

Bryliński Łukasz, Woliński Filip, Duda Piotr, Drożak Paulina, Kostecka Katarzyna, Baj Jacek. Overtraining syndrome - what we already know. *Journal of Education, Health and Sport*. 2022;12(6):192-204. eISSN 2391-8306. DOI <https://dx.doi.org/10.12775/JEHS.2022.12.06.020> <https://apcz.umk.pl/JEHS/article/view/JEHS.2022.12.06.020> <https://zenodo.org/record/6659382>

The journal has had 40 points in Ministry of Education and Science of Poland parametric evaluation. Annex to the announcement of the Minister of Education and Science of December 21, 2021. No. 32343. Has a Journal's Unique Identifier: 201159. Scientific disciplines assigned: Physical Culture Sciences (Field of Medical sciences and health sciences); Health Sciences (Field of Medical Sciences and Health Sciences).

Punkty Ministerialne z 2019 - aktualny rok 40 punktów. Załącznik do komunikatu Ministra Edukacji i Nauki z dnia 21 grudnia 2021 r. Lp. 32343. Posiada Unikatowy Identyfikator Czasopisma: 201159. Przynależność dyscypliny naukowej: Nauki o kulturze fizycznej (Dziedzina nauk medycznych i nauk o zdrowiu); Nauki o zdrowiu (Dziedzina nauk medycznych i nauk o zdrowiu).

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The authors declare that there is no conflict of interests regarding the publication of this paper.

Received: 01.06.2022. Revised: 05.06.2022. Accepted: 18.06.2022.

Overtraining syndrome - what we already know

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Abstract

Introduction: Overtraining syndrome (OTS) is a state of excess sportsmen's overload caused by too high an intensity of training. The main cause of OTS is too big a training load. Also, they are other risk factors like restrictive diets, inordinate stress, and inflated expectations of a family and a coach.

Description of the state of knowledge: despite numerous hypotheses like dysregulation of hypothalamus and pituitary, inflammatory hypothesis, and glycogen hypothesis the exact cause of OTS is not fully understood. None of these hypotheses explains completely all of the symptoms. In diagnosis, several laboratory tests are required to exclude other diseases. After it, because of possible systemic character diagnostic process of OTS is still problematic. One of the diagnostic methods relies on the measurement of hormone levels. Another potential

diagnostic method is the measurement of saliva immunoglobulins and other anti-viral proteins. Also, the measurement of serum cell-free DNA can be used. After the onset of OTS, the most important treatment method is rest, which should last for 6-12 weeks or longer. Nowadays, treatment options are looking for shortenings this time. These options are anti-inflammatory drugs and repeated hypoxia-hyperoxia exposure combined with low-intensity training. Since the only well-established treatment method is prolonged rest, prevention is the most important aspect of OTS management. Adequate education of young athletes and their parents is also important.

Summary: Overtraining syndrome is a serious problem that concerns many athletes. This problem not only affects results and careers but also sportsmen's life. Because of the wide scope of symptoms, which can be often nonspecific making the correct diagnosis can be difficult.

Keywords: Overtraining syndrome; athletes; sportsmen;

INTRODUCTION

Overtraining syndrome (OTS) is a state of excess sportsmen's overload caused by too high an intensity of training. It leads to a reduction in efficiency. Despite keeping or increasing training keenness an athlete is not capable to maintain their current physical condition [1]. According to the studies between 5 to 64% of professional athletes experience OTS at least once during their career [2]. The principal cause of OTS is too big training load. Sportsmen that surpassed individual training thresholds got OTS more often [3]. Furthermore, sportsmen are more prone to develop OTS during cycles of contests, than during preparation cycles, in which it is less common [4]. Other factors increasing the risk of OTS are restrictive diets – low-carbohydrate and low-calory diets, insufficient protein supply, inordinate stress, low hygiene, and poor sleep quality [5,6]. Also inflated expectations of a family and a coach, stress connected with the competition, ineptness to manage stress, and relations with friends and family may all increase the risk of OTS [7,8]. Moreover, the perfectionist viewpoint of an athlete is predictive of the occurrence of OTS. Perfectionists are exposed to greater stress levels while training, which for a long time leads to an increased probability of OTS occurrence [9]. Not only athletes are at risk of OTS. This problem runs onto soldiers as well. Deficiency of sleep, exhaustive stamina training, and incorrect diet result in increased risk in this group either [10,11].

SEARCH STRATEGY

We performed a literature review by Pubmed analysis based on international papers in the English language. In our analysis, we used articles published between 1992 and 2021. We searched scientific works by using terms that included the keywords: Overtraining syndrome and athletes. We discuss basic knowledge about OTS, pathomechanism, symptoms, diagnosis, and treatment based on international scientific journals available through Pubmed. Starting from a total number of 211 articles we rejected all off-topic articles. Finally, we collected 135 articles.

