Contemporary ergogenic aids

A literature review ofcontemporaryergogenic aids which have been recommendedwithin the ‘ lay’ literature to improve exercise performance

A number of psychological, mechanical, nutritional and pharmacological factors shown to limit exercise performance have been identified. Driving towards success, professional and amateur athletes attempt to identify these factors and to find techniques to minimise their likely impact. Specific nutrients or compounds used in an attempt to enhance the capacity of an individual to perform a specific task beyond effects attributable to training alone have been described as ergogenic aids (Williams, 1983). Currently, two nutritional aids have identified which are thought to reduce the rate of intramuscular metabolite accumulation, beta alanine and sodium bicarbonate. Beta alanine supplementation increases intramuscular buffering capacity by enhancing intramuscular carnosine synthesis. Whereas, sodium bicarbonate has shown to increase the extracellular buffering capacity by increasing the blood bicarbonate concentration (Requena et al. 2005). During high intensity exercise, fatigue is often associated to the excessive accumulation of metabolites, such as potassium ions (K+), hydrogen ions (H+), and phosphate ions (Pi+), and the availability of metabolic fuel sources (Fitts et al, 2008). The ergogenic potential of beta alanine and sodium bicarbonate have both become increasingly topical avenues of exploration due to the growing popularity of their supplementation by amateur and professional athletes. Therefore, this review will focus on critically evaluating the evidence on beta alanine and sodium bicarbonate, which are both currently recommended within the ‘ lay’ literature to enhance performance.

Furthermore, to make a reasoned conclusion about nutritional manipulations which could enhance performance.

Recently, a ' lay' article claimed that beta alanine supplementation enhances performance for short duration and high intensity workouts, however decreases long duration performance (Oches, 2016). The rationale for this is based on well substantiated evidence that an increased level of beta alanine in the body elicits increased carnosine synthesis. Muscular acidosis has been recognized as one of the main causes of fatigue during intense exercise and carnosine has been shown to play a significant role in intramuscular pH regulation (Artioli et al, 2010). Therefore, Carnosine loading may enhance fatigue threshold and increase high intensity exercise performance (Blancquaert et al, 2014). Nearly a decade ago, it was demonstrated that chronic beta alanine supplementation was able to increase intramuscular carnosine content, suggesting that beta alanine is the rate-limiting factor for carnosine synthesis (Harris et al, 2006). Shortly after this, Hill et al (2007) demonstrated that increased skeletal muscle carnosine content was able to increase performance in various high intensity exercises.

Following on from this, several high quality studies have explored the effects of beta alanine supplementation on sport-specific high intensity performances. These studies demonstrate that 1-10 minutes appears to be the effective time window where beta alanine is most beneficial (Salles Painelli et al, 2013). Looking closer we can see that studies which have attempted to enhance performance in exercises lasting less than one minute (Miro et al, 2013; de Salles Painelli et al, 2013) or over ten minutes (Thienen et al, 2012; Chung et al, 2014) have not found beneficial effects on performance. Whereas, studies which have examined exercises within this optimal time window have reported enhanced performance (de Salles Painelli et al, 2013; Hobsen et al, 2013). This would suggest that beta alanine supplementation may not be beneficial for enhancing short bouts of high intensity or endurance performance. A reason no positive effects are being seen in high intensity exercises lasting less than one minute may be that these exercise models are not limited by intramuscular acidosis, thereby the increased buffering capacity of beta alanine is unable to show an effect.

On closer observation we can see that some studies (Saunders et al, 2012; Ducker et al, 2013; Smith-Ryan et al, 2012) have reported that beta alanine is unable to improve repeated sprint performance and intermittent activities, where each exercise bout has been 30 seconds, signifying that beta alanine is unlikely to be beneficial in team sports, such as rugby and football. Although, it is important to mention that currently there is limited evidence examining the effects of beta alanine on sport-specific endurance events and team sport performance, consequently more research is needed before a reasoned conclusion can be made.

Robust evidence suggests that the oral dosage of 4 to 6g beta alanine per day, over 4-10 weeks, increases carnosine concentrations by 40-80% (Blancquaert et al, 2015). Regarding the studies mentioned above, a dose response relationship is observed were the studies which prescribed > 4g for a longer duration, reported greater improvements in performance compared to those that prescribed 4g for a shorter period of time. Looking closer we can see that Derave et al (2007) observed no significant differences in 400 meter running time trial performance following 4 weeks of beta alanine supplementation (4. 8 g·day â˘’1) suggesting that a larger dose over a longer duration may be needed to see enhanced performance. For example, two studies previously mentioned, showed that 4-6 weeks of 6. 4 g·day â˘’1 beta alanine supplementation improved time trial performance in well-trained subjects (de Salles Painelli et al, 2013; Hobsen et al, 2013).

