

# Theories of Tiredness in Sport

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## ABSTRACT

*Classic theories interpret the phenomena of tiredness as a consequence of biochemical changes appearing in the whole organism or in active organs. From operational point of view we can define tiredness as a reversible psychophysical condition appearing under the influence of expanded time of activities, which is manifested a series of negative changes on physiological, psychological and behavioral plan. Physiological nature was primarily related by the scientists to lack of oxygen and other nutritional material in blood or blood plasma and loading of different waste material and metabolism products. On those bases, three classical theories were founded, such as: theory of suffocation, theory of exhaustion, and theory of saturation, united in one general name as hormonal theories of tiredness. Lately, with extending of findings on the role of reticular formation, there are activation theories of tiredness being developed. Supporters of these theories have discovered a series of complex connections and relations existing through tiredness and different forms of brain work such as: exhaustion of neural cells during their activity, neural influences determining arrival of nutritious material into work active organs, disruption of harmony in neurophysiological processes, role of inhibition process etc. For explanation of mental tiredness, central brain theory of tiredness is dominantly used. Due to new findings of neurophysiology, a neurophysiological theory known as theory of changed chronaxy, starting from time constant of skeletal nerve irritability, is nowadays commonly used for explanation of physical tiredness at skeletal muscles.*

**Key words:** intensity, reduction, metabolism, material

## Introduction

In the research sense, tiredness is nowadays commonly taken as an interdisciplinary phenomenon going into several scientific disciplines, so that it is defined in accordance to their basic theoretical postulates, because of which there is no unambiguously and commonly accepted interpretation of this term. Globally viewed, in the literature we find three basic approaches in defining and researching tiredness appeared as a consequence of physical activity.

The first approach defines tiredness from the aspect of *decrease of physical efficacy*, where the accent is put on decrease of physical activity.

The second group of definitions talks about tiredness as *balance disorder* of physiological functional systems in the body that is the fall of physiological and organic equilibrium under the influence of psycho-physical effort. In the scope of this approach, tiredness is usually seen as inhibitory functional state of cortex, subcortical structures and other activating systems, appearing as a result of functional exhaustion of neural structures. It is obvious that this approach and definitions given in the scope of it represent the physiological point of view, where tiredness is interpreted as a biological protective function of organism.

The third group of definition puts *psychological aspects* of tiredness in the first plan. They talk about losing motivation and interest in proceeding sport activities and the feeling of psychophysical exhaustion (Blakemore, 1997). Very important for this aspect is primarily the subjective experience related to expanded duration of activity and exhaustion of psychophysical reserves of organism. As characteristic for this approach we can mention Pageaux's definition in which it is said: "Tiredness is self-recognizable state in which a person feels to be inadequate

to fulfill the given task, which reflects on feeling body comfort, weakness, slowness, and in cognitive plan as a feeling of futility" (Pageaux, Marcora & Lepers, 2013).

Taking into account complexity of phenomenon and different definitions regarding some aspects of tiredness, we can conclude that it is difficult to give a unique and overwhelming definition of tiredness, but from the operational aspect we can define tiredness as a reversible psychophysical condition appearing under the influence of expanded time of activities, which is manifested a series of negative changes on physiological, psychological and behavioral plan and with expressed tendency in intensity reduction or interruption of physical activity which affects reduction of sports effects and efficacy.

## Theories of tiredness

*Classic theories* interpret the phenomena of tiredness as a consequence of biochemical changes appearing in the whole organism or in active organs. Physiological nature was primarily related by the scientists to lack of oxygen and other nutritional material in blood or blood plasma that 'feeds' muscles (Kayser, Narici & Cibella, 1993). Also, in the scope of those interpretations, tiredness is related to loading of different waste material and metabolism products, such as lactic acid and other material. On those bases, three classical theories were founded, such as: *theory of suffocation*, *theory of exhaustion*, and *theory of saturation or intoxication*, united in one general name as *hormonal theories of tiredness*.