PATOMECHANISM

Despite numerous hypotheses, the exact cause of OTS is not fully understood [12]. According to one of the hypotheses it comes to dysregulation of the hypothalamus and pituitary, especially hypothalamus-pituitary-adrenal and hypothalamus-pituitary-gonads axes. As result, cortisol levels decrease and Addison disease develops [2,13]. However, studies referring to these axes and hormone levels often have contradicting results and at present moment it is hard to determine whether pituitary and hypothalamus malfunctions may cause OTS [14]. According to different hypotheses, intensive physical exercise is a risk factor causing potential muscle fibres weakening, increase proinflammatory proteins, which leads to enhancement of oxidative stress to the muscles, and this results in increased inflammation — thus vicious circle occurs. The pathological state of chronic inflammation and oxidative stress causes oxidation of proteins bound with calcium and contractile proteins which leads to lingering weakening of the muscle and increased fatigue [15]. Yet another hypothesis is the glycogen hypothesis — intensive exercises lead to a decline in muscle glycogen, which can cause increased oxidation and decrease in branched-chain amino acids (BCAA) levels — leucine, isoleucine, valine, which are used by the muscles as an alternative energy source. Because of decreased BCAA levels, an increase in serum-free tryptophan happens. This favours the penetration of free tryptophane to the brain where it is transformed into neurotransmitter 5-hydroxytryptamine. There its increased quantity may affect sleep, autonomic and endocrine functions [16–18].

SYMPTOMS

The main symptom of the OTS is a decrease in athletes' performance — their results are worse despite keeping the same intensity of training [1]. Other symptoms of OTS include pain and weakness of the muscles, chronic fatigue, enhanced effort during exercise, decreased motivation to train, sleeping problems, loss of appetite, mood swings, increased heart rate in early morning hours, heavy legs feeling, and increased frequency of contusions [19,20]. OTS may lead to dehydration, decreased libido, mood reduction, and fat tissue growth [21]. At a young age, a common symptom is chronic muscle pain, which doesn't show a good reaction to painkillers [22]. Among male sportsmen, intensive exercise may cause a decrease in testosterone levels, which may lead to hypogonadism known as exertional hypogonadism. A drop in this hormone is an effect of hypothalamus-pituitary-gonads axis dysfunction [23]. There is evidence that long exercise, and in consequence OTS might influence reproductive ability in males of medium age. According to the study by Safarinjad et al., it can cause a decrease in sperm cells number and mobility [24]. Too intensive exercise, especially if they feature stamina exercises may lead to decreased immune protection, which leads to greater infection vulnerability. This applies mostly to infections of the upper respiratory tract, digestive system, and skin [25]. Because of extensive effort blood serum glutamine decreases, which causes dysfunction of macrophages and lymphocytes. Nevertheless, it should be taken into consideration if increased infection vulnerability is not caused by too intensive workout thus not being a consequence of overtraining. Also decreased glutamine level may not have any real effect on one's immunity [26,27]. Symptoms can also concern a psycho-emotional state. Development of apathy towards sports decreased readiness for training, irritability, and mood swings are possible [28]. What is peculiar, OTS may increase the risk of depression development in an athlete, but depression may also be an OTS symptom [29].

DIAGNOSIS

In the case of differential diagnosis, several laboratory tests are required to exclude other diseases like thyroid gland disorders, exercise-induced asthma, cardiovascular disorders, enlargement of lymph nodes, anaemia, hepatitis, and rheumatological diseases [30]. Non-specific symptoms of tick-borne diseases may also resemble OTS, so they should also be included in differential diagnosis [31]. OTS should also be differentiated from depression, which can be troublesome, because fatigue, insomnia, appetite disorders, weight loss, lack of motivation, and difficulty concentrating can be present in both the illnesses [32]. Nonfunctional overreaching (OR) should also be considered in the diagnostic process. The

difference between OR and OTS include different time needed for full efficiency restoration – a few days to a few weeks in OR, and a few weeks to several months in OTS. The symptoms of OTS are usually also more intensified [12]. According to the study by Luk Buyse et al., ACTH and PRL responses during the Training Optimization (TOP) may be a suitable test to differentiate OR from OTS [33].

