chemokines, causing an inflammatory response. This local inflammation may also include migration and infiltration of blood neutrophils into the affected tissue (6,24,25), in particular into skeletal muscle, heart and liver. Neutrophils are infiltrating muscle within 1 h of exercise (6,25), after which their concentrations can remain elevated for periods as long as 5 days (25). Evidence supporting a sequential leukocyte infiltration in which neutrophils are the first cells to invade damaged tissue can be found for several types of exercise.

The effects of acute exercise on neutrophil infiltration in different muscle fiber types (*quadriceps* (white and red portions) and in *soleus*) was examined after high-intensity intermittent repetitive swimming bouts (with added body mass) (26). At 24 h after exercise MPO concentrations in red portion of m. quadriceps and in m. soleus were 4-7-fold higher as compared to white portion of m. quadriceps of rats. There were no significant differences of MPO concentration in muscles between untrained and trained animals at rest. A single-bout of exercise to exhaustion produced higher increase in MPO content in untrained compared to trained rats. The data suggest that post-exercise neutrophil infiltration is more intensive in red fibers types compared to white fiber types (26). The effect of muscle contractions, resulting from high-frequency electrical stimulation (HFES) on inflammatory cells in rat tibialis anterior (TA), plantaris (Pln), and soleus (Sol) muscles were studied at 6, 24, and 72 h post-HFES (27). Neutrophils were higher at 6 and 24 h after HFES in the Sol, Pln, and TA muscles relative to control muscles (27). When rats were subjected to intermittent downhill (-16% grade) running protocol the percentage of injured fibers was significantly increased in the solei muscle and neutrophils were elevated 18-fold relative to controls at 24 h post-exercise. (1). Pizza et al. (28) showed that lengthening contractions, isometric contractions, and passive stretches increased number of muscle inflammatory cells and that prior conditioning with lengthening contractions, isometric contractions, or passive stretches reduces neutrophils and macrophages after subsequent lengthening contractions. It was found that three days after isometric contractions or passive stretches, neutrophils were elevated 3.7- and 5.5-fold, respectively, relative to controls. Neutrophils were increased 7.9-fold after lengthening contractions. The study found that passive stretches and isometric contractions elevated neutrophils without causing overt signs of injury. Because both passive stretches and isometric contractions elevated neutrophils and provided some protection from contraction-induced muscle injury, in authors' opinion, neutrophils may contribute to the induction of a protective mechanism (28).

A number of different theories have been proposed to explain exercise-induced injury, such as mechanical (initial disruption of sarcomeres), excitation-contraction coupling failure, activation of calcium–sensitive degradation pathways, reactive oxygen species production. The neutrophilia after eccentric exercise is linked to muscle damage, and neutrophils are possibly promoting muscle damage soon after muscle injury (29). It is possible that certain aspects of neutrophil function, including release of cytolytic and cytotoxic molecules, could exacerbate pre-existing muscle injury by damaging previously uninjured muscle parts (29,30). However, it was shown that administration of an antibody that attenuated neutrophil blood borne oxidants caused substantial lessening in myofiber damage following stretch injury (31). The discrepancy concerning the role of neutrophils in injuries may result in part from differences in the mode, intensity and duration of exercise protocols. The role of neutrophils after injurious exercise is not undisputed and is being critically evaluating. For example, Lapointe et al. (32) demonstrated that exercise-induced muscle damage (EIMD) was not due to autolitic activity of neutrophils, but were rather associated with a large presence of high number of ED1+ macrophages. He pointed out that data presented as evidence in humans that EIMD leads to an increased concentration of neutrophils are not convincing and reiterated that an indisputable presentation of neutrophil infiltration in EIMD has yet to come (32). In addition, Stupka et al. (10) showed that no increase in polymorphonuclear content could be seen 24 h after a first bout of damaging lengthening contractions in both men and women. Similar findings were also obtained in a study performed in human subjects in whom lengthening contractions did not produce any significant increase above the sham group in neutrophil concentration between 0 and 48 h post-EIMD (33). These studies are suggesting that lengthening contractions could lead to a neutrophil-independent tissue injury process.

Adaptation of metabolism to physical stress and neutrophils

Adaptation of the metabolism and immune system to physical stress is crucial to normal function of general population and is also of central importance to competitive sports training (34). The ability of humans to exercise depends on the ability of skeletal muscles to convert a chemical energy to mechanical energy. Accordingly, the key to adaptation is the ability of cellular homeostasis to match the ATP demand and provision to maintain the store of ATP in contracting muscles within an acceptable range. The role of extra- and intramuscular carbohydrates and fat and the transport and uptake of these substrates to provide the majority of the metabolic fuel to give the muscle ability to synthesize ATP during exercise is important.

Cell communication occurs through chemical signals and cellular receptors by either the direct contact of molecules on cell to cell surfaces, or the release of a „chemical signal" recognized by another cell. The various intracellular signaling cascades play an important role in regulating exercise metabolism. The acute and chronic exercise alters the adenylyl cyclase signal transduction system (ACST) in skeletal muscles. The changes of such components of ACST as cAMP content, adenylyl cyclase and cAMP-dependent protein kinase activities in skeletal muscle are depended on duration, intensity of exercise, as well as on adaptation to chronic exercise (35-38). Accumulating evidence suggests that the energy-sensing enzyme AMP-activated protein kinase is important in regulating exercise metabolism, more specifically, plays an important role in contraction-stimulated glucose transport (39). Evidence is mounting that the Ca(2+)/calmodulin-dependent kinases are also implicated as a mechanism which can sense altered functional demands and trigger adaptation (40). There have been a variety of investigations into alterations in neutrophil signal transduction pathways by cAMP and protein kanase C following exercise, reviewed elsewhere (41). All over the evolution the immune system has develop the ability to defend the body from infection. The inflammatory mechanism is also now being considered in attempt to describe the etiology of the muscle adaptation process. The chain of events of muscle adaptation to exercise has been explained as damage–inflammation–repair pathways. It might involve several stages: exercise-induced muscle damage, release of chemo-attractive factors, vasodilatation, leukocyte adhesion, neutrophils and macrophages migration and activation of satellite cells (33). Evidence has been published that adaptation of skeletal muscle to physical exercise might not occur only via this classical pathway (42). Interestingly, in the resting state, the immune systems of athletes and non-athletes are more comparable than different. However, it was suggested that the immune system may play an important role in adaptation to physical stress (12). The adaptation of the responses of blood neutrophils concentrations during early recovery was studied from two bouts of eccentric arm exercise compared to non-exercise control condition (43). Neutrophil concentrations were significantly higher at 3, 6, and 9-hr post-exercise for bout one relative to bout two and control. Therefore, adaptation to eccentric exercise is associated with a lower concentration of blood neutrophils during early recovery (43). A smaller neutrophil infiltration in muscles of trained animals found after exhaustive swimming suggests protective effect of previous training to muscle injury (26). Furthermore, knowledge regarding the interaction between circulating and tissue leukocytes may be used as a means to understand the mechanisms behind the overtraining syndrome in athletes. Prolonged period of intense training may lead to slight impairment in immune parameters such as neutrophil function (44). However, because the difference in circulating cell counts between overtrained and not-overtrained individuals are small, their biological implications remain uncertain. The evident downregulation of neuthrophil function in athletes was interpreted as the body's attempt to limit inflammation caused by intense exercise training (44). To some extend the occurrence of „open window" in the immune system is reliant on the intensity and duration of exercise (45). Additional explanation for the „overtraining effect" observed in elite athletes could be that this "window" for pathogens is longer and the degree of immunosuppression more explicit. The immunodepression might take place if there will be not enough time to allow the immune system to recover, when the next bout of exercise began at immunodepressed state from the previous exercise bout (45). Additionally, the neutrophils are also known as a "last line of defense". The removal of this back-up system following extreme exercise would be matching the susceptibility of „overtrained" individuals to acquire upper respiratory tract infections (45). In fact, it was shown, that the athletes were more susceptible to upper respiratory tract infection, when they exceeded individual training edge (46). Taken together, despite existing significant controversial results, some evidence suggest that inflammatory-inducing exercise model can be used in the study of inflammatory muscle diseases in a clinical setting, as well as in constructing exercise programs for the abolition of some of the symptoms associated with these illnesses.

In summary, there was a significant progress in research, concerning biochemical and immunological aspects of exercise. Data support the view that neutrophils generally dominate the inflammation after exercise-induced muscle injury and most likely have a role in promoting muscle damage after eccentric exercise. The numbers of the infiltrated neutrophils and the scale of exercise-induced alterations in neutrophils function depend to some degree on the intensity, duration of exercise and the training status. Prolonged period of intense training may lead to slight impairment in neutrophil response. However, some investigators call into question the assumption that acute exercise has any genuine immunosuppressive effect. Therefore, the relationship between muscle and inflammatory cells may not be entirely beneficial and these interactions are rather complex. This is contrasting the arguments based on the evolutionary standpoint, that it is anomalous that muscle tissue is damaged by the function from which it evolves (exercise) and functional role of immune cells (leucocytes) in skeletal muscle should be adaptation rather than degeneration (33). Despite advances in research in this area, few studies have been conducted to directly investigate shorter duration, moderate-intensity exercise as well as the role of immune system in adaptation to exercise training. Future investigations of the relationship between inflammatory cell functions and skeletal muscle injury would probably rely more on the use of genetically modified animal models, antibody depletions of specific inflammatory cell populations, or expression profiling of inflamed muscle after injury and in such a way would further explain the complexity of the role of immune system in exercise.

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Author's contribution
A – Study Design
B – Data Collection
C – Statistical Analysis
D – Data Interpretation
E – Manuscript Preparation
F – Literature Search
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THE ATHLETIC INJURES OF SHOULDER PLEXUS IN THORACIC OUTLET SYNDROME

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Abstract

Pupka A, Szyber PP. The athletic injures of shoulder plexus in thoracic outlet syndrome. *Med Sport* 2007, 11 (1):7-10.

Aim of the study: In this paper the surgical treatment of neurological thoracic outlet syndrome (TOS) is presented.

Material and methods: The investigation of 33 patients treated in the Department of Vascular, General and Transplantational Surgery for neurological complications of the was performed. In case of the neurological symptoms of TOS the operation consisted in transaxillary resection of the first rib and surgical removal of the different anomalies in the region of the thoracic outlet. The therapy results were estimated with use of the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire of American Academy of Orthopedic Surgeons.

Results: In the neurological syndrome of TOS the restoration of complete activity of limb was observed. The DASH scale revealed worsening of limb function in 4 patients during follow-up period

Conclusions: The surgical treatment of neurological TOS halt degradation of brachial plexus. The decompression of neurovascular bundle in vascular TOS should include the first rib resection in each case.

***Key words:** Paget-Schroetter syndrome, first rib resection, compression of brachial plexus*

Introduction

The Thoracic Outlet Syndrome (TOS) consists of the symptoms of compression on the vessels (vein and artery) and nerves of the upper thoracic aperture. Compression concerns usually both nerves and vessels with domination of one group of symptoms – neurological, arterial of venous ones (1-8).