*Theory of suffocation* starts for the fact that every cell needs oxygen to work, which in the process of metabolism provides tissue breathing. Muscular cells use oxygen during their work to perform contractions though which the major part (95%) of

physical work is done. Depending on the state, an organism can provide maximally ten times more oxygen in relation to basal level, so when the work lasts longer, or when there is more tiring work is done, the aerobic capacity of a man becomes insufficient and there is a lack of oxygen for ending metabolically cycle which causes sense of tiredness.

Muscular cells for the lack of necessary amount of oxygen reduce contractile ability and that results in tiredness. After work stop and making up oxygen lack-during the rest amount of oxygen is brought into to enable muscle cells to get ready for work again.

*Theory of exhaustion*-starts from the fact that the tiredness appears as a consequence of spending and exhausting all disposable reserves of energetic material. Muscle cell for its work, that is muscle contractions, uses the energy given by degradation of adenosine triphosphate (ATP) to diphosphate and monophosphate. During the work that spent energy is compensated by degradation of glucoses from blood and glycogen from liver. When these reserves are out, the organism is getting tired and the working activity is reduced or stopped.

*Intoxication theories*-starts from the fact that the work that lasts longer, or it is harder than it can be regulated by the aerobic capacity of the person, and it includes anaerobic capacity that are also present during metabolic cycle. On one hand, metabolism of nutritional material is at that time stopped on the level of pyruvic and lactic acid loaded in the muscle cell, as on the other hand, energetic reserves of glucoses, glycogen, adenosine triphosphate, creatin phosphate) which enables metabolism to be finalized. Both of these lacks have a consequence in disorder in cell metabolism, so it comes to loading of waste products-lactic acid, phosphoric acid, carbon-dioxide and other waste material, because bloodstream is unable to remove them on time and the consequence is tiredness and work activity which is reduced or stopped.

The proofs for the above mentioned hormonal theories are found in laboratory conditions on isolated muscles of animals, as well as monitoring changes appeared in organism of a man during activities of skeletal muscles at physical work, it was soon proved that generalization of such findings on the whole organism was unjustifiable, especially in the cases where connections of muscle tissues with brain structures are not disrupted, or where not only dominates physical work based on contraction and decontraction of skeletal muscles.

It has been established that continued stimulation of neural centers and static work bring to earlier tiredness, which on the base of classical hormonal theories cannot be explained, especially when taking into account the complexity of the processes in the human body during work. For that reason, focus of tiredness phenomenon research is redirected to study of brain functions in the conditions of increased and long-term efforts, so in that sense new theories of tiredness are set:

*Activating theories of tiredness*- started to develop in the middle of 20<sup>th</sup> century, when besides physical there was an emphasis on mental tiredness and when there is a sudden expanding of findings on the role of reticular formation and other brain structures responsible for sleeping and wakefulness, which enables seeing the consequences of work in that light, even the phenomenon of tiredness.

*Centrally-brain theory* is dominantly used for explaining mental tiredness and its beginnings can be found in the works of Russian scientists Secenov and Palov, as well as their students and heirs (Luria, 1976). Supporters of this theory, in different phases of its development, have given a series of convincing evidence that tiredness in the human body is a complex phenomenon that can only be explained by hormonal changes

in blood and muscles. They consider that tiredness and its characteristics can be explained on the base of findings on neurophysiological changes appearing in CNS (Brownsberger, Edwards, Crowther & Cottrell, 2013). External demands and conditions of work in the form of stimulation effect on membrane of big brain, wherefrom the impulses leave to reticular formation that had an activating and inhibiting role, through two basic and reciprocal processes-excitation and inhibition. These two processes induce each other, at which there are two forms. The first one is alternating induction - when excitation of one center at the same time causes inhibition of the other center and vice versa. The other form of induction is self-induction-when in the same center there is alternating induction of excitation and induction processes (Pageaux, Lepers, Dietz & Marcora, 2014). As there complex and reciprocal processes between brain membrane and reticular formation, then in dependence on working activation characteristics the level of activation can be changed from maximal wakefulness and attention concentration, to the state of relaxation and sleepiness. As a result of inadequate activation or predomination of inhibitory processes in certain neural cells, the state of tiredness appears (Marcora, Bosio, & De Morree, 2008).

