Fizikális aktivitás és oxidatív stressz

Összefoglaló és kommentár

Minden elismerésem azé, aki tisztán lát az alábbi kérdésekben:

- az intenzív fizikális terhelés okoz-e oxidatív stresszt;
- az oxidatív stressz az edzésprogramok során szűrhető és szűrendő-e;
- az oxidatív stressz okozati összefüggésben van-e a túledzésnek nevezett élettani állapottal;
- antioxidáns táplálék-kiegészítőkkel a túledzés következményei csökkenthetők-e;
- az extrém terhelés során sajnos egyre gyakrabban fellépő hírtelen szívhalál és az oxidatív stressz okozati összefüggése megállapítható-e?

Kitűnő kollegámmal többszáz közleményt böngésztünk végig. Csatolom az összefoglaló referátumot; nem állítom, hogy a mélyreható elemzés valamennyi kétségünket eloszlatta volna.
Szakemberek számára alább további gondolatébresztő kivonatokat idézek.

Jelenlegi személyes véleményem:

- Az egyéni terhelés tolerancia figyelembevételével kidolgozott edzésprogram az antioxidáns kapacitást növeli, az oxidatív stressz kockázatát csökkenti.
- Túlzott edzésintenzitás oxidatív stresszt okoz. amely az igénybevett izomzat sejtjeinek mikromorfológiai károsodásához vezet (túledzés).
- Az edzésprogram során különösen fontos az antioxidás-prooxidáns egyensúly vizsgálata; az oxidatív stressz észlelése.
- Mint azt az *Antioxidáns labor* oldalon részletesen ismertettem a Biofoton szkenner olcsó, gyors, nem invazív lehetőség az antioxidáns státus monitorozására.
- Az oxidatív károsodás kockázatának csökkentése a terhelés limitálásától és/vagy az antioxidáns raktárak feltöltésétől várható (étrendi előírások, antioxidáns táplálék-kiegészítők).
- További kutatások tisztázhatják, hogy az extrém terhelések kapcsán előforduló hirtelen szívhalál és a terhelés indukálta oxidatív stressz okozati összefüggése fennáll-e.

Szakirodalmi szemelvények

1: Can J Physiol Pharmacol. 1998 May;76(5):533-8.
Radical species in inflammation and overtraining.

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Reactive oxygen species can be important in the initiation of exercise-induced muscle damage and in the initiation and propagation of the subsequent acute muscle inflammatory response. Oxygen radicals generated via the neutrophil respiratory burst are vital in clearing away muscle tissue that has been damaged by exercise and they may also be responsible for propagation of further damage. Intervention by antioxidants to limit the postexercise inflammatory response and its potential to impair optimal muscle function are of interest to serious and recreational sports participants. Although antioxidants have the potential to limit muscle oxidative stress during the postexercise period, direct evidence for their role in this is limited. It is likely that short-term training can protect muscle from subsequent exercise-induced damage and inflammation without necessarily improving muscle antioxidant status.

Although muscle antioxidant status may be enhanced by longer term training, diet, or antioxidant administration, the significance of antioxidants in limiting muscle damage during the acute inflammatory response needs to be more clearly defined. It may even be counterproductive to limit neutrophil function during the inflammatory response, since this may inhibit subsequent muscle repair.

(Annak ellenére, hogy az antioxidánsok rendelkeznek azzal a képességgel, hogy a terhelést követő oxidatív stresszt limitálják, a közvetlen bizonyítékok száma elégtelen)

PMID: 9839079 [PubMed - indexed for MEDLINE]

Related Links

Oxidative stress and delayed-onset muscle damage after exercise. [Free Radic Biol Med. 2004] PMID:15256219

Estrogen and gender effects on muscle damage, inflammation, and oxidative stress. [Can J Appl Physiol. 2000] PMID:10953066

Response and adaptation of skeletal muscle to exercise--the role of reactive oxygen species. [Front Biosci. 2007] PMID:17569613

Exercise and oxidative stress: significance of antioxidants with reference to inflammatory, muscular, and systemic stress. [Exerc Immunol Rev. 2001] PMID:11579745

Exercise at old age: does it increase or alleviate oxidative stress? [Ann N Y Acad Sci. 2001] PMID:11795515

2: Exerc Immunol Rev. 2001;7:108-33.
Exercise and oxidative stress: significance of antioxidants with reference to inflammatory, muscular, and systemic stress.

