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REVIEW

Physical and cognitive consequences of fatigue: A review

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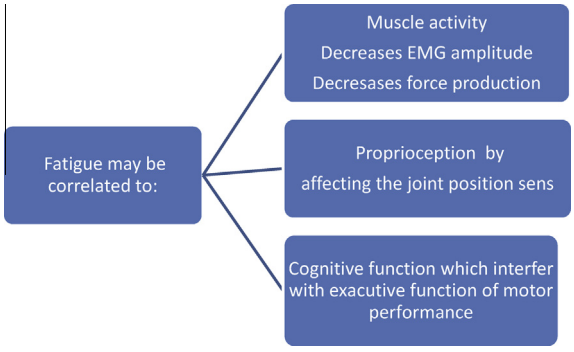
GRAPHICAL ABSTRACT



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ABSTRACT

Fatigue is a common worrying complaint among people performing physical activities on the basis of training or rehabilitation. An enormous amount of research articles have been published on the topic of fatigue and its effect on physical and physiological functions. The goal of this review was to focus on the effect of fatigue on muscle activity, proprioception, and

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cognitive functions and to summarize the results to understand the influence of fatigue on these functions. Attaining this goal provides evidence and guidance when dealing with patients and/or healthy individuals in performing maximal or submaximal exercises.

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Introduction

Fatigue can be instigated by various mechanisms, ranging from accumulation of metabolites within muscle fibers to generation of an inadequate motor command in the motor cortex [1]. The effect of fatigue on other domains as physical or cognitive performance was not fully understood and it is still under investigation. The purpose of this review was to search the literature pertaining to the association between fatigue and muscle activity, proprioception, and cognition to help the health professionals in their planning of a training program and/or attempting to measure the performance in patient subjects

Fatigue is a common feature of many physical, neurological, and psychiatric disorders. Despite being commonly identified as a sign or a symptom of a disease or side effect of a treatment, fatigue has been considered as a subjective experience. Great efforts have been made to conceptualize or define it in a clear way to be at variance from normal experiences such as tiredness or sleepiness [2].

"Fatigue" is a term used to describe a decrease in physical performance associated with an increase in the real/perceived difficulty of a task or exercise [3]. From another aspect, fatigue is defined as the inability of the muscles to maintain the required level of strength during exercises [4]. Alternatively, it can be defined as an exercise induced reduction in muscle's capability to generate force. The term muscle fatigue was used to denote a transient decreases in the muscle capacity to perform physical activity [5]. Performing a motor task for long periods induces motor fatigue, which is generally accepted as a decline in a person's ability to exert force [6]. Fatigue is reflected in the EMG signal as an increase of its amplitude and a decrease of its spectral characteristic frequencies [7].

Fatigue occurs due to the impairment of one or several physiological processes, which enable the contractile proteins to generate force. This effect was known as task dependency and was considered to be one of the principles that have been emerged in this era, so far [8–10]. According to this principle, there is no single cause of muscle fatigue [11]. The process of fatigue is gradual and includes important physiological changes, which occur before and during mechanical failure [12]. Boyas et al. [13] have introduced several principles to characterize the phenomena of muscle fatigue that occur in response to physical activity, namely "exercise induced fatigue". These principles stress on the fact that there is no single mechanism to induce fatigue, but it is a complex mechanisms that may include organic central nervous system (CNS) abnormalities (central fatigue), peripheral nervous system dysfunction, or skeletal muscle disease [13]. The central fatigue designates a decrease in voluntary activation of the muscle (i.e. a decrease in the number and discharge rates of the motor units (MUs) recruited at the start of muscle force generation), whereas, peripheral fatigue indicates a decrease in the contractile strength of the muscle fibers and changes in the mechanisms underlying the transmission of muscle action potentials. These phenomena occur at the nerve endings and neuromuscular junction (NMJ) and are usually associated with peripheral fatigue [14]. However, data on this phenomenon are scarce and have only been gathered in animal experiments. Notably, intracortical inhibition could also be involved in the drop of muscle performance under fatiguing conditions. McNeil et al. [15] suggested increases in the intracortical inhibition as fatigue progressed, during 2-min maximum voluntary contraction (MVC) of the elbow flexors. Lastly, motoneurons (mainly those in fast-twitch MUs) are