Regarding training status, Bex et al (2013) showed that well-trained subjects may be more responsive to beta alanine supplementation compared non-trained subjects. Furthermore, a recent study (de Salles Painelli, 2014) directly comparing whether well-trained subjects respond differently to beta alanine in comparison to non-trained subjects reported that beta alanine improves performance to a comparable extent in both well-trained and non-trained subjects. These observations are in agreement with the studies mentioned above where improvements were seen in well-trained subjects (Hobsen et al, 2013; Derave et al, 2007; de Salles Painelli, 2014). This illustrates the efficacy of beta alanine as an ergogenic aid irrespective of the training status of the subjects. Therefore, athletes as well as recreationally fit subjects could benefit from beta alanine supplementation. Overall, the scientific literature supports the claim that beta alanine supplementation has the potential to enhance short duration high intensity workouts performance. In addition, the evidence supports that beta alanine has a weakened ergogenic affect with regards to long duration performance (Oches, 2016).

Another recent claim made within the ‘ lay’ literature, states that sodium bicarbonate improves endurance performance by lowering blood lactate levels (Strength & Fitness UK, 2017). Further recommends are that endurance athletes should supplement with 0. 3g·kg $^{-1}$ of body mass to see improvements in endurance race performance. Lastly, it is suggested that the dose of beta alanine should be split into several smaller doses and ingested throughout the day. The rationale for this claim is based on the putative concept that the disassociation of lactic acid forms lactate and H+ which in turn decreases intracellular and extracellular pH. As mentioned before, sodium bicarbonate increases the extracellular buffering capacity by increasing the blood bicarbonate concentration, thereby causing an efflux of H+ from the muscle cells to the blood. Consequently, any ergogenic potential that sodium bicarbonate may impose depends upon the physiological demands of the exercise being adequate enough to induce a performance inhibiting level of metabolic acidosis.

Looking closer we can see that there is substantial evidence demonstrating the ergogenic effect of sodium bicarbonate improving performance during short duration high intensity exercise. This effect has been reported within a range of exercise modalities which are known to elicit decreases in intracellular and extracellular pH, such as single bouts of supramaximal exercise (Thomas et al, 2015; Driller et al, 2012), high-intensity intermittent activities (Tan et al, 2010; Miller et al, 2015), and certain skill-based sports, such as judo and tennis (Tobias et al, 2010; Wu et al, 2015). In contrast, research investigating the use of sodium bicarbonate as a buffering aid in endurance performance has shown more inconclusive results (George and MacLaren 1988; McNaughton et al, 1999; Stephens et al, 2002; Northgraves et al, 2014).

Delving deeper, studies which reported improvements in performance were those that tended to exhaust subjects in 1 to 7 minutes using repeated exercise bouts or single intervals (Thomas et al, 2015; Driller et al, 2012; Miller et al, 2015). The improvements seen here are likely to have been due to the energy system being utilized at the time, as much evidence illustrates that sprint-based exercises accumulate more intracellular and extracellular acid compared to endurance-based exercises (McNaughton et al, 2016), so it is likely that they will benefit more from the buffering capacity of bicarbonate than endurance athletes. For example, Northgraves et al (2014) reported no improvements for 60 minute time trial performance following sodium bicarbonate supplementation (0. 3g·kg $^{-1}$ body mass) compared to Thomas et al (2015) where performance was enhanced by a 2. 2% increase in mean power output during 70 seconds of all-out sprint. It must be pointed out that not all anaerobic based studies have observed a benefit following supplementation. The major differences in these studies are the timing of the dose and the trained state of the study subjects. It is also possible that large individual differences exist as far as response to supplementation is concerned.   For instance, a recent observation shows that individuals respond differently to 0. 3g·kg $^{-1}$ body mass sodium bicarbonate supplementation, where time to peak pH ranged from 10 to 90 min post ingestion (Miller et al, 2016). This shows a high variability in the dose-response from sodium bicarbonate and holds a considerable limitation to all previous research that have usually utilized a standard pre-ingestion time of between 60 and 90 minutes and interpreted the response as an average of the group. This observation may have considerable practical implication, as a more personalized approach to sodium bicarbonate supplementation can be employed by athletes to elicit larger ergogenic effects. With regards to the dosage, substantiated evidence suggests that 0. 3g·kg $^{-1}$ – 5g·kg $^{-1}$ body mass of sodium bicarbonate is effective. Doses which are not within this range show to be less advantageous for enhancing performance and have shown to cause gastrointestinal discomfort (REF).

Regarding training status, a common conception is that well-trained athletes are less likely to benefit from the use of sodium bicarbonate as their buffering systems are already so well developed. Although, a recent observation is that well-trained subjects are able elicit gains in performance from sodium bicarbonate more readily compared to non-trained subjects (Carr et al, 2011). This observation appears to be in line with the studies mentioned in this review which employed short duration high intensity exercise. For example, studies involving well-trained subjects showed improvements in performance (Thomas et al, 2015; Driller et al, 2012) whereas, smaller improvements were observed in studies involving non-trained subjects (Peart et al, 2013; Vanhatalo et al; 2010). Looking closer we can see that Vanhatalo et al (2010) reported no improvements in 3-min all-out sprint performance were observed following a dose of 0. 3g. kg. bm sodium bicarbonate, among recreationally active subjects. Whereas among well-trained subjects, Driller et al (2012) reported ~3% performance improvement in average power during a 4 minute all-out sprint following the same sodium bicarbonate supplementation (0. 3g. kg. bm).

