

Conference Abstract

# Will wearable sweat lactate sensors be the next big thing in cycling?

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**Abstract:** The use of wearable sensors in cycling is rising. Besides heart rate, we can now measure more and more variables continuously and in real-time like glucose (in interstitial fluid), core body temperature (at the heart rate belt), muscle oxygenation (with NIRS at the upper leg), and sweat rate (with wearable sensors). These sensors may provide more insights into what is happening during exercise and possible can be used to optimize performance.

One of the recent additions to the list of variables that can be measured with wearable sensors is the concentration of lactate in sweat. Since blood lactate is a key performance indicator in sport physiology and can be used to monitor exercise intensity, there is a lot of interest in measuring lactate during exercise. Nonetheless, blood lactate has the disadvantages that it is invasive, painful, not continuous, and that the exercise has to be interrupted to measure. If lactate can be measure non-invasively and in real-time in sweat, this will open much more insights and possibilities to monitor lactate concentration during exercise. However, the relationship between sweat lactate and blood lactate still remains unclear. Since sweat lactate concentrations are higher in sweat (1-30 mM) than in blood (1-15 mM), there is debate on the origin of lactate in sweat. Lactate can be produced by the sweat glands itself, derivate from the lactate in blood, or a combination of both. Further research is needed to explore the origin of lactate in sweat.

In the past researchers were using different sweat collection methods to analyze lactate in sweat. With these methods sweat was collected during a certain time period and the lactate concentration was analyzed afterwards. Most of these studies found no or even a negative relationship between sweat lactate concentration and exercise intensity. This can probably be explained by the dilution of the sample due to the increase in sweat rate with increasing intensity. With the recent developments in wearable sweat sensors, sweat lactate can now be measured continuously when there is a constant supply of new sweat. Using these sensors, there is no dilution of the samples which can results in a positive relationship between sweat lactate and exercise intensity (and also blood lactate). This review article will give an overview of the existing literature about the link between sweat lactate (measured with wearable sensors) and exercise, and the usability of wearable sweat lactate measurements in endurance sports like cycling.

In this review we give an overview of the different sweat collection methods and wearable sweat sensors. To explore the relationship between wearable sweat lactate and exercise we searched for relevant articles measuring the sweat lactate concentration with wearable sensors during exercise. We included research articles using sweat lactate during exercise as one of the outcome variables and concept articles where newly developed sweat lactate sensors where tested during exercise. This resulted in 17 articles (Anastasova et al., 2017; Enomoto et al., 2018; Gao et al., 2016; Gillan et al., 2021; Guan et al., 2019; Jia et al., 2013; Karpova et al., 2020; Komkova et al., 2022; Lamas-Ardisana et al., 2014; Mao et al., 2020; Muramoto et al., 2023; Onor et al., 2017; Seki et al.,

2021; Vinoth et al., 2021; Xuan et al., 2022, 2023; Zhao et al., 2019). In 10 of these articles they found a positive relationship between sweat lactate concentration and exercise intensity and in 7 articles the found no or a negative relationship. This indicates that sweat lactate can possibly be a non-invasive alternative for blood lactate, but more structured research is needed to explore the origin and mechanisms of lactate in sweat and its relationship with exercise intensity. Sweat lactate can therefore be the next big thing in cycling if these wearable sweat lactate sensors come onto the market.

**Keywords:** Sweat lactate; sensors; cycling; monitoring

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