Main symptoms of TOS differ depending to a level of compression on the brachial plexus, subclavian artery or vein. (1-8). The leading symptom is the shoulder and upper limb pain most characteristic for plexus and artery affection. (1-13). When the brachial plexus is compressed the neurological symptoms occur. It includes motoric, sensoric and vegetative (sympatical) disorders (1-13). Chronic brachial plexus compression leads to increasing pain and neurological disorders of the upper limb. The neurogenic pain is segmentary, radiating to plexus, back, scapula, minor pectoral muscle or neck and occipital region. The complications of artery compression includes ischemia and aneurysm and endanger limb or patient's life (9-13). Typical for subclavian artery compression are symptoms of upper limb ischemia: cold, paleness, Raynaud's syndrome, effort pains (intermittent claudication), muscles atrophia, trophic lesions and necrosis of the hand (9-13). In case of the subclavian vein compression the swelling of the upper limb, livedo or vein thrombosis could occur. Finally it leads to depletion of the limb function (14-24).

The complications of TOS occur mainly in young patients and are closely related with physical effort of the upper limbs. It concerns the physically active persons, especially these practicing strength disciplines (body-building, weight lifting, rowing) and sports requiring most wide range of movement in the shoulder joint (gymnastics, swimming). The complications occur also during the forced limb position, for example during the sleep after hard training (1-8).

The qualification for surgery in case of TOS consists in clinical tests and non-invasive examinations (X-rays, Duplex-Doppler, reoangiography, electromyography) or invasive methods in elected cases (flebography, arteriography) (1-8).

The standard treatment of TOS is the first rib resection and excision of other bone or fibromuscular pathologies (2-4,7,8,23-33). In some cases it is possible to avoid open surgery by conservative treatment consisting in rehabilitation, painkillers or physiotherapy (34-37). The surgery is necessary in case of vascular complications of compression (2-4,8-12). In case of arterial dysfunction the vascular reconstruction should complete the treatment (8-12). Each attempt to invasive treatment of neurological TOS should be preceded by conservative treatment (34-37).

Material and methods

33 patients had been treated in Department of Vascular, General and Transplantation Surgery in years 1991–2005 for TOS with neurological complications. Six of them trained professionally sports (3 body-builders, 2 swimmers and 1 gymnastics).

Initial diagnosis was made according to positioning tests and Duplex-Doppler sonography. In diagnosing of TOS the electrophysiological examination (especially the velocity of conduction in the brachial plexus) had been used. In qualification to surgery of the neurological TOS the EMG had always been performed (33 patients). In neurophysiological examination the two parameters were evaluated: the velocity of conduction in motoric and sensoric fibres of the brachial plexus and shape and duration of the evoked potentials. EMG was performed also in the postoperative period.

All patient evaluated the treatment effect according to DASH questionnaire (Disability of Arm, Shoulder and Hand) created by American Academy of Orthopedic Surgeons 1–12 years after surgery. This questionnaire is used mainly by orthopedic surgeons (38). DASH includes 30 questions concerning upper limb performance and some symptoms. The answers are given as the score between 1 (no symptoms) and 100 (full range of symptoms). The scale is divided into five ranges: 0-19 (no significant pathology), 20-39 (slight disorders), 40-59 (increasing pathology), 60-79 (significant distress) and 80-100 (very serious upper limb disorders). DASH includes also two questionnaires consisting of four questions concerning evaluation of limb performance in sports, music instruments and at work. The scale is similar to previous one.

Results

In all patients with leading neurological symptoms of brachial plexus compression the deviations in electrophysiological examination were present (tab.1). In 29 patients the anomalies in evoked potentials were revealed. The velocity of conduction in nerves was decreased in 14 patients. That patients underwent surgery. The transaxillar resection of the first rib were performed and in 9 cases the operation were completed by removal of additional cervical rib or fibromuscular pathology. All patients had evaluated the results of the treatment by filling the DASH questionnaire. 23 of them proclaimed only slight distress after treatment. In one case patient came about complete tear of the

Table 1. *The patients with neurological complications of TOS*

Characteristic	Neurological complications
Number	33
Age	32-57
Male	8
Female	25
Wysiłek fizyczny	3
Injury	9
Anticonception	–
First rib resection	33
Cervical rib resection	9

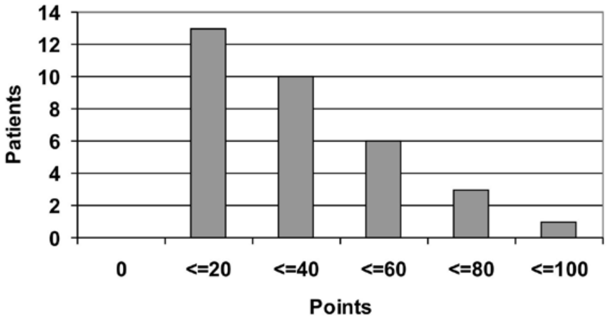

Fig. 1. *The DASH scale- neurological complications. The function/ symptoms of the upper limb*

brachial plexus. EMG showed improvement of velocity of conduction in 10 patients and decreasing of amplitude of evoked potentials in next 10 patients.

Discussion

Many authors indicates vascular complications in TOS (8-24). The vein thrombosis is most serious complication of venous component of TOS (4,10,16, 19,22,26,28,30,32,33,36,39). The physical effort, long-term forced position of the limb lead often to Paget – Schroetter syndrome (14-24,39). The main method of diagnosis is the flebography (14-24,39). This examination was performed in each case of acute subclavian vein thrombosis (14-22,24). Most accurate is Seldinger's method (14-22,24). This method allows to use local thrombolysis and eventual endovascular angioplasty (16-19,21). It is generally regarded that there is no obligation to use endovascular stents in case of decompressing surgery (16-19,21). Open surgery decompression of the subclavian vein prevents the restenosis (23,24). Currently the venous thrombectomy is very rarely performed because of the risk of the recurrent thrombosis (14-22,24). The flebography allows to diagnose the cause of the compression in thoracic outlet region (7,8,24). It is possible to confirm the subclavian vein compression during the provocation test (hyperabduction).

The established diagnosis of TOS is the indication for the surgery. The operation consists in resection of the first rib and scalenectomy (7,8,17-20,23,24). The transaxillar access provides the best cosmetic results which is quite important especially for women (4,8,23-25,29,32). The surgery allows to recover and continue the normal life (17,19,20,24). In this research that phenomenon was shown by the DASH questionnaire (24,39). This scale allowed very details diagnose of the pathology in the upper limb (39). DASH questionnaire was used by authors in our country to evaluation of the results of treatment of TOS (24).

Arterial complication of TOS are caused by anomalies of the first rib, misunion of broken collarbone or presence of the additional cervical rib (2-5,8,9,11,12). The subclavian artery aneurysm causes usually peripheral embolisation of the upper limb (2-5,8,9,12). The complications of compression of the artery requires the decompressing surgery and vascular reconstruction (8-12). The operation consists in resection of the first rib and excision of additional cervical rib or fibromuscular anomalies (2-4,7,8,23-33). The necessity of vascular anastomosies determines the over and/or subclavicular access (8-10,12,33). In case of aneurysm the vascular prosthesis or saphenous vein interposition is used (8-12). Because of the risk of compression there is an indication for reinforced prosthetic grafts (8-12). There are reports of endovascular procedures of treating the aneurysms and stenoses of subclavian artery in TOS (40). The follow-up of such patients shows the increased risk of restenosis and indicates the decompressing operation (40). The wide area of vascular surgery and necessity of removal of the first rib endanger the brachial plexus which could be occasionally damaged (8,12).

In case of neurological TOS the qualification to surgery should be supported by electrophysiological examination of the brachial plexus (4,8,35-37). The EMG is one objective examination confirming presence of compression (8). The presence of anomalies in nerves conduction or changes in evoked potentials establishes an indication to surgery (8).The aim of surgery is to prevent the degeneration of the nerves. Lack of improvement after first rib resection in 6 patients (according to DASH) was caused by irreversible degeneration of the brachial plexus shown in electrophysiological examination (4,8). The surgery of neurological TOS allows to shorten the healing time and immediate back to normal activity. This fact is important especially for athletes who do not want to give up their carrier.

Conclusions

1. The surgery of neurological TOS stops the degeneration of the brachial plexus.
2. General treatment including surgery allows patients to continue their normal activity or sport carrier.
3. The decompressing surgery should include the resection of first rib and all fibromuscular and chondroosseous anomalies.

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A – Study Design
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C – Statistical Analysis
D – Data Interpretation
E – Manuscript Preparation
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THE INFLUENCE OF SHALLOW AND DEEP WATER EXERCISE ON THE SPECIFIC MORPHOPHYSIOLOGICAL INDICATORS AND LEVEL OF PHYSICAL FITNESS

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Abstract

Piotrowska-Całka E, Karbownik-Kopacz J. The influence of shallow and deep water exercise on the specific morphophysiological indicators and level of physical fitness. *Med Sport* 2007; 11 (1): 11-16.

An overview of the literature compares influences of training by means of running on land and in shallow and deep water and aerobics exercises. Examples of how training in water enhances cardiovascular efficiency, muscle strength and endurance, stamina, flexibility and emotional well being of inactive individuals as well as actively training athletes. The results achieved and presented in the survey confirm the possibility of increasing physical fitness by training in water.

Key words: *aqua aerobic, shallow and deep water training, physical fitness, morphophysiological indicators*

Introduction

When thinking about physical activity in water what usually comes to mind, are swimming, rehabilitation and preventive treatment. During the past few years water has become a popular environment for many heterogeneous activities including aquatic exercise. It is a fact that an aquatic workout is often the best form of physical activity for people with musculoskeletal conditions and impairments due to it's reduced weight-bearing properties. Exercising in water is safer than on dry-land because the forces induced on the joints are greatly reduced. When standing in water, the body is subjected to two opposing forces: downward vertical force of gravity and upward vertical force of buoyancy (1).

Exercises done in water are designed for the body in an upright position. The primary goal of these activities is to improve physical efficiency, and depth of the water does not matter (it can be shallow or deep water). Shallow water programs are typically performed in water that ranges from mid-rib cage to mid-chest in depth. This provides the benefits of reduced impact while still maintaining proper alignment and control of movement and allows for activities that sufficiently train all the major muscle groups against the water's resistance. Deep water exercise is most successful at a depth where a body can be suspended vertically and is free to move in any direction and speed, without experiencing impact or weight bearing stress (1).

Exercises in water are becoming the most popular form of physical fitness. Water is a natural environment where harmony between human nature and exercises can be achieved, an environment in which almost everyone can work hard without pain, and relax at the same time. Almost everybody can benefit from aquatic exercises despite the fact that there is very little research supporting the benefits of exercising in water. This review is an attempt to summarize published research on the subject.