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Many studies have demonstrated that intense muscular work generates considerable amounts of reactive oxygen species (ROS). In order to prevent oxidative stress, the body contains a large number of nonenzymatic and enzymatic antioxidants that either prevent ROS formation or scavenge radical species. Oxidative stress can lead to damage or destruction of cellular macromolecules such as lipids, proteins, and nucleic acids. Therefore, oxidative stress has been associated with decreased physical performance, muscular fatigue, muscle damage, and overtraining. It has been hypothesized that the body's physiological amount of antioxidants is not sufficient to prevent exercise-induced oxidative stress and that additional antioxidants are needed to reduce oxidative stress, muscular damage, or overshooting inflammation. However, some but not all investigations have demonstrated oxidative stress following physical exercise, and also, findings concerning the role of antioxidants in reducing oxidative stress are equivocal. In addition, a clear association between the amount of exercise-induced muscular, metabolic, hormonal, or inflammatory stress and levels of antioxidant vitamins could not be established consistently. Therefore, although the theoretical background may be sound, there is no scientific evidence to

recommend increased quantities of antioxidants to physically active people exceeding the amount provided by a healthy, balanced nutrition.

(Jóllehet, néhány -nem minden- kutatás kimutatta, hogy a terhelést oxidatív stressz követi, az antioxidánsok szerepével kapcsolatos vélemények ellentmondásosak)

PMID: 11579745 [PubMed - indexed for MEDLINE]

Related Links

Antioxidants: what role do they play in physical activity and health? [Am J Clin Nutr. 2000] PMID:10919970

Role of vitamin E and oxidative stress in exercise. [Nutrition. 2001] PMID:11684385

Exercise at old age: does it increase or alleviate oxidative stress? [Ann NY Acad Sci. 2001] PMID:11795515

Oxidants, antioxidants in physical exercise and relation to thyroid function. [Horm Metab Res. 2005] PMID:16175497

Oxidative stress, exercise, and antioxidant supplementation. [Toxicology. 2003] PMID:12821281

3: Can J Appl Physiol. 2005 Apr;30(2):186-95.
The effects of moderate, strenuous, and overtraining on oxidative stress markers and DNA repair in rat liver.

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Physical exercise above a certain load has been suggested as being a cause of oxidative stress. We have tested whether training with moderate (MT), strenuous (ST), or over (OT) load can cause alterations in the activities of antioxidant enzymes, lipid peroxidation, protein oxidation, DNA damage, or activity of 8-oxoG-DNA glycosylase (OGG1) in rat liver. The levels of corticosterone decreased in all exercising groups but the differences were not significant. Adrenocorticotrophin hormone (ACTH) levels decreased, not significantly, in MT and OT compared to C. Activity levels of antioxidant enzymes did not change significantly in the liver. The levels of reactive carbonyl derivative (RCD) content decreased in the liver of exercising animals, and the differences reached significance between control and moderately trained groups. The changes in the levels of lipid peroxidation (LIPOX) were not significant, but were lower in the exercised groups. The 8-hydroxydeoxyguanosine (8-OHdG) levels increased in the OT group, and the activity of OGG1 measured from crude cell extracts tended to increase in MT and ST. The findings of this study imply that overtraining induces oxidative damage to nuclear DNA, but not to liver lipids and proteins.

(Eredményeink szerint a túledzés a sejtmag DNS oxidatív károsodását okozza)

PMID: 15981787 [PubMed - indexed for MEDLINE]

Related Links

The effects of moderate-, strenuous- and over-training on oxidative stress markers, DNA repair, and memory, in rat brain. [Neurochem Int. 2005]
PMID:15863241

Exercise training decreases DNA damage and increases DNA repair and resistance against oxidative stress of proteins in aged rat skeletal muscle. [Pflugers Arch. 2002]
PMID:12457248

Carbohydrate-energy restriction may protect the rat brain against oxidative damage and improve physical performance. [Br J Nutr. 2003]
PMID:12568668

Stress-dependent induction of protein oxidation, lipid peroxidation and anti-oxidants in peripheral tissues of rats: comparison of three stress models (immobilization, cold and immobilization-cold). [Clin Exp Pharmacol Physiol. 2007]
PMID:17439411

Myocardial antioxidant status and oxidative stress after combined action of exercise training and ethanol in two different age groups of male albino rats.
[Acta Biol Hung. 2007] PMID:17585507

4: Int J Sports Med. 2006 Feb;27(2):87-93.
Antioxidant status and oxidative stress in professional rugby players: evolution throughout a season.

