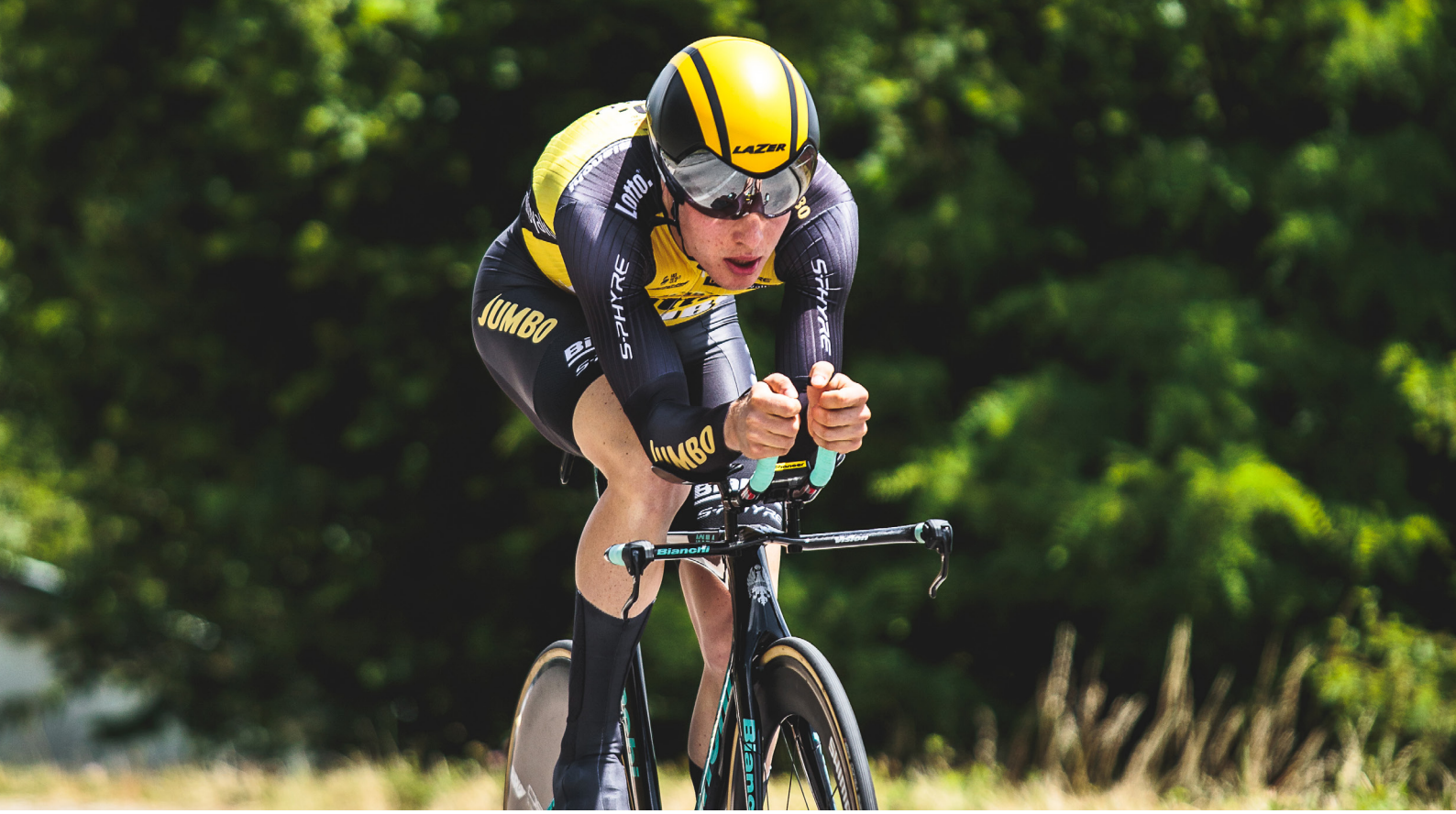

The BASES Expert Statement on Extracellular Buffering Agents

Produced on behalf of the British Association of Sport and Exercise Sciences by Prof Lars McNaughton FBASES, Dr Sanjoy Deb, Dr Lewis Gough, Dr Matt Higgins, Dr Mike Price FBASES, Prof Craig Sale and Dr Andy Sparks.

Introduction

Research investigating nutritional ergogenic aid strategies that delay the occurrence of metabolic acidosis during high intensity exercise have been widely investigated for many decades. The exogenous enhancement of the bicarbonate (HCO_3-) buffering system is believed to have an important role in offsetting muscle fatigue, by attenuating hydrogen cation (H^+) increases. Ingestion of sodium bicarbonate ($NaHCO_3$) and other buffers such as sodium citrate, sodium lactate and sodium phosphate may be ergogenic by increasing blood bicarbonate concentration (HCO_3-) within the extracellular fluid, elevating pH above the normal values of 7.35-7.40. Research suggests that oral ingestion leads to more high intensity work completed, and improved exercise capacity or performance (McNaughton, 1992). Currently, the use of buffering agents, by athletes for competition and training is typically based upon ingesting $NaHCO_3$. Whilst other buffering agents have been used, the ease of purchase of sodium bicarbonate continues to ensure this is the most common buffering agent. The scientific literature regarding acute buffering supplements demonstrates a high degree of inter/intra individual variability (Heibel *et al.*, 2018). Many factors such as training status, individual variation in acid-base kinetics, intensity/duration of exercise, and gastrointestinal disturbances, have been identified as possible causes. This expert statement provides current information and guidance for athletes and practitioners who are using or considering the use of exogenous buffers.