The properties of water

When a body is immersed in water hydrostatic pressure is perceivable. The density of water is 1 gram/milliliter, and that pressure, also represented in grams per milliliter, is numerically equal to the depth of the water in centimeters. This means the deeper a body is immersed in water, the greater the effects of hydrostatic pressure (2). During a physical workout muscles are working hard and hydrostatic pressure supports the muscles by providing blood which includes oxygen to deep and superficial tissues, causes widening of the blood vessels which decreases blood pressure. Hydrostatic pressure on the body is equally distributed and can be a massage for the whole body, as well as reduce edema of the lower limbs. Hydrostatic pressure does not have a direct influence on the intensity of a workout, but does indirectly decrease heart rate (HR) (3). During a workout in water, the heart is working more efficiently. The veins and arteries become more elastic and the capillaries improve their ability to exchange oxygen with cells. Regular workouts enhance collateral circulation and volume of the heart's contractions, thus increasing cardiac output. In turn this increases blood supply to the muscles, decreases the metabolic rate of muscles, decreases respiration rates as well as blood pressure all at the same time.

Buoyancy can resist or assist movement in the water (just like gravity can resist or assist movement on land), because it decreases the effect of gravity**.** When the body is immersed to the waist, water eliminates about 50% of body's weight; when immersed to the chest about 70-75%, when to shoulders about 90% of body's weight (4). Because thermal conduction is increased in water, thermal conditions are different in comparison to air. Thermal conduction of water (53 kcal/m^2/h/cm/°C) is about twenty-five times higher than thermal conduction of air (2 kcal/ m^2/h/cm/°C). The internal temperature of the body is diffused faster than in air by 12 to 25 times. In swimming pools the temperature of water is about 27-28°C and it is accepted as the optimal temperature for swimming (it does not disturb thermal balance). It is, however, too low for exercising and is the reason why heart rates decrease. On the other hand this situation is a motivational force for remaining in motion causing an increase in energy expenditure (3).

The density of water is 0,9997 g/cm^3 and is approximately 800 higher than the density of air (0,00129 g/cm^3). Water creates resistance in all directions, which is about 4 to 42 times higher than in air depending on the speed, type and area of movement. This is why both antagonists and agonists muscle groups are working simultaneously while exercising in water.

The effectiveness of exercising in water on cardiovascular efficiency

According to accessible results of published materials it becomes apparent that research conducted, until now, has concentrated on the compatibility of physical activity in water to theories of general athletic training as well as how beneficial these activities are in enhancing physical fitness. The primary form of water exercises was usually walking and running in water of various depths. Studies also included various types of aquatic exercises such as aqua aerobics and aqua step. The studies were performed identical on land and in the water. The majority of research of deep water running concentrated on the ability to sustain or improve aerobic capacity. A comparison of the results in post running programs in water with post running programs on a treadmill on land were conducted (5). The research programs were based on different training schedules lasting four to ten weeks. In a group of advanced runners, after four weeks of deep water running (DWR), the maximum oxygen consumption ($\dot{V}O_2max$) was reduced by 1.8% (pre=63,4±1,3; post=62,2±1,3 $\dot{V}O_2max$) (6). However in another study, after six weeks, the highly fit subjects maximal oxygen consumption improvement was not significant and increased it only by 1,5% (pre=58,7±4,7; post=59,6±5,4 $\dot{V}O_2max$) and by 3% (pre=58,4±2,3; post=60,1±3,6 $\dot{V}O_2max$) (7). In the case of beginner runners, post training changes were also differentiated. After a six weeks experimental program, untrained females were not unable to sustain pre-experiment $\dot{V}O_2max$ levels. The authors noticed significant decreases by 6,75% (pre=42,9±3,3; post=40,0±1,8 $\dot{V}O_2max$) (8). In another study Michaud et. al. (9) had ten inactive subjects (female=8, males=2; mean age=32,0yr) completing a eight weeks aerobic interval DWR program in which improvements in $\dot{V}O_2max$ by 10,6% (pre=29,3±8,2; post =32,8±8,0 $\dot{V}O_2max$) were noted.

The experiments in which there was a decrease of $\dot{V}O_2max$ levels in post training programs, both in shallow and deep water, were noticed probably as result of improper manipulation of training variables, in particular frequency, intensity and duration of training. The authors of research regarding water training used minimal standards accepted by the American College of Sports Medicine (ACSM) for maintenance of cardiovascular fitness, which for advanced athletes were not adequate in maintaining aerobic efficiency (6,7). In spite of conflicting results, DWR is being used to complement normal training schedules by allowing athletes as well as recreational athletes, with back and other joint injuries, to work out in a gravity assisted environment as opposed to no training to help maintain aerobic capacity. DWR is a very good alternative as compared to interrupting a training schedule, due to injury, resulting in a 14-16% decrease of aerobic efficiency (10). A list of successful applications of water training programs includes American regional and national athletic teams in ice-hockey, baseball, basketball, and track & field. Special DWR programs designed for different types of athletics are prepared by Cooper Aerobic Institute and other organizations which promote physical activity in water. In Europe DWR training is used in training programs of Austrian and German Nordic skiers and Nordic biathletes. Experiments including systematic exercises in shallow-water regardless of format, such as aqua-step, aerobic exercises or running, have shown potential for increasing aerobic efficiency in groups of beginner female with an increase of $\dot{V}O_2max$ from 5,6 to 18,9% (11-16). The conclusion of all these results is supported by facts that maintaining and improving aerobic capacity and endurance through DWR and/or water exercises in shallow or deep water is as efficient on land, regardless of the age between 18 to 63 (15-20). It would appear equally important and beneficial to adopt guidelines to current cardiovascular exercise programs so that they may be adapted to water.

An evaluation of energy expenditure in water of different depths has shown the following: in water around waist-high the energy expenditure was about 4,8 to 6,8 MET (21) depending on the fitness level of participants. Exercise on aqua-step devices gave the following results: 7,4 MET (step height 17,5 cm) and 9,9 MET (step height 30 cm) (12).

The influence of a water environment on heart rate

There are numerous factors which affect training heart rate. On the land these factors include: caffeine, medication, stress and general health. In the aquatic environment heart rate can be additionally affected by the water's temperature, reduced gravity, partial pressure, the dive reflex* and reduction of body mass (1) as well as fitness level and age. Research conducted at Adelphi University has shown that heart rate in water is 13% lower than on land under comparable conditions (3). The relationship between HR and the temperature of water was investigated by Evans and Cureton (12). They concluded that HR does not change during exercises in water of temperatures in between 30° to 35°C, whereas in water temperature between 18° to 25°C HR decreased up to ten to fifteen beats per minute as compared to running exercises of comparable intensity on land (22).

Heart rate, in regard to the depth of the water, indicated that standard exercises performed in chest/arm deep water gave a reduction of ten beats per minute as compared to the same exercises on land (23,24). Exercise with hand held accessories, for example, may increase HR, however data did not reflect the intensity of training and subsequently did not affect the overall performance of the cardiovascular system (25).

The bodies natural physiological adaptation to regular exercise is bradycardia, (a reduction of HR at rest). Eight weeks training cycles in shallow water were found to be more effective than the same training on land, giving HR reduction of seven beats per minute as compared to six beats per minute on land (14,15,18). Even more effective was training in deep water, giving HR reduction of eleven beats per minute (17). These values are similar to those reported after land-based training.

Velocity of motion in water and energy expenditure

Kravitz and Mayo (10) have shown that while running with the same $\dot{V}O_2max$ and perceived intensity of running, there was a 39% reduction of step frequency in water as compared to land running. This means that applying the same criteria of cadence for running in the water and on land which was found to lead to sequential drop outs from the exercise program (5). Exercise in the water is more intense and needs to be differentiated accordingly. Coad and colleagues (26) compared energy expenditure during walking and running on treadmill and in water respectively. The criteria was the same cadence of steps in both environments. The results have shown that energy expenditure is greater by about 4,8 kcal/min in water than on land. Deep water running and treadmill running were very similar in energy expenditure, respectively 11,8 kcal/min for treadmill and 11,5 kcal/min in water. DeMarea (27) found, that deep water running causes 13,5 kcal/min with 60% $\dot{V}O_2max$ and 18,9 kcal/min for 80% $\dot{V}O_2max$. In conclusion – similar exercises in water demands a much greater expenditure of energy than on land, but are also dependent on the depth of the water in which the exercises are done.

Like in any form of activity, motivation plays a large factor on how people will commit themselves to anything they do. Gehring, Keller and Brehm (28) tried to answer the question: how big a part does motivation play in completing exercises? Recreational participants were not able to replicate the intensity of land exercises versus competitive athletes who did. Similar tests were performed by Hoeger, Varner and Fahleson (18) with water aerobics and found the same results in noncompetitive female subjects. Despite the lower intensity of exercises authors saw increases in $\dot{V}O_2max$ in noncompetitive females. This result proved that exercises do not have to be overly intensive to be effective.

Body Composition

Significant decreases in body fat have been observed in several studies conducted on shallow water aerobics. Training three days per week for 50 minutes a session, an eleven weeks training program completed by sedentary college-aged women produced a 5.8% relative decrease in body fat (pre=24,2±3,3%, post=22,8±3,0%) (11). Hoeger et al. (15) reported decreases in body fat with previously sedentary women exercising three days a week, twenty minutes a day at 70-85% of heart rate reserve for eight weeks. A 7,5% decrease in fat, as measured by skin fold thickness, was similar to the 5% decreases seen in the land-based low-impact aerobics group. No changes occurred in the control group. Sanders (29) examined the effects of shallow and deep water exercise on body fat of younger (28,0±6,5yr) and older (52,0±8,3yr) women. All subjects achieved significant reductions in body fat

* Dive reflex – This is a primitive reflex associated with a nerve found in the nasal area. When the face is submerged in water, this reflex lowers heart rate and blood pressure. Some research suggests the face does not even need to be in the water for the dive reflex occur. Some experience its affects when standing in chest deep water.

following the eight weeks program with decreases of 11.9% for the younger and 5, 8% for the older participants. Diet was not controlled neither program.

Bone Density

The theory regarding whether exercising in water maintains and increases bone density is controversial in respect to the reduction of gravity which is considered the most important factor in maintaining optimal bone density. The positive results of discussion ensued several experiments. One of the first experiments was based on measurements of the forearm and the wrist bones, showing significant increases of bone mass density (BMD) after exercises as compared to initial values (30). Tsukahara (31) confirmed that mineral density of the lumbar spine in groups of postmenopausal women, who exercised over a 45 month period, was significantly higher than beginners and sedentary control group. The rate of change in bone mass density of the lumbar spine over 1 year was -0.92% in the sedentary group and +1,55% in advanced exercise group. Bravo's (32) and Littrell's and Snow's (20) research included postmenopausal women, 50 to 70 years of age, with spinal or femoral bone densities just below the fracture threshold. Their studies showed that after twelve months of shallow water exercise programs with twenty-seven participants (>5 years past menopause), no significant changes in BMD were found in either the femoral neck or lumbar spine. In a study presented by Harush (33) an experimental group between the ages of 55,5±4,0 participated in a seven month water exercise program. Bone density was measured in four different parts of the body: vertebrae L1-L4, the femoral neck of both legs, the proximal radius and midshaft of the tibia. This investigation did not show any significant pre- or post-test differences in bone density for both the experimental and the control groups. Women in the experimental group, in some cases, increased their BMD as compared to the control group, in which was observed non significant average decreases of BMD in the right leg only.