After the stage of differential diagnosis, the further diagnostic process of OTS is still problematic. Due to its possible systemic character, combinations of several biomarkers are needed to improve the correctness of diagnosis and enable OTS prevention [34]. One of the diagnostic methods relies on the measurement of hormone levels. In the diagnosis of OTS, stimulation tests of ACTH, GH, and prolactin can be helpful. In such tests, the rise of hormone levels after stimulation is reduced, however, more research is needed to evaluate their diagnostic value [35,36]. In a study conducted among 51 men aged 18-50 years old, of which 14 presented OTS, OTS patients typically presented elevation of estradiol level, and decrease of testosterone level. What is more, the results of the abovementioned tests were similar to the results typically presented among men with a sedentary lifestyle. This discovery suggests that OTS may reduce the beneficial impact of sport on the body [37]. ECLIA tests of the circadian rhythm of cortisol secretion may be useful to evaluate stress reaction to physical exercises. Cortisol levels obtained at the same hour on consecutive days may be beneficial in the diagnosis and prevention of OTS [38]. Another potentially useful diagnostic method is saliva testing. Levels of saliva cortisol, testosterone, and free testosterone/cortisol ratio may indicate if the athlete's physical regeneration level is insufficient. A >30% decrease in the free testosterone/cortisol ratio suggests insufficient regeneration which may contribute to OTS development. Another potential diagnostic method is the measurement of saliva immunoglobulins and other anti-viral proteins. As prolonged and intensive physical exercises may result in a decrease in saliva IgA, they may indicate upper respiratory tract infections and physical overburden during physical exercises [39–41]. Another peculiar diagnostic method refers to the measurement of serum cell-free DNA (cfDNA). An elevation of overall cfDNA serum level may be caused by aseptic systemic inflammation, as well as by prolonged and intensive physical exercises. However, the use of cfDNA as an independent biomarker still needs more evaluation [42,43]. However, Flavio Adsuaru Cadegiani et al.,[6] stated that after differential diagnosis and application of the proper diagnostic methods, 100% sure diagnosis of OTS would be feasible, but the diagnostic methods require further evaluation among greater populations. The methods are EROS-CLINICAL based on 9 clinical parameters,

EROS-SIMPLIFIED which is used when EROS-CLINICAL findings are ambiguous. The EROS-COMplete is an even more advanced clinical tool including 18 clinical parameters and 2 inclusion criteria for OTS. EROS-RISK, which is another diagnostic tool, can be used to indicate patients who are prone to develop OTS [6].

TREATMENT

After the onset of OTS, the most important treatment method is rest, which should last for 6-12 weeks or longer, concerning the individual patient's conditions [30]. Studies referring to the possible OTS etiology lead to the search for adequate treatment options. Based on the hypothesis of the chronic inflammatory process, the use of anti-inflammatory drugs seems to be a promising option. On the other hand, some authors regarding chronic oxidative stress as a cause of OTS, suggest that the use of EUK-134, a mimetic of SOD/catalase may be beneficial in the prevention of oxygen-stress-induced muscle fatigue. What is important, the abovementioned options are still hypothetical treatment methods [15]. An interesting treatment option, evaluated in a pilot program by Davide Susta et al., [44] is repeated hypoxia-hyperoxia exposure combined with low-intensity training. The authors reported improvement in physical efficiency, hypoxia toleration, and balance of the autonomic nervous system after the course of such treatment. This method could potentially reduce the time needed to complete efficiency regeneration after OTS [44].

On the other hand, amino acids supplementation seems not to be a solution. Oral supplementation of BCAA amino acids did not provide the expected benefits. Similarly, supplementation of glutamine did not provide benefits in the treatment of mild OTS despite its elevated serum levels. Alike, arginine aspartate supplementation is not related to physical efficiency improvement [45,46]. Since the only well-established treatment method is prolonged rest, prevention is the most important aspect of OTS management. Preventive advice consists of careful training planning including avoidance of monotony and abrupt increases in training burdens. A proper lifestyle is also important, including increased protein and calories intake appropriate for the planned exercises, enabling to rest after the exercises, adequate amount and quality of sleeping, proper fluids supply, regular medical tests, and avoidance of concurrent mental and physical efforts [47,48]. Adequate education of young athletes is also important, including avoidance of training mistakes, and maintaining a proper proportion between training and rest. Parental education on the topic of OTS is also important.

It is worth emphasizing that there is a necessity to provide an adequate amount of time to rest, and the main aim of the sport is fun and gaining new abilities [49,50].

SUMMARY

Overtraining syndrome is a serious problem that concerns many athletes. This problem not only affects results and careers but also sportsmen's life. Because of the wide scope of symptoms, which can be often nonspecific making the correct diagnosis can be difficult. Development of methods of diagnosis, treatment and combining already existing methods will allow in future early diagnosis, and reduction of time of recovery.

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