Sodium bicarbonate, citrate and lactate

Recent developments have focused on attempts to make buffering supplement ingestion more effective for exercise performance, by examining the dose, timing and delivery method. A novel methodological change (Miller *et al.*, 2016) developed the individual time to peak (TTP - pH or HCO_3-) alkalosis ingestion method to align peak alkalosis with performance onset. Times ranging between 10-180 min were observed despite ingestion of the same dose (Miller *et al.*, 2016), suggesting that a generic pre-exercise ingestion period is not necessarily appropriate (e.g. 60 or 90 min for all athletes). Similarly, Jones *et al.* (2016) showed the range of time to peak bicarbonate concentrations were between 30 and 180 min for doses of between 0.1 and 0.3 $g \cdot kg^{-1}$ BM. Traditionally, doses of 0.3 $g \cdot kg^{-1}$ BM were the accepted standard (McNaughton, 1992), however, such doses may cause gastrointestinal (GI) upset in some athletes. Recent investigations using individualised TTP have suggested that 0.2 $g \cdot kg^{-1}$ BM of $NaHCO_3$ may cause similar ergogenic responses whilst reducing GI symptoms (Gough *et al.*, 2017). Gough *et al.* (2017) reported that 4 km time trial cycling was improved to a similar extent by 8.3 and 8.6 s following 0.2 $g \cdot kg^{-1}$ BM and 0.3 $g \cdot kg^{-1}$ BM compared to a placebo. Current findings suggest that a dose of 0.2 $g \cdot kg^{-1}$ ingested at individual peak alkalosis can achieve an absolute change in HCO_3- from baseline of ~5 $mmol \cdot l^{-1}$, which is the level suggested to be required to elicit an ergogenic effect (Heibel *et al.*, 2018), but also ensures athletes begin an event at their optimal buffering capacity. Given that the severity of GI upset following supplementation is subject to individual variation, supplementing with smaller doses, or splitting the dose over time, may be useful. Recent work has shown that the use of delayed-release or enterically coated capsule ingestion of $NaHCO_3$ can also reduce GI discomfort compared to fluid ingestion due to their gastro-resistant properties (Hilton *et al.*, 2019).

An alternative exogenous buffer is sodium citrate, but its use is less prevalent than $NaHCO_3$ due to the difficulties of obtaining it. Urwin *et al.* (2016) showed that TTP alkalosis could take between 180-210 min following ingestion of 0.5$g \cdot kg^{-1}$ BM of sodium citrate,

although data were restricted to mean group responses only. Given the move towards individualised ingestion, this may explain why minimal effects of sodium citrate supplementation have been reported on performance. Given the larger molecular weight of sodium citrate (258.06 $g.mol^{-1}$) compared to $NaHCO_3$ (84.007 $g.mol^{-1}$), it is likely that mean TTP will be longer.

Calcium and sodium lactate have both been suggested as extracellular buffers (McNaughton *et al.*, 2019). The research on these buffers is limited and equivocal and obtaining them is difficult (Oliveira *et al.*, 2017). Based on such limited evidence, further research is required to understand the best form of ingested lactate (i.e. sodium or calcium lactate), exercise type and duration, and dose that will produce consistent ergogenic effects.

Despite promising findings from an individualised ingestion strategy, understanding changes in acid-base balance following $NaHCO_3$, and other buffer supplementation requires individuals to have access to blood gas analysis, to identify the individual TTP blood HCO_3. Given the mechanism of exogenous buffering agents relates to alterations in acid-base balance, the ergogenic effect is limited to exercise that induces fatigue through disturbances to this system. As such, sports/events that require athletes to perform above the lactate threshold for extended periods may benefit from supplementation. Current research suggests that this effect is most efficacious during high intensity exercise that lasts between 1-10 min. It has also been suggested that sports involving high intensity efforts (e.g. hill climbs during road cycling competitions and team sports), may benefit from $NaHCO_3$ ingestion. In addition to their ergogenic properties, buffering supplements should also be considered as training aids, with a growing body of research demonstrating their potential to augment training adaptations.

Conclusion

Current work suggests that utilising an individualised approach to dosing to coincide with a peak (HCO_3-) or pH and performance time is the most efficacious strategy. The individualised strategy using both 0.2 and 0.3 $g \cdot kg^{-1}$ BM doses, seems to produce repeatable blood and performance responses, which suggests that ($NaHCO_3$) has a greater ergogenic effect than previously thought. Careful consideration should be afforded to the delivery method, given the effects on TTP and associated GI symptoms. Using recent research, athletes and practitioners should gain the most from these buffering substances and ingestion strategies.

Recommendations

Athletes should (re)consider their use given the recommendations below and in conjunction with the suggested protocols:

1. Research suggests that buffering substances are most likely ergogenic for performances of 1-10 min and/or exercise intensities that are considerably higher than lactate and Critical Power (CP) thresholds.
2. Athletes are recommended to undertake out of competition testing to understand their TTP and GI responses to 0.3 and 0.2 $g \cdot kg^{-1}$ BM $NaHCO_3$ doses.
3. Athletes should seek assistance in determining their TTP using blood samples at 10 min intervals with 0.3 $g \cdot kg^{-1}$ BM $NaHCO_3$.
4. Athletes should assess subjective measures of GI upset during TTP assessment.
5. Athletes with unacceptable levels of GI upset should experiment with a 0.2 $g \cdot kg^{-1}$ BM $NaHCO_3$.
6. The use of delayed release or enterically coated capsules, or splitting the dose, may alleviate GI symptoms but should be sourced from suppliers that use batch testing or at the very least, from reputable sources. ■

Note: A figure outlining recommended individualised and traditional sodium bicarbonate ingestion strategies is included in the PDF download version.

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