All of the above surveys, including women during and after menopause, were based on training programs recommended by the AEA (Aquatic Exercise Association) and American College of Sports Medicine (ACSM). Exercises took place in shallow water, three times per week, over a period of 45-60 minutes, lasting 16-20 months. As a result of the exercise programs there was reduction in BMI and the resistance provided by the water was enough to have positive influence on BMD. It has been shown that it is possible to maintain and in fact stimulate increased bone mass by exercising in water. However it would be very valuable for instructors to have a more precise description of specific exercises most suitable for maintaining and increasing bone density.

Muscular Strength and Endurance

Few researchers have examined the effects of water exercises on muscular fitness. Sanders (29) found improvements in both strength and endurance in younger (26,0±5,9yr) and older (52,0±8,3yr) women. Subjects participated in an eight weeks program with exercise sessions in a combination of shallow and deep water using aquatic equipment. No specific muscular strength and endurance exercises were incorporated into the aqua aerobics program. Bench presses and curl-ups were evaluated pre- and post-training to assess muscle strength. Increases in these parameters occurred probably as result of stabilization techniques designed to maintain proper body alignment. However, it was noted that the impressive increases in musculoskeletal fitness observed in these studies can be partially due to the initially low level of fitness of the subjects.

After eight weeks, untrained females (26,0±5,9yr) who performed shallow water aerobic exercises achieved significantly greater gains in several strength measurements such as left knee flexion, left shoulder extension, left shoulder flexion and right shoulder extension compared with the control group (15,19). Water aerobics produced greater gains in muscular strength than low-impact (land) aerobic exercises. Simpson and Lemon (17) has also found strength benefits from aerobic exercise in deep water. After 8 weeks of training subjects improved isokinetic quadriceps and hamstring strength (p<0,01). Kruel and Martin's (34) studies were to analyze the effects of an aquatic gymnastics resistance program applied in healthy women, aged 38-67 years divided into four groups. After eleven weeks, results demonstrated increases statistically significant in dynamic maximal force from hip abductors, elbow flexors and extensors among all four groups, independent of equipment use.

Hertler et al (35) found that experienced runners were capable of maintaining leg strength through DWR (deep water running). Researchers had subjects complete a four week land-based running program prior to dividing the runners in half with participants either continuing the land-based training or engaging in deep water running. Isokinetic testing measured concentric and eccentric contractions of the upper and lower leg and found no difference in leg strength between DWR and land-based running post-training. This indicates that the resistive properties of water possibly facilitated the development of muscular strength and endurance in inactive participants both younger and older adults while maintaining leg strength of competitive athletes. More research in this area is necessary before solid conclusions can be drawn concerning this aspect of health-related fitness.

Flexibility

Improvements in flexibility and joint range of motion have been found in research conducted in the aquatic environment. The primary test used by all of the investigators to test flexibility was the sit-and-reach test, which evaluates low back and hamstring flexibility. Hoeger et al. (15) observed a 10,5% improvement in the modified sit-and-reach following eight weeks of shallow water aerobics. This was not surprising to the researchers because low back and hamstring exercises were integrated into the stretching warm-up and cool down phases of the program. Seedfeldt and Abraham (16) incorporated flexibility exercises into eleven weeks of aqua step training. Twenty-two subjects were assessed on the sit-and-reach test with 5,4% improvement being achieved. The positive changes do not seem to be limited to shallow water aerobics. After eight weeks of deep water training Simpson and Lemon (17) noted a 7,3% increase (pre=34,1±2,1cm, post=36,6±1,8cm) flexibility. In another study Sanders (29) combined shallow and deep water exercise for eight weeks. The subjects were separated into younger (28,0±6,5yr) and older (52,0±8,3yr) adults. Results revealed small, non-significant, improvements in the sit-and-reach for the younger and older subjects.

Current studies although small in number support the improvement of flexibility through shallow and deep water training. Exercise participants are able to use the buoyant properties of water to decrease joint stress while gaining flexibility. Additional research needs to be conducted using various flexibility tests as well as training regimens of increased length.

Mental Health

Application of systematic physical exercises is widely considered to be an effective method to counteract and eliminate psychological stress. So far, beneficial and favorable influence of aquatic exercises on emotional condition has been substantiated with a rather superficial research. However, the research carried out to date has established that a positive impact of aqua aerobic on mental health is very substantial and visible. According to previously conducted research, aqua aerobic improves general and mental health as well as it contributes to the improvement of self-efficacy and self-esteem. This applies to both younger and older female participants in water exercise sessions (21-75 years old) (36,37). The research with adult women supports that the camaraderie and social support in the group-led aquatic setting appears to serve as an incentive for individuals to continue participating in the program (37). The research carried out by Knecht (19), has established that even single bout of water exercise session can cause considerable changes and have beneficial effect on the anxiety and moods level. Knecht registered that a single session can decrease the anxiety level among participants but any further improvements during subsequent training units has been proved yet. Other research conducted by Sanders (38) compared three forms of physical activity: aerobic, aqua-aerobic and yoga with regard to female participants' impressions. This comparison revealed that women practicing aqua-aerobic demonstrate lower level of negative moods than women participating land aerobic or yoga. Women practicing aqua-aerobic described themselves as generally more relaxed in comparison with others.

The result of these representative studies, in spite of different forms of exercise and differences in lengths of the experiments, all concluded that deep water training (feet not touching the bottom of the pool) as well as aqua aerobics in shallow water created an environment which improved cardiorespiratory efficiency on the same level as was achieved through training on dry land. Workouts in water promoted improvement in both musculoskeletal and motor systems. Measurable health advantages were obtainable for advanced athletes as well as individuals just beginning on their journey to a safe, healthy and attractive form of exercise. An effective way of improving ones physical fitness can be a rationally designed training program adapted to specific environmental conditions in conjunction with optimal frequency and intensity adapted to the participant's ability during each training session or the entire training process.

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THE TREATMENT OF DEEP VEIN THROMBOSIS IN ILIOFEMORAL SEGMENT – THE ATHLETICS INJURES

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Abstract

Pupka A, Szyber PP. The treatment of deep vein thrombosis in iliofemoral segment –the athletics injures. *Med Sport* 2007, 11 (1) 17-19.

Aim of the study: In this study the efficacy of thrombolytic treatment of thrombosis of deep veins in iliofemoral segment in athletes was presented.

Materials and methods: The study comprised 2 patients (culturists amateurs) that underwent treatment because of venous thrombosis in iliofemoral segment, in the Department of Vascular, General and Transplantological Surgery, who underwent thrombolytic therapy with the application of tissue plasminogen activator – rt-Pa. In both patient antithrombotic drugs and anticoagulants were used in the further treatment.

Results: In the booth athletes treated with thrombolysis the full patency of deep veins of iliofemoral segment was achieved. In booth patients thrombotic changes in popliteal-tibial segment maintained, conditioning postoperative symptoms of postthrombotic syndrome.

Conclusions: Venous thrombolysis is proper treatment in deep veins thrombosis in iliacofemoral segment.

Key words: *vein thrombosis, phlegmasia cerulea dolens, thrombolysis, athletes*

Introduction

Acute thrombophlebitis of lower extremities is a specific type of venous thrombosis (1-5). The most frequent localization of the disease is lower limbs (1-5). As a consequence of rapidly increasing thrombosis of superficial veins, deep veins and veins of small and large pelvis, venous outflow pathway from a lower extremity gets totally closed. It leads to the development of phlegmasia cerulea dolens of the limb (2-7). The first symptoms of the disease are rapid, acute, stinging pain of the thigh and shank. Simultaneously skin cyanosis is observed associated by rapidly growing edema of the lover limb (2-7). Together with edema increase, hemodynamic disturbances in circulation occur, which in extreme cases lead to oligovolemic shock (2-7).

Extensive venous thrombosis and massive edema of a lower limb are the causes of stopping arterial blood inflow (2-7). Pulse on foot arteries and popliteal artery decreases and in extreme cases. The lack of arterial blood inflow results from a spontaneous arterial contraction and the pressure of transudative fluid entrapped in inextensible fascial compartments on arteries. In the disease process of a longer duration arterial thrombosis develops. A resulting acute ischemia of the limb together with increasing venous thrombosis make the cause of gangrene of peripheral parts of the lower extremity (9-14). Coexistence of hemodynamic disturbances resulting from oligovolemic shock makes the course of blue painful edema of a lower limb very severe. Death rates gain 30% and in 30-50% cases the limb is amputated (2-7).

Phlegmasia cerulea dolens of a lower limb develops most often on the grounds of venous failure in the course of varicosity, inflammatory foci in the organism or cancer disease (2, 7). More seldom occurring causes of thrombophlebitis of a lower limb are iatrogenic factors (e.g. venous catheterization), and genetically conditioned disturbances of coagulation system (e.g. deficiency in C and S proteins, antithrombin III, antiphospholipid syndrome) (2, 8).

Materials and methods

In the years 2005-2006 in the Clinic of Vascular, General and Transplantological Surgery, 2 patients - culturists amateurs after the physical effort on bodybuilding gym (aged 19 and 27) were treated due to venous thrombosis in iliofemoral segment. Thrombosis at both culturists appeared a dozen or so hours after exercises of legs (knee bending with the bar). They were diagnosed on the basis of clinical symptoms, Duplex-Doppler examination and venography examination. The examinations were conducted also in the course of treatment (venography) and postoperative observation (Duplex-Doppler).

In this patients massive lover limb edema was found without the characteristics of acute ischemia, but associated by pain. Doppler examinations showed occlusion of the veins of deep system of a lower extremity and iliac veins. All of the patients were treated with tissue plasminogen activator (rt-PA). Thrombolytic drug was given into the superficial venous system of the upper limb. Thrombolysis lasted from 24 to 72 hours and was under control of venographic examination. The applied dose of rt-PA was 2 mg/hour. After finishing the thrombolytic treatment the patients were administered heparin intravenously (whose administration started during thrombolysis). The therapy was continued using low-molecular heparin or anticoagulants.

Results

Full potency of venous system of iliofemoral segment was achieved in booth patients. In booth patients thrombotic changes in popliteal-tibial segment maintained, conditioning postoperative symptoms of post-thrombotic syndrome. Post-thrombotic syndrome switched off both culturists from tilling of sport.

Discussion

Clinical symptoms in the shape of painful massive edema of a lower limb reaching inguinal ligament, as well as bluish skin color suggest phlebothrombosis in the area of a lower limb and in iliofemoral segment (1-17). Pain within the limb, mobility disturbances and the lack of peripheral pulse suggest coexistence of acute ischemia (2-7). The basic examination in the diagnosis of phlegmasia cerulea dolens is ultrasonography with dual imaging, which shows the lack of flow within deep veins of a lower limb and in iliofemoral venous segment (3). Performance of venography examination using catheter enables application of local thrombolytic therapy and the control of its effects (6,7,9-11,15).

Acute ischemia of a limb developing in the course of deep vein thrombosis determines therapeutical treatment. The treatment of choice is thrombolytic therapy or surgery (1-12,14-17).