Finaud J, Scislowski V, Lac G, Durand D, Vidalin H, Robert A, Filaire E.

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Physical training is known to increase the antioxidant defence system and reduce exercise-induced oxidative stress. However, intense physical aerobic and anaerobic training and competition such as those imposed on professional rugby players, can induce an increase of oxidative stress which can be implicated with the arrival of overtraining. The aim of this study was to test the effect of training and competition load on oxidative stress, antioxidant status, haematological, and cell damage markers in high-level rugby players during a competitive season. Blood samples were collected four times in one year. Oxidative stress (Rmax), antioxidant (vitamin E, uric acid, TAC, and lag phase), haematological (neutrophils and monocytes) and biochemical (CK and myoglobin) parameters, as well as training and competition load, and competition results were measured. Intense periods of training and competition (T1 and T4) induced a significant higher maximum rate of conjugated dienes oxidation (+67.2% in T1 and +40.6% in T4) compared to those observed at the reference time (T3). Those periods also induced an increase in uric acid (+6.9% and 3.2%), and inflammatory markers such as monocytes (+13.3% and 10.7%). On the other hand, vitamin E (-8.7% in T1) and lag phase (-23.0% and -14.7%) were lower during these periods showing a possible training-induced antioxidant down-regulation. The less intense period of training (T2) was accompanied by lower neutrophils (-8.5%), CK (-53.7%), and myoglobin (-16.2%) values. The results suggest that oxidative stress and antioxidant measurement are significant in the biological follow-up of athletes.

(Intenzív tréning az oxidatív stressz megjelenését, ez pedig a túledzés állapotát váltja ki. … Eredményeink szerint az oxidatív stressz és az antioxidáns státus markereinek nyomonkövetése az atléták ellenőrzésének fontos komponense)

PMID: 16475052 [PubMed - indexed for MEDLINE]

Related Links

Biochemical assessments of retinol, alpha-tocopherol, pyridoxal--5-phosphate oxidative stress index and total antioxidant status in adolescent professional basketball players and sedentary controls. [Int J Adolesc Med Health. 2007]
PMID:17593769

Effects of alpha-tocopherol, beta-carotene and ascorbic acid on oxidative, hormonal and enzymatic exercise stress markers in habitual training activity of professional basketball players. [Eur J Nutr. 2001]
PMID:11905959

Evaluation of autoantibodies against oxidized LDL (oLAB) and blood antioxidant status in professional soccer players. [Int J Sports Med. 2005]
PMID:15643538

Lipid peroxidation and antioxidant status in professional American football players during competition. [Eur J Clin Invest. 2002]
PMID:12486869

Nutrition antioxidant status and oxidative stress in professional basketball players: effects of a three compound antioxidative supplement. [Int J Sports Med. 2000]
PMID:10727077

5: Sports Med. 2006;36(4):327-58.
Oxidative stress : relationship with exercise and training.

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Free radicals are reactive compounds that are naturally produced in the human body. They can exert positive effects (e.g. on the immune system) or negative effects (e.g. lipids, proteins or DNA oxidation). To limit these harmful effects, an organism requires complex protection - the antioxidant system. This system consists of antioxidant enzymes (catalase, glutathione peroxidase, superoxide dismutase) and non-enzymatic antioxidants (e.g. vitamin E [tocopherol], vitamin A [retinol], vitamin C [ascorbic acid], glutathione and uric acid). An imbalance between free radical production and antioxidant defence leads to an oxidative stress state, which may be involved in aging processes and even in some pathology (e.g. cancer and Parkinson's disease). Physical exercise also increases oxidative stress and causes disruptions of the homeostasis. Training can have positive or negative effects on oxidative stress depending on training load, training specificity and the basal level of training. Moreover, oxidative stress seems to be involved in muscular fatigue and may lead to overtraining.

