

Wearable Technology for Athletes: Information Overload and Pseudoscience?

In an effort to maintain a winning edge, monitoring health and training load has become a key focus for athletes, coaches, and sports scientists. In this context, wearables are appealing because they are lightweight, can be worn close to and/or on the skin surface, and detect, analyze, and transmit information about various internal and external variables.¹ Wearables are currently a \$6-billion industry¹ and are projected to be a \$25-billion industry as early as 2019.² Despite this popularity, very few wearable devices have been tested rigorously and independently to determine their accuracy, reliability, and validity. The main limitations of current wearable devices center around the following factors¹: the need to place devices at specific anatomical locations; movement artefact; frequency of data sampling; monitoring of a few selected variables (as opposed to a suite of variables); lack of measurement of environmental factors (e.g., temperature, humidity, altitude, UV radiation); uncertainty about accuracy of data interpretation (by athletes/algorithm vs trained professional); inability to transmit data indoors, underwater, and in built-up areas; and interference from other physiological responses (eg, vasoconstriction, hypovolemia). In addition to these technical issues, the development and marketing of wearable technology are associated with various ethical considerations relating to consumer awareness.

Increasing recognition of the importance of sleep for athletes has stimulated a proliferation of devices to measure sleep duration and/or quality. Most of these are in the form of wristwatch-type devices that use accelerometry to detect movement. Other devices are designed to be placed on the athlete's bed and again use accelerometry to detect movement. Very few of these devices have been compared with the gold standard of polysomnography, and the manufacturers often do not share the algorithms used to detect sleep and wake. Sleep monitoring is a good example of scientists and support staff embracing a popular sport-science trend, with many using monitoring devices that have not been validated. Careful consideration of how data collected from sleep monitoring are presented to athletes is necessary. Given the relationship between stress/anxiety and sleep, athletes may become overburdened if they have problems with their sleep, especially around competition. Furthermore, whether it is necessary for athletes to have information about their sleep readily available each night is questionable. Having unreasonable expectations about sleep (ie, that we should sleep perfectly each night) can contribute to these problems involving sleep for athletes.

The wearable market has provided opportunities to collect an almost endless amount of data, which has opened up opportunities in medicine, occupational health, and sport. However, with the flood of data-collection opportunities there also are downsides.³ As scientists we must be vigilant with regard to measurement and the concepts of reliability and validity.⁴⁻⁶ Furthermore, careful attention should be given to whether these devices provide accuracy and precision when deployed. Given the importance of protecting and developing health and talent, what and how variables are measured matter greatly.^{5,7}

Many companies who develop and sell sport/fitness technology have not taken the appropriate steps to validate their measurement processes, yet they have perfected their marketing.

Once sport becomes competition, it is arguably no longer sport. This ideology could explain why individuals look for shortcuts in sport—and possibly in the sport-technology industry, as well. An example is the recent introduction of transcranial direct-current stimulation devices (tDCS) in sport technology. Companies making such technology make strong claims of performance and health benefits, but the research remains mixed, and clarity is needed to assess safety and positive impact.⁸ Some companies have applied their own normative value of acceptability while looking for a commercial edge. This often means that critiquing and questioning of science is minimal (or nonexistent) for the sake of market presence and sales.

A great cause for concern is that the sport community (athletes, coaches, etc) may be convinced by pseudoscience due to sport-technology companies using neuroscience and social psychology in their marketing plans.^{9,10} We live in a time where we are surrounded by both the pressure for our attention and an excessive proliferation of information. Sport-technology companies have used knowledge about our human attraction/attention tendencies to influence us through their presentations. They do this by ensuring that supportive works in marketing material closely resemble peer-reviewed articles, when these works are not in fact peer reviewed. It is unfortunate that we find ourselves in a place where individuals can convincingly assert “facts” that sound truthful but largely amount to pseudoscience.¹¹ The information overload we experience from sensationalized media and the extent of unchecked information made available on the Internet are substantial contributors to confusion in athletes and teams.

When dealing with athletes, in particular elite athletes, appropriate evidence-based scientific principles should apply to the use of both wearable and performance-enhancing technology. The following recommendations should be considered when using devices: (1) The primary driving principle should be to first do no harm, and direct implications on athlete health and safety should be of utmost concern; (2) questions should then be asked regarding the scientific basis for the device; (3) if there is no or minimal scientific evidence, data should be collected in situ, in a controlled and systematic manner; and (4) implications for the athlete should always be considered (eg, too much information, unnecessary information, or information that may cause stress and anxiety). Although as scientists we may appreciate the collection of numbers and data, this must be weighed against the potential negative influences on the athlete. If the use of GPS monitoring has taught us anything, it is that time, rigor, and careful analysis are required before truly meaningful data are available for athletes and coaches.

Shona L Halson, Associate Editor, IJSP

Jonathan M. Peake, Queensland University of Technology

John P. Sullivan, CSCS Sport Science

References

1. Duking P, Hotho A, Holmberg HC, Fuss FK, Sperlich B. Comparison of non-invasive individual monitoring of the training and health of athletes with commercially available wearable technologies. *Front Physiol.* 2016;7:71.
2. Koytcheva M. Wearables market to be worth \$25 billion by 2019. 2015. <http://www.ccsinsight.com/press/company-news/2332-wearables-market-to-be-worth-25-billion-by-2019-reveals-ccs-insight>.
3. Piwek L, Ellis DA, Andrews S, Joinson A. The rise of consumer health wearables: promises and barriers. *PLoS Med.* 2016;13(2):e1001953.
4. Bassett DR Jr, Rowlands A, Trost SG. Calibration and validation of wearable monitors. *Med Sci Sports Exerc.* 2012;44(1 Suppl 1):S32–S38.
5. Evenson KR, Goto MM, Furberg RD. Systematic review of the validity and reliability of consumer-wearable activity trackers. *Int J Behav Nutr Phys Act.* 2015;12:159.
6. Kooiman TJ, Dontje ML, Sprenger SR, Krijnen WP, van der Schans CP, de Groot M. Reliability and validity of ten consumer activity trackers. *BMC Sports Sci Med Rehabil.* 2015;7:24.
7. Chambers R, Gabbett TJ, Cole MH, Beard A. The use of wearable microsensors to quantify sport-specific movements. *Sports Med.* 2015;45(7):1065–1081.
8. Horvath JC, Carter O, Forte JD. Transcranial direct current stimulation: five important issues we aren't discussing (but probably should be). *Front Syst Neurosci.* 2014;8:2.
9. Khushaba RN, Wise C, Kodagoda S, Louviere J, Kahn BE, Townsend C. Consumer neuroscience: assessing the brain response to marketing stimuli using electroencephalogram (EEG) and eye tracking. *Expert Syst Appl.* 2013;40(9):3803–3812.
10. Krishna A. An integrative review of sensory marketing: engaging the senses to affect perception, judgment and behavior. *J Consumer Psychol.* 2012;22(3):332–351.
11. Zhao J, Al-Aidroos N, Turk-Browne NB. Attention is spontaneously biased toward regularities. *Psychol Sci.* 2013;24(5):667–677.