Thrombolytic treatment undergoes with the application of streptokinase, or more often using tissue plasminogen activator (rt-Pa) (2,6-11,15). The patients with thrombosis lasting not longer than 1-3 days are qualified for this treatment. During rt-Pa administration fewer hemorrhagic complications and allergic symptoms including anaphylactic shock are observed. The most proper way of thrombolytics application is their administration through a catheter with several side outlets directly into the thrombus, complemented by heparin treatment (6,7,9-11,15). Such mode of thrombolytic drugs administration enables the shortening of their application time and the limitation of a drug quantity. In the case of the remaining after the treatment stenosis in the deep venous system percutaneous angioplasty is performed (PTA) and possible stent implantation (6,7,9-11,15). Always implantation of filters to cava vein should be considered. All of the patients obtain anticoagulants orally in the further course of treatment.

Surgery is performed in patients in which the disease process does not last longer that 7 days, and in the cases, when the usage of thrombolytic drugs is strictly contraindicated (1-5,8,12,14). Venous thrombectomy operation is performed in intraoperative protection against pulmonary obstruction using Fogarty catheter or temporary filter implanted into the inferior caval vein trough the common femoral vein on the healthy side (1,3-5,17). The patient is settled in the reverted Trendelenburg position. Catheter implantation can be unnecessary in the case of a surgery performed in intratracheal general anesthesia with the application of positive end-expiratory pressure, which by increasing the pressure in cava vein prevents pulmonary embolism. The removal of thrombuses from deep veins of a lower limb is performed with the help of pulsating compression from the periphery of the extremity to the groin. Such a way of thrombectomy does not destroy valves of deep venous system. In the case of a recurring pulmonary obstruction, the necessity of filters to cava vein should be considered (2,16). In the further treatment heparin and anticoagulants are used orally. Venous thromectomy may be complemented by the performace of a temporal arteriovenous fistula between an artery and the common femoral vein (1,8,14). Such fistula requires later closing and thus the necessity of a surgical intervention. An arteriovenous shunt through the fistula may be the cause of the ischemia of the lower limb and right ventricular failure.

Conclusion

1. The physical effort (bodybuilding) can be at the bottom of pronouncements veins thrombosis.
2. Venous thrombolysis is proper treatment in deep veins thrombosis in iliacofemoral segment.

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A – Study Design
B – Data Collection
C – Statistical Analysis
D – Data Interpretation
E – Manuscript Preparation
F – Literature Search
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ACTIVITY PARAOXONASE AND ARYLESTERASE AND ITS RELATIONSHIP TO ANTIOXIDAT PROFILES IN YOUNG BASKETBALL PLAYERS AND SEDENTARY CONTROLS

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Abstract

Yılmaz N, Eren E, Erel O. Activity paraoxonase and arylesterase and its relationship to antioxidat profiles in young basketball players and sedentary controls. *Med Sport* 2007; 11(1): 20-26.

Background: Physical activity (PA) is known to increase the antioxidant defense system and reduce exercise-induced oxidative stress. Nevertheless, the precise mechanisms by which regular training is responsible for this protection are not completely clear. The cohort studies that have indicated benefits of physical activity have all focused on middle aged or older participants. The current study focuses on 10 year old young basketball players.

Materials and methods: Antioxidant profiles (α-tocopherol, retinol, pyridoxal-5-phosphate, ceruloplasmin, total antioxidant status (TAC), biliurubin, and uric acid); oxidant status (Total peroxide (TPx) lipid hydroperoxides (LOOHs)), serum paraoxonase (PON) and arylesterase (ARE) activities were evaluated in 31 well-trained young basketball players and 30 sedentary age- matched controls.

Results: Although the sportsmen were not receiving any special diet or vitamin supplementation they showed a slightly improved antioxidant status, mainly represented by increased paraoxonase ($p<0.01$), arylesterase levels ($p<0.05$) and an enhanced antioxidant status. The latter was evidenced by an increment in TAC, higher serum retinol, pyridoxal-5-phosphate and α-tocopherol ($p<0.05$) concentrations and elevated ratio of paraoxonase/HDL-C ($p<0.01$). Only, serum retinol concentrations was positively correlated with serum paraoxonase activities in basketball player subjects ($r = 0.409$, $p<0.02$), while no correlation with sedentary control subjects.

Conclusions: In biological systems, cells respond to mild oxidative stress by inducing their antioxidant defenses and other protective systems. Increased paraoxonase and arylesterase activities, TAC and enhanced vitamin levels in young basketball players might indicate eliminated oxidative stress. It proves once again that PA provides disease prevention.

Key words: *paraoxonase, arylesterase, α-tocopherol, basketball, young*

Introduction

It is generally accepted that PA plays a beneficial role in the prevention of disease (1). Nevertheless, a paradox seems to arise when considering that aerobic exercise is closely related to higher oxygen consumption and, thus, more pronounced oxidative stress which can be defined as an increase in the intracellular steady state concentration of oxidants over physiological values. Heavy endurance exercise increases the rate of oxygen consumption in humans up to 20-fold, which induces oxidative stress and generates excess oxygen free radicals (2). The human body contains an elaborate antioxidant defense system that depends on dietary intake of antioxidant vitamins and minerals and the endogenous production of antioxidant compounds. In addition, there are enzymatic and nonenzymatic defense systems against oxygen radicals in aerobic organisms. In fact, the mild oxidative stress induced by repeated bouts of aerobic exercise stimulates the expression and increases the de novo protein synthesis of some antioxidant enzymes (3, 4). HDL capacity to inhibit LDL oxidation can be assigned to different factors such as HDL chemical composition, the content of liposoluble antioxidants and the presence of associated enzymes like PON1. PON1 is a HDL associated enzyme with three activities which are paraoxonase (PON), arylesterase (ARE) and dyazoxonase and is a Ca^{2+}-dependent serum esterase that is synthesized in the liver and is a protein of 354 amino acids (43 kDa). PON1 circulates in plasma exclusively bound to HDL particles and it exhibits substrate-dependent activity polymorphism in humans. The alloenzyme named R is more active than the Q one towards paraoxon. For other substrates like phenylacetate, there is no difference between the two alloenzymes (5, 6). Pathologic states such as renal disease, diabetes mellitus, cardiovascular disease, and liver cirrhosis are associated with decreased PON1 activity and various dietary and lifestyle factors have been reported to influence serum PON1 activity (7, 8). Tobacco smoking has been associated with reduced PON1 activity and extracts of cigarette smoke inhibited PON1 activity in vitro (9). Pharmacologic therapy with simvastatin and hormone replacement therapy, on the other hand, have been reported to increase serum PON1 activity (10). An atherogenic diet reduced PON1 activity in mice, and this decrease correlated with a decrease in plasma HDL-cholesterol (11). Pomegranate juice consumption or the intake of vitamin C and E supplements may increase serum PON1 activity. Ethanol has been shown to inhibit serum PON1 activity, but moderate alcohol ingestion seems to increase it (12, 13).

To our knowledge, there is no data concerning the paraoxonase and arylesterase activities in young basketball players. The objective of this study was to determine whether PA has different effects on the antioxidant defense system in young sportsmen depending on the PON and ARE. For this purpose, we measured the plasma levels of enzymatic and nonenzymatic oxidant and antioxidants were also studied in samples from young sportsmen and control subjects.

Material and Methods

Subjects

Two groups comprising 31 basketball players, (average age ± SD, 10.77±1.8 years) and 30 sedentary controls (average age ± SD, 10.1±1.2 years) were studied. All subjects were male. The training programmed consisted of both morning and afternoon sessions lasting approximately 1.5-2 h and consisting of a mixed regimen of cross-country running and aerobic interval running, which comprised 80% of the volume; the remaining 20% involved high-intensity shuttle running and game-specific conditioning. Also the control subjects were high school students who had a sedentary lifestyle and did not practice any sport regularly. All of the subjects selected were healthy without familial or personal history of diabetes or dyslipidaemia and normal thyroid, hepatic and renal functions. None of the subjects was taking any drug known to affect lipid and lipoprotein metabolism. Special care was taken to exclude subjects who were taking anabolic drugs, vitamins or other antioxidants, or who were smokers. None of the subjects was following a special diet. A face to face interview was conducted with every participant and a detailed food frequency questionnaire was completed in order to obtain information about their dietary habits. The quality, quantity and frequency of consumption of red meat, chicken, fish, eggs, vegetables, fruits, milky products and soft drinks was similar in all of the subjects.

After a 12-h overnight fast, venous blood was drawn from the antecubital vein, they were all evaluated at the same time. The samples were collected into clean tubes for analyses of vitamins and into heparin-containing tubes for determination of total antioxidant potential. Samples were maintained in a cold chamber (4°C) for 1h until separation by centrifugation at 1500g for 15 min at 4°C, and immediately used for routine determinations. Aliquots were also stored at − 70°C for the determination of PON and ARE activities, which were carried out within 30 days. The study protocol was approved by the Ethical Committee of the School of Medicine and Biochemistry, University of Gaziantep. Informed consent was obtained from all participants' parents.

Measurement of paraoxonase and arylesterase activities

The enzyme PON 1was evaluated employing two different substrates: paraoxon (Sigma Chemical Co.; PON activity) and phenylacetate (Sigma Chemical Co.; ARE activity). Paraoxonase activities measurements were performed in the absence of salt (basal activity). The rate of paraoxon hydrolysis (diethyl-*p*-nitrophenyl-phosphate) was measured by monitoring the increase of absorbance at 412 nm at 25°C. The amount of generated *p*-nitrophenol was calculated from the molar absorptivity coefficient at pH 10.5, which was 18,290 $M^{-1}cm^{-1}$. Paraoxonase activity was expressed as $U{\cdot}L^{-1}$ serum. Measurements were all carried out within the same assay. Within-run precision (CV) was 5.5%.

Phenylacetate was used as a substrate to measure the arylesterase activity. Enzymatic activity was calculated from the molar absorptivity coefficient of the produced phenol, $1310{\cdot}mol^{-1}{\cdot}L^{-1}{\cdot}cm^{-1}$. One unit of arylesterase activity was defined as 1 µmol phenol generated per min under the above conditions and expressed as $U{\cdot}L^{-1}$ of serum Measurements were all carried out within the same assay. Within-run precision (CV) was 4.8%. (14).

Determination of serum vitamins

The deep-frozen serum and plasma were thawed and mixed to disperse possible precipitates. The extraction of liposoluble vitamins and Vitamin B6 (pyridoxal-5-phosphate) was carried out using n-hexane after deproteinization with ethanol. Liposoluble vitamins (Retinol, α-tocopherol) were determined by High Performance Liquid Chromatography (HPLC) in the n-hexane extract of plasma after drying in nitrogen current and redissolving in methanol. This assay allows the simultaneous determination of vitamins A and E in serum in single isocratic HPLC run, interassay precision is <4.5% and intrassay precision is <3% . The HPLC was a Chromosystem® with a UV detector. Retinol and α-tocopherol were determined at 325 and 295 nm, respectively. Also soluble vitamin B6 was determined by HPLC (ChromoSystem®) with fluoresence detector. This assay is designed for the reliable determination of the active coenzyme form of vitamin B6, pyridoxal-5-phosphate (PLP), in serum. The sample clean-up procedure includes an effective protein precipitation step to liberate the analyte from its bound status .Subsequent derivatisation produces a fluorescent PLP-derivative. The chromatographic determination is run on an isocratic HPLC system.