(Fizikális tréning a pro- és antioxidáns homeostasis zavarát, azaz oxidatív stressz okozhat. … Az oxidatív stressz az izomfáradtság és túledzés valószínű oka)

PMID: 16573358 [PubMed - indexed for MEDLINE]

Related Links

Biochemical assessments of retinol, alpha-tocopherol, pyridoxal--5-phosphate oxidative stress index and total antioxidant status in adolescent professional basketball players and sedentary controls. [Int J Adolesc Med Health. 2007]
PMID:17593769

Oxidative stress, exercise, and antioxidant supplementation. [Toxicology. 2003]
PMID:12821281

Antioxidants and physical performance. [Crit Rev Food Sci Nutr. 1995]
PMID:7748472

Interaction of vitamin E and exercise training on oxidative stress and antioxidant enzyme activities in rat skeletal muscles. [J Nutr Biochem. 2007]
PMID:16644199

Analysis of cellular responses to free radicals: focus on exercise and skeletal muscle. [Proc Nutr Soc. 1999] PMID:10817171

6: Int J Adolesc Med Health. 2007 Apr-Jun;19(2):177-86.
Biochemical assessments of retinol, alpha-tocopherol, pyridoxal--5-phosphate oxidative stress index and total antioxidant status in adolescent professional basketball players and sedentary controls.

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Physical training is known to increase the antioxidant defence system and reduce exercise-induced oxidative stress. However, intense physical aerobic and anaerobic training with competition, such as those imposed on young professional basketball players can induce an increase of oxidative stress, which can be implicated with overtraining. The aim of this study was to test the effect of training and competition load on oxidative stress, antioxidant status, and vitamin levels in basketball players. Oxidative Stres Index (OSI 1), Total Peroxide (TPx) antioxidant (vitamin E, A and The total antioxidant status (TAC 1)), biochemical lipid parameters, as well as training results were measured. Results showed that all plasma vitamin levels were significantly higher in basketball players (vitamin A: 1.61 +/- 0.05 mmol/l, vitamin E: 26.45 +/- 0.72 mmol/l, vitamin B6: 10.58 +/- 0.7 mgr/l) than sedentary controls (vitamin A: 1.22 +/- 0.04 mmol /l, vitamin E: 19.24 +/- 0.73 mmol/l, vitamin B6: 6.0 +/- 0.35 mgr/l) ($p < 0.01$). In addition TAC 1 was 2.06 +/- 0.02 and 1.89 +/- 0.01 mmol Trolox eq/L in basketball players and controls, respectively ($p < 0.01$). Conversely OSI was 0.89 +/- 0.09 arbitrary unit and 0.88 +/- 0.071 arbitrary unit in basketball players and controls, respectively ($p > 0.05$). However, total plasma peroxide level (TPx) of basketball players and controls was not statistically different (18.55 +/- 2.07 and 17.18 +/- 1.61 micromol H2O2/L, respectively; $p > 0.05$). We conclude that physical exercise increase antioxidant levels and cause balance of the homeostasis. Training can not have positive or negative effects on oxidative stress depending on training load. The results suggested that oxidative stress and antioxidant measurement are significant in the biological follow-up of young basketball players.

(Az eredmények a sportolók oxidatív státusának nyomonkövetésére figyelmeztetnek)

PMID: 17593769 [PubMed - indexed for MEDLINE]

Related Links

Antioxidant status and oxidative stress in professional rugby players: evolution throughout a season. [Int J Sports Med. 2006]
PMID:16475052

Effects of alpha-tocopherol, beta-carotene and ascorbic acid on oxidative, hormonal and enzymatic exercise stress markers in habitual training activity of professional basketball players. [Eur J Nutr. 2001]
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Nutrition antioxidant status and oxidative stress in professional basketball players: effects of a three compound antioxidative supplement. [Int J Sports Med. 2000]
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Nutritional and plasmatic antioxidant vitamins status of ultra endurance athletes. [J Am Coll Nutr. 2007]
PMID:17906181

Soccer players under regular training show oxidative stress but an improved plasma antioxidant status. [Clin Sci (Lond). 1999]
PMID:10087245

7: Toxicology. 2003 Jul 15;189(1-2):41-54.
Oxidative stress, exercise, and antioxidant supplementation.