Conclusion

To summarise the literature reviewed, offering conclusions on the value and appropriateness of lay literature available to modern day athletes and performers.

(Synergist with bicarbonate ; Co-supplementation of Î²-alanine and sodium bicarbonate, to increase both intracellular and extracellular buffering capacity, was shown to result in additional improvements above Î²-alanine alone).

This is where you will make your conclusions about the truth of the claims.

References

Artioli, G. G., Gualano, B., Smith, A., Stout, J. and Lancha Jr, A. H., (2010). Role of beta-alanine supplementation on muscle carnosine and exercise performance. *Med Sci Sports Exerc* , *42* (6), pp. 1162-1173.

Bex, T., Chung, W., Baguet, A., Stegen, S., Stautemas, J., Achten, E. and Derave, W., (2013). Muscle carnosine loading by beta-alanine supplementation is more pronounced in trained vs. untrained muscles. *Journal of applied physiology* .

Carr AJ, Hopkins WG, Gore CJ. Effects of acute alkalosis and acidosis on performance: a meta-analysis. Sports Med. 2011; 41: 801Y14.

Chung, W., Baguet, A., Bex, T., Bishop, D. J. and Derave, W., (2014). Doubling of muscle carnosine concentration does not improve laboratory 1-hr cycling time-trial performance. *International journal of sport nutrition and exercise metabolism* , *24* (3), pp. 315-324.

de Salles Painelli, V., Roschel, H., De Jesus, F., Sale, C., Harris, R. C., Solis, M. Y., Benatti, F. B., Gualano, B., Lancha Jr, A. H. and Artioli, G. G., (2013). The ergogenic effect of beta-alanine combined with sodium bicarbonate on high-intensity swimming performance. *Applied Physiology, Nutrition, and Metabolism* , *38* (5), pp. 525-532.

de Salles Painelli, V., Saunders, B., Sale, C., Harris, R. C., Solis, M. Y., Roschel, H., Gualano, B., Artioli, G. G. and Lancha Jr, A. H., (2014). Influence of training status on high-intensity intermittent performance in response to Î²-alanine supplementation. *Amino acids* , *46* (5), pp. 1207-1215.

Ducker, K. J., Dawson, B. and Wallman, K. E., (2013). Effect of Beta alanine and sodium bicarbonate supplementation on repeated-sprint performance. *The Journal of Strength & Conditioning Research* , *27* (12), pp. 3450-3460.

Mero AA, Hirvonen P, Saarela J, et al. Effect of sodium bicarbonate and betaalanine

supplementation on maximal sprint swimming. J Int Soc Sports Nutr

2013; 10: 52.

Fitts RH. The cross-bridge cycle and skeletal muscle fatigue. J. Appl. Physiol.

2008; 104: 551Y8

Nieper, A., (2005). Nutritional supplement practices in UK junior national track and field athletes. *British journal of sports medicine* , *39* (9), pp. 645-649.

Oches, E. (2016). *Everything You Need To Know About Beta Alanine.* Available: https://gymjunkies. com/beta-alanine/. Last accessed 12th Feb 2017.

Petróczi, A., Naughton, D. P., Pearce, G., Bailey, R., Bloodworth, A. and McNamee, M., (2008). Nutritional supplement use by elite young UK athletes: fallacies of advice regarding efficacy. *Journal of the International Society of Sports Nutrition* , *5* (1), p. 22.

Saunders, B., Sale, C., Harris, R. C. and Sunderland, C., (2012). Effect of beta-alanine supplementation on repeated sprint performance during the Loughborough Intermittent Shuttle Test. *Amino acids* , *43* (1), pp. 39-47.

Solheim, S. A., Nordsborg, N. B., Ritz, C., Berget, J., Kristensen, A. H. and Mørkeberg, J., (2016). Use of nutritional supplements by Danish elite athletes and fitness customers. *Scandinavian journal of medicine & science in sports* .

Smith-Ryan, A. E., Fukuda, D. H., Stout, J. R. and Kendall, K. L., (2012). High-velocity intermittent running: effects of beta-alanine supplementation. *The Journal of Strength & Conditioning Research* , *26* (10), pp. 2798-2805.

Van Thienen, R., Van Proeyen, K., Vanden Eynde, B., Puype, J., Lefere, T. and Hespel, P., (2009). b-Alanine improves sprint performance in endurance cycling. *Med Sci Sports Exerc* , *41* (4), pp. 898-903.