Determination of antioxidant status

The total antioxidant status (TAC) level was determined by novel automated methods developed by Erel (15). In the method (TAC 1), hydroxyl radical, the most potent biological radical, is produced by the Fenton reaction and reacts with the colorless substrate o-dianisidine to produce dianisyl radical, which is bright yellowish-brown. The assay results are expressed in millimole Trolox equivalent units per litre, and the precision of this assay is excellent–lower than 3% (15). Serum ceruloplasmin ferroxidase activity measurement method was developed by Erel. The serum sample was incubated with a known amount of ferrous ion in 0.45 $mol \cdot L^{-1}$ acetate buffer (pH 5.8). During the catalytic oxidation of ceruloplasmin, ferrous ions are oxidized to ferric ions (16,17). Serum uric acid, billirubin, triglycerides, total cholesterol and HDL-cholesterol were determined by colorimetric methods using auto analyzer (Roche ©Modular).

Determination of oxidant status

Total peroxide (TPx) concentrations of the plasma were determined by the FOX2 method with minor modifications. The FOX2 test system is based on the oxidation of ferrous iron to ferric iron by the various types of peroxides contained in the plasma samples, in the presence of xylenol orange, which produces a coloured ferric–xylenol orange complex whose absorbance can be measured. Aliquots (200 µl) of plasma were mixed with 1.8 ml of FOX2 reagent. After incubation at room temperature for 30 min, the vials were centrifuged at 12,000 g for 10 min. The absorbance of the supernatant was then determined at 560 nm. The total peroxide content of the plasma samples was determined as a function of the difference in absorbance between the test and blank samples, with a solution of H_2O_2 used as standard. The coefficient of variation for individual plasma samples was less than 5 % (18). Lipid hydroperoxide (LOOHs) levels was measured by the ferrous ion oxidation-xylenol orange (FOX-2) method as previously described (19).

In the subjects, measurements of spirometry were performed (Sensormedics© Corporation) and compared to predicted normal values for spirometry.

Statistical analysis

Statistical analysis was carried out using a statistical package for social sciences (SPSS 9 for windows). All the data were tested for their normal distribution. Results are expressed as means±SD and $p<0.05$ was considered statistically significant. The data obtained from the study and control groups were compared using Students t-test and chi-square test. Bivariate comparisons were examined using Pearson correlation coefficients (*r*) and values were corrected for ties. Differences were considered statistically significant at P<0.05.

Results

The clinical and laboratory features of the subjects are shown in Table 1. In the present study, sportsmen and healthy controls showed similar age and anthropometric characteristics. Compared with the control group, the study population there was no significant difference between the groups in BMI, weight and age. Smilarly serum levels of non-enzymatic defense systems, uric acid (UA), bilirubin and ceruloplasmin did

Table 1. *General parameters from basketball players and sedentary controls*

	Basketball player (n=31)	Sedentary control (n=30)
Age (years)	10.77±1.18	10.10±1.25
Weight (kg)	39.2±7.39	37.3±2.87
Training load (h/week)	12	0
BMI ($kg \cdot m^{-2}$)	21.7±2.3	22.3±1.9
Forced Vital Capacity(FVC1)	2,47±0.74*	1.65±0.32
Triglycerides ($mg \cdot dL^{-1}$)	100±38	98±39
Total cholesterol ($mg \cdot dL^{-1}$)	148±19.4*	129±19
HDL cholesterol ($mg \cdot dL^{-1}$)	53.3±4	52±3
Creatinine ($mg \cdot dL^{-1}$)	1.0 ± 0.8	0.9 ± 0.7
Calcium ($mg \cdot dL^{-1}$)	9.6 ± 1	10.0 ± 1.2
Alanine aminotransferase ($IU \cdot L^{-1}$)	18 ± 5	15 ± 7
Aspartate aminotransferase ($IU \cdot L^{-1}$)	31 ± 11	21 ± 5
WBC	6,885±2,156	7,833±1,751
Hemotocrit	39,33±3,08	38,11±2,1
Haemoglobin	13,39±1,26	12,99±0,82391

Values are expressed as mean ± SD
Statistically significant different from sedentary control,*p<0.05,**p<0.01

Table 2. *Antioxidant status from basketball players and sedentary controls*

	Basketball player (n=31)	Sedentary control (n=30)
Enzymatic antioxidants		
Paraoxonase activity ($U \cdot L^{-1}$)	181±76**	117± 71
Arylesterase activity ($U \cdot L^{-1}$)	91.9±7.8*	87.5± 8.3
Paraoxonase /HDL-C ratio	3.39**	2.25
Oxidant status		
TPx (μmol $H_2O_2 \cdot L^{-1}$)	18.55±2.07	17.18± 1, 61
LOOHs(μmol$\cdot L^{-1}$)	5.09± 2.5	5.3± 3.1
Hydrosoluble antioxidants:		
TAC (mmol Trolox equiv.$\cdot L^{-1}$)	2.06±0.02*	1.89 ± 0.01
Ceruloplasmin	286±57	299±44
Uric acid (mg$\cdot dL^{-1}$)	4.3 ± 0.6	4.1 ± 0.6
Total bilirubin (mg$\cdot dL^{-1}$)	0.9 ± 0.2	1.0 ± 0.4
Vitamin B6 (3.6-18 μg$\cdot L^{-1}$)	10.58±0.7*	6.0 ±0.35
Liposoluble antioxidants		
Vitamin E (11.6-46.4 μmol$\cdot L^{-1}$)	26.45±0.72*	19.24± 0.73
Vitamin A (1.05-2.45 μmol$\cdot L^{-1}$)	1.61±0.05*	1.22±0.04

Values are expressed as mean ± SD
Statistically significant different from sedentary control,*$p<0.05$, **$p<0.01$

not different levels in basketball player than sedentary control subjects (Table 2) and apparently represented the intense level of daily training.

As expected serum PON, ARE activities and Forced vital capacity (FVC1) (Table 2) were significantly higher in subjects with basketball player than sedentary controls. Suprisingly, serum triglyceride and cholesterol levels, also significantly higher levels than age mathched control subjects (p value was <0.05 for each comparison).

In addition, all vitamin levels of serum in young basketball players (vitamin A: 1.61±0.05 μmol$\cdot L^{-1}$,vitamin E: 26.45±0.72 μmol$\cdot L^{-1}$, vitamin B6: 10.58±0.7 μgr$\cdot L^{-1}$) were significantly higher than sedentary control subjects (vitamin A: 1.22±0.04 μmol/l ,vitamin E: 19.24±0.73 μmol$\cdot L^{-1}$, vitamin B6: 6.0±0.35 μgr$\cdot L^{-1}$).On the other hand, vitamin levels were not above normal ranges between individuals in the basketball player subjects and the sedentary control subjects ($p<0.05$, Table 2).

Another similar result was increased measurement of plasma levels of TAC (2.06±0.02 and 1.89±0.01 mmol Trolox eq.$\cdot L^{-1}$) in basketball player than control subjects, respectively ($p<0.01$). However, serum LOOHs (5.09±2.51 and 5.33±3.14 μmol$\cdot L^{-1}$) and TPx levels (18.55±2.07 and 17.18±1,61 μmol $H_2O_2 \cdot L^{-1}$) were not statistically different in basketball player and control subjects ($p>0.05$, Table 2). Only, serum retinol concentrations was positively correlated with serum paraoxonase activities in basketball player subjects ($r = 0.409$, $p<0.02$), while no correlation with sedentary control subjects ($p>0.05$ for each comparison, Table 3). However, serum vitamin B6 and E level were positively correlated with serum cholesterol level in basketball player subjects ($r = 0.412$; $r = 0.364$, $p<0.05$, respectively) and control subjects($r = 0.630$, $r = 0.742$, $p<0.05$, $p<0.01$, respectively), while serum triglyceride, HDL-C, TPx, LOOHs level and TAC value were not correlated with antioxidants in all subjects ($p>0.05$ for each comparison).

Table 3. *Significant correlations among parameters in the basketball player group*

	r	p
Retinol- paraoxonase	0.409	0.02
Vitamin B6- cholesterol	0.412	0.05
Vitamin E- cholesterol	0.364	0.05
PON–ARE	0.358	0.014

PON1; Paraoxonase 1, *ARE*; arylesterase

Discussion

To our knowledge, the role of physical activity (PA) on PON1 activity, particularly the effects of regular of PA, has not been yet established in young subjects. PON1 is an enzyme related with the antioxidant activity of HDL (20). Paraoxonase (PON) and arylesterase (ARE) are esterase enzymes that have antioxidant characteristics. PON1 activities decrease significantly during aging (21). In this study PON1 activity was determined in healthy young subjects aged to 10 and no similarity in PON1 activities of basketball players and sedentary controls was found. It has been shown that PON1 activities were higher to values found in basketball players, no significant correlation between PON1 activities and HDL was observed. Although, HDL level was also similar in sportsmen and controls in this research. Furthermore, the higher paraoxonase activity, measured as arylesterase, could also contribute to HDL protective action. Regular physical activity is associated with an increase in high-density lipoprotein cholesterol (HDL-C), whose antioxidant and protective effect for disease is well known. Our study showed that in spite of the oxidative environment generated by the higher oxygen consumption that takes place during aerobic physical activity, neither LOOHs nor TPx were elevated. Different authors evaluated LDL susceptibility to in vitro oxidation in relation to physical activity. In most prospective studies which evaluated an acute exercise bout, LDL resulted to be more oxidable after the intervention. On the other hand, in the present study, no difference was evidenced in lipid (LOOHs) oxidability between both groups of subjects, which were very similar in age, anthropometric characteristics, and lipid, lipoprotein profile. The present study showed that training was associated with increased basal PON1 activity in the young basketball players. As a previous report of a cross-sectional study showed that significantly increased PON1 activity and α-tocopherol values in well-trained rugby players compared with sedentary controls (20). However, the different design and participant characteristics make it difficult to compare the other studies. The participants in the study by Evelson .et al. were all males who attended in 15 well-trained rugby players and 15 sedentary controls. They were older (23 ± 3 years mean±SD), and a significant percentage of them took several types of medication. Kleemola et al. studied basically young and healthy volunteers who were University students and employees; more than 70% of the group studied were women (11). In contrast, the participants in our study were selected from the male basketball players, the age range was wide (10.77±1.18 years). One important difference are that the use of vitamin supplements or other medication and chronic disease were a cause of exclusion in our study but not in the others, and this may contribute to the differences in the conclusions.

We found no significant association between PON/ARE and total lipids, vitamin B6, or vitamin E. Other studies have recently investigated the relationship between dietary factors and serum PON1 activity in humans. Jarvik et al. reported a direct relationship between vitamin C and E intake and serum PON1 activity. However, Kleemola et al. did not confirm these results: they observed an inverse relationship between serum PON1 activity and the intake of ß-carotenes (11, 13).

The present study has potential limitations. One limitation is that we did not analyze any of the PON1 polymorphisms at the 5'promoter region. Several PON1 gene promoter polymorphisms have been described recently that influence the enzyme's serum concentration (21). Another limitation is that we did not measure serum PON1 concentrations.

