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Letter to editor

Performance Enhancement by Brain Stimulation

Dear Editor-in-chief

Number of substances and strategies are available to increase performance in sport (Catlin and Murray, 1996). Since 2004, the World Anti-Doping Agency (WADA) posts an updated list of substances and methods prohibited to athletes. Drugs (e.g., steroids, stimulants) are a major part of this list; however, technologies and methods (e.g., gene doping) are increasingly being identified and added (WADA, 2017). Among technologies and methods that might exert a potential effect on athletic performance, brain stimulation has recently been subjected to extensive discussion. Neuro-enhancement for doping purposes has been termed "neurodoping" in the literature (Davis, 2013); however, this concept needs further documentation before the term "neurodoping" can be used properly.

Two major non-invasive techniques of brain stimulations are transcranial magnetic stimulation (TMS) (Hallett, 2007; Rossi et al., 2009), and transcranial direct current stimulation (tDCS) (Stagg and Nitsche, 2011). In TMS, an electric coil held over the head applies magnetic pulses to create currents in the brain. In tDCS, a low, continuous electrical current is delivered to the brain by using surface electrodes attached on the scalp. TMS and tDCS have been used in both research and clinic (Shin and Pelled, 2017) for example to examine alterations in cognitive function or motor skills or to assist in recovering motor function after a stroke (Gomez Palacio Schjetnan et al., 2013) or reducing fatigue in patients with multiple sclerosis (Saiote et al., 2014).

In an opinion paper, it was proposed that use of emerging brain stimulation techniques might also enhance physical and mental performance in sports (Davis, 2013). The assumption was based on several reports. For example some studies have shown that TMS could shorten reaction times to visual, auditory and touch stimuli, reduce tremor, and enhance the acquisition of complex motor skills. Based on the current evidence, a recent review (Colzato et al., 2017) has summarized that overall brain stimulation by some techniques including TMS and tDCS seem to speed up motor learning, and motor skills in sport activities. Considering that performance enhancement can be seen (Colzato et al., 2017), one would ask how and by which mechanism.

Davis proposed that there would be two ways that brain stimulation could possibly improve sport performance (Davis, 2013). One way is to benefit from brain stimulation before performance to, for instance, reduce stress level or muscle tension or to enhance focus for a quicker action. The other way would be potential use during training for athletic performance that can eventually help athletes to learn motor skills better. Presented research results are mainly based on the experimental set up; therefore, it is important to identify whether physical and mental performance gains under experimental conditions would also be meaningful in a real world competition. To study actual gain by brain stimulation, future investigations must properly be designed, include placebo and control arms, remain blinded until after data analysis, and include objective assessments in addition to subjective outcomes.

Time-course of beneficial effect in certain sport competition is not clear. It has been shown that repetitive applications of tDCS can increase the effects of stimulation (Nitsche and Paulus, 2011); but, it is not clear if this is the case for athletic performance. There is no evidence on side effects especially for long term use of these techniques. Overall, these techniques are considered non-invasive and safe (Rossi et al., 2009). Under medical application, it has been notified that some individuals are highly responders while others do not respond well. This might be the case for athletes. Additive or synergistic effects of these techniques together with other techniques or methods of performance enhancement have not yet been investigated either. Therefore, further studies are required to address these uncertainties or providing an optical protocol.

Discussing neuro-enhancement with sport bodies, athletes, and authorities seems necessary to facilitate providing a technical, ethical, or regulatory framework for further investigation (Park K, 2017). In contrast to many other substances or strategies listed in prohibited performance-enhancing drugs or strategies, neuro-enhancement cannot be detected with a simple blood test. In addition, since these techniques can be used differently for different types of sport activities, it is not easy to determine whether it must be prohibited or be given legitimacy as an aid to training and development of athletes.

In short, although brain stimulation is a valuable scientific tool and a beneficial medical procedure, it does not look wise to let it be used limitlessly and for non-medical purposes at least for the time being that several points are unanswered about efficacy and safety.

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