Scientists discovered a series of complex connections and relations between tiredness and different forms of work brain such as: exhaustion of neural cells during their activity, neural influences determining coming of nutritious material into the working active organs, disrupting coordination of neurophysiological processes, special role of breaking or inhibition processes etc.

Due to new findings in neurophysiology, a neurophysiological theory known as theory of changed hronaxy is more and more used with skeletal muscles to explain physical tiredness, and it starts from the timely constant of irritation of skeletal nerve (McGillis, Semmler, Jakobi, & Enoka, 2003). It is well known that thick myelinated neural fibers have limited time interval during which they can transmit impulses onto the active muscle. Their hronaxy is from 0.00025 to 0.001 s. After every done stimulant comes the time when the nerve membrane is depolarized. That is the time of its refractivity, when stimulants cannot be transmitted through the nerve or affect the muscle fibers. Which high-demanding works when it comes to speed, repetitiveness and preciseness, the stimulus spreads more frequently, the hronaxy time is shorter than physiological and happens at the time of refractivity, when reflects on speed and work quality, and there is nuisance which indicates to tiredness and reduction or stop of physical activity.

## Conclusion

So far, there hasn't been a way found for direct and objective measuring of amount of tiredness, nor it can be expressed in such a simple way in certain measuring units, as for example energy consumption is expressed. All the measuring can be divided into three groups, according to basic indicators of tiredness expression: 1) Physiological measuring; 2) Psychological measuring; 3) Medical measuring.

It means that different indicators can be used for tiredness measuring and the signs often registered through different methods and techniques which commonly include: 1) Indicators of quality and quantity of sports activity; 2) Scales for measuring subjective experience of tiredness; 3) Electroencephalography (through EEG); 4) Critical frequency of fusion of visible stimulus; 5) Psychomotor and psychosensory tests; 6) Mental tests.

Tiredness measuring through the above mentioned indicators and methods is usually done before, during and after work. Therefore the given value has relative significance, because it is compared to values in the state of inaction, or to the values of some control person. So far, there hasn't been a way found for

measuring tiredness in some absolute units. In order to get as reliable indicator of the kind and degree of tiredness as possible, nowadays several objective indicators are used in combination or correlation with subjective estimation of tiredness.

## REFERENCES

- Blakemore, C. (1997). Mechanisms of mind. *Cambridge University Press, Cambridge*, 69-75.
- Brownsberger, J., Edwards, A., Crowther, R., & Cottrell, D. (2013). Impact of mental fatigue on self-paced exercise. *Int. J. Sports Med.*, 34(12), 29-36.
- Kayser, B., Narici, M., & Cibella, F. (1993): Fatigue and performance at high altitude. *In: Hypoxia and molecular medicine*, 222–234.
- Luria, A.R. (1976). Cognitive Development: Its cultural and social foundations. Cambridge, MA *Harvard University Press*, 121-127.
- McGillis, C.J., Semmler, J.G., Jakobi, J.M., & Enoka, R.M. (2003). Motor unit discharge differs with intensity and type of isometric contraction performed with the elbow flexor muscles. *Med. Sci. Sport Exerc.*, 35, 280-283.
- Marcora, S.M, Bosio, A., & De Morree, H.M. (2008). Locomotor muscle fatigue increases cardiorespiratory responses and reduces performance during intense cycling exercise independently from metabolic stress. *J. Physiol Regul Integr Comp Physiol*, 294, 874– 883.
- Pageaux, B., Lepers, R., Dietz, K.C., & Marcora S.M. (2014). Response inhibition impairs subsequent self-paced endurance performance. *Eur. J. Appl. Physiol.*, 114, 1095–1105.
- Pageaux, B., Marcora, S.M., & Lepers R. (2013). Prolonged mental exertion does not alter neuromuscular function of the knee extensors. *Med. Sci. Sports Exerc.*, 45(12), 54-64.

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