It was established in both clinical and experimental studies that PON1 and ARE activities decrease in some disease (22). It remains unclear whether the effect of exercise training on PON1 activity response to PA goes through direct or indirect mechanisms. An exercise produced an increase in certain antioxidant gene transcription and a reduction in lipoperoxidation in trained rats, but these effects were not observed in untrained specimens. In humans, exercise training appears to enhance antioxidant systems and reduce lipid peroxidation, improving plasma oxidant status (23-25). The global antioxidant activity, enhanced by exercise training, might indirectly mitigate the inhibition of PON1 caused by acute exercise-induced oxidative stress, and, as a result, PON1 activity may recover basal levels faster in trained status. Besides these effects, exercise training may also exert a direct action on the PON1 protein or PON1 carrier lipoprotein. PON1 enzyme is mainly linked to the HDL particle (26). However, no correlation was found between HDL-C levels and PON1 activity either in all subjects. Therefore, it is unlikely that HDL-C changes explain changes in PON1 activity.

Oxidative stress has been found to be linked to the development of disease. In this respect, the balance between free radical generation and antioxidant activity seems to play a key role in the pathogenesis of diseases (27). TAC was 9% higher in sportsmen than in controls. The elevation in plasma activities of antioxidant capacity and the higher levels of free radical scavengers of low molecular mass may compensate the oxidative stress caused by physical activity. Accordingly, plasma antioxidant vitamin levels (A and E) were found to be significantly elevated in the basketball players (28, 29). In addition, these subjects showed high concentrations of PLP (B6) in plasma compared with controls. While retinol is bound to the specific plasma carrier retinol binding protein (RBP) and thus homeostatically regulated as in other mammals, however, vitamin E are transported bound to all three plasma lipoprotein fractions (VLDL, LDL and HDL) of humans. Because of this non-specific transport by plasma lipoproteins, PLP and α-tocopherol a concentration are greatly affected by both dietary supplementation and changes in the lipoprotein metabolism (30-32). In our study plasma PLP and α-tocopherol concentrations in all subjects were only affected by cholesterol levels (positively correlations) which might be indicative of their mobilization from liver and/or adipose tissue. Several studies have pointed out that exercise may decrease the tissue pool of antioxidants such as vitamin E and vitamin A, as well as postulating these antioxidants may be transferred from one body compartment to another as a result of exercise, while other authors have pointed out that tocopherol plasma and plasma retinol concentrations are increased following intense exercise (33, 34). Indeed, it is well known that the increased activity of the sympathetic nervous system occurring during intense muscular exercise induces the release of free fatty acids from adipose tissue (34).

The high production of ROS may be responsible for a series of physiological and biochemical changes that occur during exercise. Through the process of evolution, the lungs have developed elaborate biological defense systems that include very efficient antioxidant protective mechanisms against oxidative stress. It is only when the balance between oxidant and antioxidant is altered that the lung-defense systems cannot cope with the continuous oxidant attacks. In the lungs, the „oxygen paradox" shows the importance of maintaining a sufficient level of antioxidants and the role they play. First, vitamin E content increased in the lung after oxidant exposure, which was described as a mobilization of the vitamin under oxidative stress. The reported increase in lung vitamin E content after oxidant inhalation is not limited to the lung or the inhalation route alone, suggesting that mobilization constitutes a general response to oxidative stress (35). Physical exercise would activate signal transduction pathways that in turn might cause antioxidant mobilization (especially fat) if the body's antioxidant stores are high (36). The improved plasma total antioxidant capacity was possibly enough to prevent exercise induced oxidative damage, and the adaptive response of body be associated with enhanced antioxidant status such as TAC. Training not increases oxidant concentrations in plasma, (LOOHs, TPx). Few studies have examined the vitamin Pyridoxal-5-phosphate (PLP) status of physically active young people. PLP, which is the active cofactor for 113 known enzymatic reactions, including the formation of many key neurotransmitters (37-39). It is still unknown whether these adaptive mechanisms differ in elderly and young subjects, and it can be supposed that the endogenous antioxidant system in exercising elderly subjects is not relevant for the same adaptive mechanisms as compared with that in exercising young subjects. In young subjects in absorptive and metabolic capacity might influence their food choice and could lead to deficiencies in antioxidant vitamins and trace elements (40, 41).

The present research reveals the fact that regular basketball training shows beneficial effect on antioxidant defense system (41-43). Furthermore; the sportsmen who are under intense training programs have normal TPx and LOOHs values which do not cause negative effect on their sportive performance. The role of antioxidants in the general maintenance of homeostasis has already been established (44, 45).

UA serves as a free radical scavenger *in vivo*. Plasma UA can trap peroxyl radicals in aqueous phase and contribute to the plasma antioxidant defense (46). During exercise, energy-rich purine phosphates are used and catabolized, resulting in accumulation of hypoxanthine, xanthine and UA in tissues. The conversion of hypoxanthine to xanthine and UA is associated with the formation of toxic oxygen free radicals (46). Bilirubin was shown to efficiently scavenge peroxyl radicals *in vitro* and to act as a metal-binding species, thus functioning as a selective antioxidant (47).

Our results are in contradiction with those of Robertson et al. (48), where blood UA was lower in high-training runners (80–147 km/week) than in low-training runners (16–43 km/week), and which was even lower than in sedentary subjects.

In summary, regular exercise was associated with an increase in PON1 activity in adolescent basketball player subjects. PA also increases antioxidant levels and causes balance of the homeostasis the results suggest that oxidative stress and antioxidant measurement is significant in the biological follow-up of young basketball players.

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A – Study Design
B – Data Collection
C – Statistical Analysis
D – Data Interpretation
E – Manuscript Preparation
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GOALS IN SPORTS CAREER AND MOTIVATION AS THE MEASURE OF PROFESSIONALISM IN SNOWBOARDING

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Abstract

Tyka A, Blecharz J, Tyka A. Goals in sports career and motivation as the measure of professionalism in snowboarding. *Med Sport* 2007; 11(1): 27-31.

Aim of the study: The study examined goals in sports career and motivation of snowboarders from Europe, USA and South America, who took part in World Cup contests.

Material and methods: The study was conducted in the season prior to the Winter Olympic Games in Turin. Forty participants (28 men and 12 women) competing in all events were interviewed about their goals mainly in sports career, but also about other motives for practicing snowboard, their leisure time activities and coping strategies. Competitors were asked to fill in the questionnaire prepared particularly for this survey. What is more they were asked to do Zaleski's goal questionnaire (1991) which consisted of two parts: in the first one they had to establish goals for different periods of time: for next week, next month, a year, long term goal, life goal and main goal in sports career. The second part included questions about goals' dimension as well as the dimension of action. Couple of questions were distinguished in order to describe goals dimension as well as intentional behavior. Snowboarders were obliged to answer these questions having goal in sports career in mind.

Results: Leading competitors in snowboarding have very professional attitude towards their sports' discipline, they take both training and competing seriously. The closeness of Winter Olympic Games determined main goal in snowboarders' sports career. Some of them wanted only to take part in this event some of them declared they want to stand on the podium. The most common motive was positive emotion reached from snowboarding.

Conclusions: 1. The ability to set the goals made for accomplishing them. 2. Internal motivation played a vital role in snowboarders sports career. 3. The competitors were more eager to accomplish the goal of huge importance. 4. After attaining the goal - satisfaction was higher when athletes put more effort into the action of accomplishing the goal.

***Key words**: snowboarding, motivation, goal questionnaire, competitors*

Introduction

The performance in different sports disciplines is no longer only due to physical abilities but also balanced diet and psychological skills. The reason for that is obviously simple: sporting standards are improving and so should do the sportsmen. The success is often the result of team's work but still the most crucial thing is competitor's professional attitude towards training both physical and psychological. It is said that one of the common motivation instruments is establishing goals. This is also a practical technique used to improve concentration, leisure time management and building self-assurance (1). The important thing is to distinguish the difference between the result, such as winning halfpipe contest and achieving goal, for example learning new trick in halfpipe. Competitors admit that when the winning pressure is low and their effort is connected with an activity that they can control rather than set on result, which also depends on other competitors, they feel more self-confident, feel less fear and can concentrate more (2). Undoubtedly proper motivation plays also a vital role for achieving success. "Without contestant's desire to improve the result other psychological factors such as concentration, emotional control or belief in oneself would be useless in sport. Motivation affects everything else that has influence on sports attainments: physical condition, technical and tactical training, psychological groundwork, even lifestyle including sleeping, diet and relations with other people.(..) Motivation on the highest level means contestant's responsibility for achievements' level or even more – it is the way of life"(3).

Purpose

The aim of the study was to indicate sports goals and motives for practicing snowboard among athletes from top world rankings. The second idea was to recognize snowboarding itself as it is comparatively new and not well explored discipline. Precise information about snowboarders' silhouette, their philosophy of life, ways of spending free time, attitude towards discipline would be useful either for coaches and sports psychologists in future work with snowboarders.

Methods

Participants

Forty snowboarders participated in this study. Among them 28 men and 12 women who practiced different snowboard events and competed in World Cup contests. The competitors came from fourteen countries from Europe, USA and South America. The most numerous group was aged between 19 and 26 – 67,5%, the next group - 30% - was older than 27 years, the smallest group, under 18 years, was just 2,5%.

Procedures

Two instruments were used in order to conduct this research: questionnaire prepared particularly for this survey and Zaleski's goal questionnaire (1991). First one included 9 closed questions, 2 opened ones and 8 half-opened questions. The questions were mainly about snowboarders' attitude towards their discipline, motives for practicing snowboard, leisure time activities and coping strategies. The second consisted of two parts: in the first - athletes had to establish goals for different periods of time: for next week, next month, a year, long term goal and main goal in sports career. The second part included 58 questions about goal's dimension as well as the dimension of action. Competitors had to answer all questions having in mind goal in sports career. Each question had 7 possible answers on Likert scale. Couple of questions were distinguished by using VARIMAX analysis (4) in order to describe goal's dimension (importance, chance, conflict) and intentional behavior (effort, stamina, satisfaction).

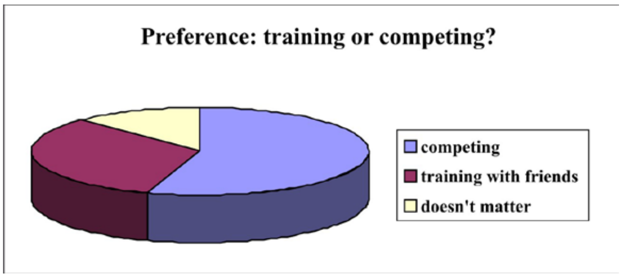
The study was conducted in the season prior to the Winter Olympic Games.

Results

General characteristics of participants

70% of competitors who filled in the questionnaire started snowboarding 7 years ago. They usually took part in contests 9-15 times a year – 47,5%. Being asked about the most important success in sport they mentioned: concrete top position – 45%, positive emotions – 25%, ability to practice snowboard without the detriment to health – 17,5%, being professional – 10%, "still working for the biggest success" – 2,5%. 62,5% of athletes thought that snowboard as a discipline is an extreme sport, when asked about the event they practice - only 52,5% admitted the same – those were contestants in PGS, PSL, SBX. Asked for preference – snowboarders had chosen competing (55%) rather than training (32,5%), 12,5% said it did not matter (watch figure 1 below), the main factor they mentioned for distinction was pressure – some of them needed it for improving, some of them admitted it disturbed them. Among answers for competing were voices of SBX riders saying that taking part in contests is sometimes the only way to train as there are no professional courses for snowboard cross apart from those prepared particularly for the races.