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Cells continuously produce free radicals and reactive oxygen species (ROS) as part of metabolic processes. These free radicals are neutralized by an elaborate antioxidant defense system consisting of enzymes such as catalase, superoxide dismutase, glutathione peroxidase, and numerous non-enzymatic antioxidants, including vitamins A, E and C, glutathione, ubiquinone, and flavonoids. Exercise can produce an imbalance between ROS and antioxidants, which is referred to as oxidative stress. Dietary antioxidant supplements are marketed to and used by athletes as a means to counteract the oxidative stress of exercise. Whether strenuous exercise does, in fact, increase the need for additional antioxidants in the diet is not clear. This review examines the markers used to determine oxidative stress in blood and muscle samples (e.g. lipid peroxidation, expired pentane, malondialdehyde (MDA), F2-isoprostanes, congugated dienes, and 8-hydroxy-2'-deoxyguanosine (8-OhdG)), the changes in oxidative stress markers induced by exercise, and whether athletes require antioxidant supplements.

(Antioxidáns táplálék-kiegészítők forgalomban vannak, és számos atléta fogyasztja is ezeket azzal a céllal, hogy ezáltal csökkentsék az edzés kapcsán fellépő oxidatív stresszt. Az antioxidáns pótlás hasznát igazoló bizonyítékok hiányosak)

PMID: 12821281 [PubMed - indexed for MEDLINE]

Related Links

Antioxidants: what role do they play in physical activity and health? [Am J Clin Nutr. 2000] PMID:10919970

Protective role of vitamin E on the oxidative stress in Hansen's disease (Leprosy) patients. [Eur J Clin Nutr. 2005] PMID:16015260

Moderate exercise with a dietary vitamin C and E combination protects against streptozotocin-induced oxidative damage to the blood and improves fetal outcomes in pregnant rats. [Clin Chem Lab Med. 2004] PMID:15202787

Antioxidants and physical performance. [Crit Rev Food Sci Nutr. 1995] PMID:7748472

Moderate exercise combined with dietary vitamins C and E counteracts oxidative stress in the kidney and lens of streptozotocin-induced diabetic-rat. [Int J Vitam Nutr Res. 2005] PMID:15830924

8: Crit Rev Food Sci Nutr. 1995 Jan;35(1-2):131-41.
Antioxidants and physical performance.

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Performance of strenuous physical activity can increase oxygen consumption by 10- to 15-fold over rest to meet energy demands. The resulting elevated oxygen consumption produces an "oxidative stress" that leads to the generation of free radicals and lipid peroxidation. A defense system of free radical scavengers minimizes these dangerous radicals. Indirect measurements of free radicals generated during exercise include assessing products of lipid peroxidation that appear in the blood (e.g., malondialdehyde and conjugated dienes) or expired in the breath (pentane). Changes in antioxidant scavengers and associated enzymes (e.g., glutathione, tocopherol, glutathione peroxidase) also provide clues about demands on the defense system. Physical training has been shown to result in an augmented antioxidant system and a reduction in lipid peroxidation. Supplementation with antioxidants appears to reduce lipid peroxidation but has not been shown to enhance exercise performance. The "weekend athlete" may not have the augmented antioxidant defense system produced through continued training. This may make them more susceptible to oxidative stress. Whether athletes or recreational exercisers should take antioxidant supplements remains controversial. However, it is important that those who exercise regularly or occasionally ingest foods rich in antioxidants.

(A „hétvégi” atléta antioxidáns rendszere nem olyan fejlett, mint a rendszeres edzésben lévőé. Emiatt ők jobban ki vannak téve az oxidatív stressz veszélyének. A táplálék-kiegészítők fogyasztásának haszna nem egyértelmű. Az antioxidáns vitaminokban dús táplálkozás mindazonáltal a sportolók számára különösen fontos.)

PMID: 7748472 [PubMed - indexed for MEDLINE]

Related Links

Antioxidants: what role do they play in physical activity and health? [Am J Clin Nutr. 2000] PMID:10919970

The role of antioxidant vitamins and enzymes in the prevention of exercise-induced muscle damage. [Sports Med. 1996] PMID:8776010

Oxidative stress, exercise, and antioxidant supplementation. [Toxicology. 2003] PMID:12821281

Free radicals, exercise and antioxidant supplementation. [Proc Nutr Soc. 1998] PMID:9571703

Blood free radical antioxidant enzymes and lipid peroxides following long-distance and lactacidemic performances in highly trained aerobic and sprint athletes. [J Sports Med Phys Fitness. 1997]
PMID:9509820