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EDITORIAL

Nicotine and exercise performance: another tool in the arsenal or curse for anti-doping?

Toby Mündel[1] · **I. Mark Olfert**[2]

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In this issue of EJAP, Johnston et al. (2018) report on the ergogenic aid of nicotine to enhance anaerobic performance in nicotine-naïve individuals. Here, the authors find that following oral consumption of 5 mg of nicotine, athletes who are nicotine naïve significantly increased their peak (and average) power output, as well as heart rate and blood pressure, which they attribute to nicotine's sympathomimetic effect. While these are not the first data to make such an observation, the current study is notable for using a randomized, double-blind, cross-over design that delivered nicotine (or flavor-matched placebo) via orally-dispensed strips. It should be noted that the benefits of nicotine to athletic performance has been somewhat controversial, as some studies show benefits (e.g. Mündel and Jones 2006) whilst many others show marginal to no benefit (e.g. Fogt et al. 2016). But, most of the existing studies have significant limitations (such as lack of determination of nicotine levels as a manipulation check, lack of participant blinding or suitable placebo-control, and more tolerable delivery systems with fewer side-effects) leaving clear and robust interpretation of nicotine effects often difficult to make. Based on the strength of the current study design, these data certainly add credence to the potential benefit(s) of nicotine for repeated bouts of anaerobic exercise, and will likely embolden athletes to want to use nicotine to achieve that extra edge during athletic events. At present, professional anti-doping bodies do not ban nicotine, and so its use and interest among athletes is likely to increase. While the data by Johnston et al. provide robust evidence of the benefits of nicotine on repeated anaerobic performance, there are several points to further consider before athletes (particularly nicotine naïve) choose to take nicotine.

First, nicotine is among the most addictive substances known to man, and there is a wide variation in individuals' tolerance and sensitivities to nicotine, such that some users may require increasing usage/dosage and develop greater dependence with increasing regularity of use. This could itself cause either depressive (at higher doses of nicotine) or inhibitory (with increased tolerance) effects that could lead to an ergolytic impact.

Second, timing of nicotine consumption and the influence of, for example, nutrition (meals, ingredients such as menthol or grapefruit) will likely alter the rate of nicotine clearance, reducing or delaying the maximal effect observed. Women, including those taking oral contraception, and those of certain ethnicities will metabolize nicotine differently from a Caucasian male. Thus far, existing studies have been limited to young, healthy males.

Third, exercise is often performed under conditions of thermal stress (whether outdoors in the heat, or indoors with restrictive clothing and/or without suitable air-conditioning). Whilst nicotine is known to reduce skin blood flow, this combination could have undesired effects leading to hyperthermia.

Finally, the delivery method is likely to be critically important and have a significant influence on the potential outcomes. While patches, gum, and/or orally dissolved strips are undoubtedly the 'cleanest' method for delivering nicotine, they each possess their own limitations in optimal systemic drug delivery (Mündel 2017) that may limit the desired performance outcomes. The development of electronic nicotine delivery systems, more commonly known as electronic cigarettes (E-cigarettes), provides another new and rapid delivery method that may be appealing to some, particularly younger athletes. However, it should be noted that emerging evidence suggests that E-cigarettes are

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✉ I. Mark Olfert
imolfert@hsc.wvu.edu

[1] School of Sport, Exercise and Nutrition, Massey University, Palmerston North, New Zealand

[2] Division of Exercise Physiology, Toxicology Working Group, Department of Physiology, Pharmacology and Neuroscience, West Virginia University School of Medicine, One Medical Center Dr, PO Box 9227, Morgantown, WV 26506, USA

unlikely to be risk-free, and likely pose greater pulmonary (Chun et al. 2017) and cardiovascular (Olfert et al. 2017) risks than that which is currently being advertised. Whether the observed pulmonary and vascular dysfunction is due to nicotine or some other component of the liquid (e.g. carbonyl compounds, metals, etc.) is not yet fully understood, but this topic is of great interest and under active investigation. Moreover, since E-cigarettes have only been around for little over a decade, the overall long-term health effects in humans are entirely unknown. But, if animal exposure studies are a harbinger for chronic vaping in humans (as they have historically been shown for exposure to cigarette smoke), recent evidence indicates that even relatively low levels of chronic E-cigarette vapor increases arterial stiffness and reduces vascular reactivity, both of which are considered early pre-clinical indicators and hallmark evidence in the development/progression of cardiovascular disease.

While Johnston et al. (2018) have provided tantalizing and robust data that can paint nicotine as another tool in an athlete's arsenal, these data only emphasize the need for further rigorous investigations determining the magnitude and under what conditions nicotine enhances sports performance; this is especially the case as a reported 25–50% of team/strength athletes actively consume nicotine in-competition. Notwithstanding any potential short-term benefit in performance that may exist for some sporting activities, these gains may be short-sighted when weighed against the highly addictive nature of nicotine and the potential curse of dependence over a lifetime. Moreover, depending on the route of delivery (such as with E-cigarettes), the risk toward long-term health is still poorly determined.

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