Figure 1. *Snowboarders' preference for choosing a way to improve their riding skills*



Motives for practicing snowboard

The purpose of the questionnaire was also to get information about motives for practicing snowboard. Table 1 presents the results.

Table 1. *Motives for practicing snowboard*

Motives for practising snowboard	Percentage
Fun, pleasure	90%
Fasion	5%
Specific snowboard atmosphere	27,5%
Keeping fit	22,5%
Money benefis	22,5%

Participants could choose more than one answer, 90% responded that they practiced snowboard just for fun and pleasure. Other driving reasons were: specific snowboard atmosphere, keeping fit and money benefits. Apart from these contestants had a possibility to mark their own motives – here came: satisfaction from winning and breaking own barriers – 15%, passion – 10%, traveling and meeting new people – 10%.

The questionnaire provided information about the level of professionalism in snowboarding. Exploratory questions concerned: ways of coping with stress before the start, situations that have negative impact on start disposition, ways of spending free time and obeying training schedule.

Ways of coping with stress before the start

Snowboarders had a choice between five suggested answers: listening to the music, using condiments, concentrating, talking "about nothing" with other competitors, warming up, they could also write their own alternatives. There were no limits on marking the answers. 12,5% declared they did not feel stressed at all before the start. Only 2,5% admitted to smoking cigarettes. The most popular answer was concentrating – 52,5%, warming up – 35%, talking to the others – 32,5%. Snowboarders' choices were: breathing activities – 7,5%, positive thinking – 5%, showing to the others that one does not care - 5%, meditation – 2,5%.

Having in mind psychological techniques of coping with stress it has to be noticed that 47,5% professional snowboarders did not use them at all! Those who took advantage of these techniques pointed: visualization – 32,5%, mental training and relaxation – both for 20%. Complete results are depicted in table 2.

Table 2. *Psychological techniques for reducing stress*

Chosen technique	Percentage
Visualization	32,5%
Mental training	20%
Biofeedback	2,5%
Relaxation	20%
Meditation, breathing activities	7,5%
Yoga	2,5%
Not using at all	47,5%

Starting situation

Athletes admitted that there were factors, which distracted them. Most of them pointed long journey for tournament – 52,5%, unfavorable weather conditions - 40% as well as a party day before the contest – 40%. Table 3 presents all answers.

Table 3. *Factors that have negative impact on starting situation*

Factors that have negative impact on starting situation	Percentage
Party before contest	40%
Long journey for tournament	52,5%
Inability to fall asleep before the start	20%
Unfavorable weather conditions	40%
Lack of financial support	22,5%
Small, not cured injuries	2,5%
Unhappiness, sadness	2,5%
Menstruation	2,5%
Misunderstanding between contestant and coach	2,5%
Scattered thoughts	2,5%

Attitude towards training and free time

Obeying training schedule seem to be the most important measure of professionalism in sport. Probably that is why 55% tried to follow training rules, 20% admitted that it was significantly crucial to them, but still 25% said they did not care about it or nothing like training schedule existed for them. Precise answers are in table 4.

Table 4. *Obeying training schedule*

Possible answers	Percentage
Definitely yes	20%
Yes, I am trying	55%
I do not care about it	12,5%
Nothing like this exists for me	12,5%

Table 5. *Ways of spending free time*

Leisure time management	Percentage
Skateboarding	25%
Listening to the music	55%
Sleeping	35%
Watching snowboard movies	35%
Studying	57,5%
Parties with friends	65%

Participants could choose between six possible answers. The most popular ways of spending leisure time were: parties with friends – 65%, listening to the music – 55% and studying – 57,5%. Similarly to other questions athletes had a chance to provide their choices, which were: playing other sports (football, tennis, basketball, surfing…) – 25%, spending time with friends and relatives – 10%, working – 12,5%, reading, going to cinema and theatre – 10%, planning the future – 2,5%.

Goal Setting (Zaleski's Goal Questionnaire)

There were no limits to the number of chosen goals. Snowboarders could point more than one goal for each category as well as they could leave free space in the other. That is why the percentage applies to surveyed athletes.

After doing goals' content analysis it was possible to distinguish forthcoming goals' categories:

I. Set for next week:
1. Goals connected with sports career, training, good start in contests, learning new trick – 65%
2. Recreation, spending time with relatives, taking a rest – 5%
3. Catching up with studies – 7,5%
4. Becoming better after injury, coming back home – 12,5%
5. Indefinite – 10%

II. Set for next month:
1. Improving sports career – 62,5%
2. Amusements (concerts, travels, photo-shootings) – 12,5%
3. Studying, extra courses (MBA) – 7,5%
4. Indefinite – 16,5%

III. Set for a year:
1. Competing in Winter Olympic Games – 45%
2. Good standings in World Cup contests, learning new trick – 20%

3. Possibility of combining sports career with everyday life, staying healthy and happy – 17,5%
4. Traveling, surfing – 10%
5. Indefinite – 10%

IV. Long term goals:
1. Set up family, find a job – 32,5%
2. Continuing sports career, more successes – 20%
3. Personal goals such as having fun, living without problems, understanding oneself – 12,5%
4. Finish studies, find a precise job (coach, sports manager) –12,5%
5. Indefinite – 30%

V. Life goals:
1. Personal goals such as: being happy, true for oneself and others, live good – 67,5%
2. Other:
- good results – 2,5%
- travelling – 2,5%
- being successful person generally –2,5%
3. Indefinite – 25%

One of the main intention of this study was to identify professional snowboarders' goals in sports career. This time participants were obliged to provide the answer, but they could choose more than one goal. The answers are showed beneath:

VI. Main goals in sports career:
1. Being professional, take part in photo-shootings, have sponsors – 30%
2. Good starts in contests – 20%
3. Staying healthy – 7,5%
4. Competing in Winter Olympic Games – 40%
5. Gold Olympic medal – 7,5%

In the second part of Zaleski's questionnaire snowboarders were asked to answer 58 questions about goal's dimension as well as the dimension of action. Competitors had to answer all questions having in mind goal in sports career. Some questions were distinguished in order to describe goal's dimension (12 questions):
– importance – expressed subjective assessment of how important is the goal, higher score meant higher significance;
– chance – concerned subjective probability of accomplishing the goal;
– conflict – expressed the level of commitment to achieve this goal at the expense of other important goal, higher score meant bigger conflict and more difficulties in completing a goal;

intentional behavior (11 questions):
– effort – meant the amount of energy used to accomplish the goal;
– stamina – concerned capability to overcome problems and obstacles that appeared on the way of achieving the goal;
– satisfaction – described positive emotional state either during the action of accomplishing the goal and after attaining the goal (5).

Taking all answers about intentional behavior into consideration the smallest difference from the average applied to satisfaction (standard deviation = 2,1) which meant that most of the snowboarders reached a lot of positive emotion either during the action of accomplishing the goal and after attaining it. Keeping goal's dimension in mind the most noticible difference in answers was about the importance of the goal. The reason for that could be either inability to measure goal's significance by the athletes or a large number of set goals of the same importance.

Discussion

The results of the investigation revealed the new view to snowboarding. We can no longer conceive it as a discipline for people who do not obey any rules (6). Snowboarders from top world rankings are real professionals. The results of this study stand for this statement. They are not only obeying training schedule, but also live quite healthy life. In accordance with expectations the choice of main goal in sports career was determined by forthcoming Winter Olympic Games in Turin. 40% of competitors declared the willingness to take part in the Olympics, 20% said they always wanted to compete well and 7,5% were eager to reach Olympic gold medal. What is worth noticing is that most participants who filled in the questionnaire took part in the Olympics – so they had reached their goal! Moreover three people were in top 5, which is a great result especially when famous American and Finnish snowboarders did not participate in the study and they actually stood on the podium in almost all events (7). Next three athletes were in top 10. What has to be noticed is the fact that these were only snowboarders interviewed personally and as far as the questionnaire was anonymous some competitors (who

Table 6. *Average and maximum scores of each dimension*

	Intentional behavior			Goal's dimension		
	Effort	Stamina	Satisfaction	Importance	Chance	Conflict
Average	26,5	18,6	10,4	23,9	20,4	12,8
Maximum	35	28	14	35	28	21
Standard deviation	4,8	3,9	2,1	5,3	3,9	3,4

got the questionnaire from their coaches) remained anonymous. After analyzing answers from goal questionnaire we can admit that snowboarders' goals hierarchy at the beginning concerned sports attainments, but with the goals set for longer periods of time competitors chose happiness, health, having family and good job. These are quite obvious and very popular goals among people. The resemblance was also noticed in sports goals, which are not so different from other athletes' goals. Who would not like to go to the Olympics? (8). What is more snowboarders declared that the questionnaires made them think more about what is really important to them and also helped them to name the goals. They mentioned that they did not realize some of the goals until they had to write them down. Maybe this is a guideline on what should coaches concentrate on? What has to be acknowledged is the fact that the ability to name the goal helps to achieve that goal, so it is more probable to accomplish the goal that can be established without much thinking. What is interesting 47,5% of the athletes do not use any psychological ways of coping with stress such as visualization, mental training or relaxation. It may be quite disconcerting. However maybe this is the way of showing their individualism? Or maybe this is the area that they have to work on more to improve their achievements? One of the possibilities to strengthen motivation is using psychological mechanisms of coping with stress as it is one of the method used to get rid of anxiety (3). Snowboarders are probably not aware of the techniques they could use so they might be thought some of them. Not only popular psychological methods (mentioned earlier) but also "thought-stopping" exercises in which they have to list negative statements that come to their minds when they are training and competing and replace them by more positive statements (9). Coaches should also pay attention in what ways external motivation is provided and whether it does not distract competitors from more significant internal motivation as without it there is no way of talking about valuable results in sport. In order to avoid this situation they should be familiarized with fundamentals of attainment motivation in sport (3). Being aware of factors that have negative impact on athletes it is possible to reduce some of them – come earlier to the destination place when the journey is tiring, teach snowboarders techniques to fall asleep in easier way even in a stressful situation. Going to the party in the evening before the contest can also be controlled (10), but still there are factors that we can not rule such as weather conditions, sometimes lack of financial support. The only thing coaches can do is to minimize the significance of these distractions. The results of the study show snowboarders' true attitude towards discipline and may help coaches and psychologists in their future work with competitors. What can be noticed is the fact that there are still areas in snowboarding that the team have to work on more to improve sports result.

Conclusions

World-famous snowboarders declared professional attitude towards their discipline. The most motivating factor was fun and pleasure gained from snowboarding. The closeness of Winter Olympic Games determined main goal in snowboarders' sports career. The ability to set the goals made for accomplishing them. The competitors were more eager to accomplish the goal of huge importance. When huge importance and big effort were concerned it was probable that also endurance would be on the high level. After attaining the goal - satisfaction was higher when athletes put more effort into the action of accomplishing the goal.

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F – Literature Search
G – Funds Collection