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The effects of novel ingestion of sodium bicarbonate on repeated sprint ability

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The effects of sodium bicarbonate ingestion on repeated sprint ability

Abstract

Purpose: To examine the influence of an acute dose of sodium bicarbonate ($NaHCO_3$) on buffering capacity and performance during a repeated sprint ability (RSA) protocol. **Methods:** Eleven (mean ± SD: age 24.6 ± 6.1y; mass 74.9 ± 5.7kg; height 177.2 ± 6.7cm) participated in the study, undertaking four test sessions. On the first visit to the laboratory, each participant ingested 300 $mg \cdot kg^{-1}$ of $NaHCO_3$ (in 450ml of flavoured water) and blood samples were obtained at regular intervals to determine the individual times peak pH and HCO_3^- response time. During the subsequent visits, participants ingested either 300$mg \cdot kg^{-1}$ of $NaHCO_3$, or 270 $mg \cdot kg^{-1}$ BM of NaCI or no drink followed by a RSA cycling protocol (10 x 6s sprints with 60s recovery), which commenced at each individuals pre-determined ingestion peak pH response time. Blood samples were obtained pre-exercise, and after the 1^{st}, 5^{th} and 10^{th} sprint to determine the blood pH, HCO_3^- and lactate (La^-) responses. **Results:** The total work completed during the repeated sprint protocol was higher ($P < 0.05$) in the $NaHCO_3$ condition (69.8 ± 11.7kJ) compared with both the control (59.6±12.2 kJ) and placebo (63.0±8.3 kJ) conditions. Peak power output (PPO) was similar ($P > 0.05$) between the three conditions. Relative to the control and placebo conditions, $NaHCO_3$ ingestion induced higher ($P < 0.05$) blood pH and HCO_3^- concentrations pre-exercise and during the bouts, and higher lactate concentrations ($P < 0.05$) following the final sprint. **Conclusion:** The results from the present study suggest that $NaHCO_3^-$ improves the total amount of work completed during RSA through enhanced buffering capacity.

KEY WORDS: ergogenic, total work, power RSA

INTRODUCTION

There are many factors which contribute to optimal team, football and hockey as well as individual sports performance, such as judo, boxing and some racquet sports. However, the importance of an athlete's ability to cope with repeated bouts of high intensity exercise is axiomatic (Artioli et al., 2007, Girard *et al.* 2011). Athletes involved in such disciplines must contend with repeated maximal or near maximal efforts interspersed with brief recovery intervals consisting of complete rest or low to moderate intensity activity (Roth, 1991). Time-motion analysis in team sports has shown that sprinting generally constitutes 1-10% of the total distance covered during match-play and such actions often precede decisive moments in the game (Girard et al., 2011; Spencer et al., 2004; Buchheit et al., 2010). Repeated sprint ability (RSA) is the term used to define the fitness component that requires players participating in team and racquet sports to perform repeated sprints within a relatively short time frame (Girard et al. 2011).

There is a reversible decline in force production by muscles when contracting at or near their maximum capacity which is regularly observed in athletes when performing RSE, however, the task-dependant nature of fatigue propounds that the mechanisms of fatigue may differ (Bishop, 2012). Ability to sustain repeated sprint exercise is thought to be influenced by several physiological factors such as limitations with energy supply as towards the latter end of the sprints for example with the depletion of adenosine triphosphate phosphocreatine stores (Bishop, 2012; Girard et al. 2011), and maximal oxygen uptake (Bishop and Spencer, 2004; Spencer et al. 2008) and oxygen uptake kinetics (Dupont et al. 2005). Conjoint mechanisms also include muscle excitability through marked ionic disturbances at the skeletal muscle level, leading to the Na^+ -K^+ pump becoming unable to re-accumulate the potassium (K^+) efflux (Bishop, 2012), the accumulation of inorganic phosphate, increase in hydrogen ions (H^+), corresponding decrease in pH and augmented lactate formation (Gaitanos et al. 1993). All of which have been found to contribute to the development of fatigue and a decline in power output (Mendez-Villanueva et al. 2008).

Current research appears to support the view that a low pH may affect sprinting performance (Bishop et al. 2004; Artioli et al. 2007) via its adverse effects on contractile machinery (i.e. interference with Ca^{2+} release from the sarcoplasmic reticulum and its binding to troponin) and/or by inhibiting the ATP yield from anaerobic glycolysis, through allosteric interference with key regulatory enzymes phosphofructokinase and glycogen phosphorylase (Spreit et al. 1985). At the onset of anaerobic exercise, the working muscles produce protons which are rapidly transported out of the muscle cell to be treated by circulating buffers, such as bicarbonate, and this process comprises the first line of defence against H^+ accumulation (Sale et al. 2011). As such, many researchers consider exogenous sodium bicarbonate ($NaHCO_3$) supplementation appropriate to exploit this mechanistic chain of events through increasing the body's alkaline reserve thereby enhancing muscle buffering capacity and performance in highly training athletes (for review, see McNaughton et al. 2008). Over the last two decades, accumulating research has provided ample support for the assertion that increased extracellular pH and augmented HCO_3^- content enhance the H^+/La^- efflux from exercising muscle (McNaughton, 1992; Raymer et al. 2003; Burke & Pyne 2007). An increase in the extracellular concentration of bicarbonate enhances the intracellular/extracellular H^+ gradient during intense anaerobic exercise, working in conjunction with an increase in the activity of the H^+/La^- co-transporter (Roth, 1991), consequently allowing more work to be completed from the exercising muscles during repeated bouts of anaerobic exercise.

The H^+ buffering systems of the body are positively associated with RSA during team sports (Rampinini et al., 2009) therefore, an intervention designed to increase buffering capacity may be of benefit to this type of exercise. Evidence for this is borne out in research by Lavender and Bird (1989) who reported that ingestion of $NaHCO_3$ significantly improves sprinting performance consisting of ten, 10 sec cycle sprints interspersed with 50 sec recovery. Ducker et al. (2013) findings lend support to the claim that $NaHCO_3$ improves RSE performance consisting of three sets of six, 20 m sprints with 25 sec recovery and 4 min between each set. However, Matsuura and colleagues (2007) did not find significant results with two sets of ten, 10 second cycling sprints interspersed

with either 30 second or 360 sec recovery. It is unclear why there are such disparities in previous findings, however, such inconsistencies could be a result of contrasting dosing regimens and possible implications on gastrointestinal (GI) discomfort (Carr et al*.,* 2011).

Although the above studies have examined $NaHCO_3$ ingestion on maximal sprint performance, the protocols employed have not taken inter-individual variability in responses to $NaHCO_3$ in account. It has been suggested that a beneficial effect of induced alkalosis on performance requires a sufficient time for the H^+ gradient between the intramuscular and vascular compartments to develop, and therefore a more pronounced ergogenic effect might be expected if peak threshold elevations in blood pH is calculated prior to the commencement of activity (McNaughton & Cedaro, 1991). Therefore, a novel aspect of the present study is that peak responses were calculated prior to the commencement of exercise trials, thus allowing subjects to obtain the maximum level of ergogenicity from $NaHCO_3$ consumption (Saunders et al., 2014). The aim of this work was to examine the influence of an acute dose of sodium bicarbonate ($NaHCO_3$) on buffering capacity and performance during a RSA cycling protocol. It was hypothesised that RSA would be improved following supplementation prescribed in an individual fashion based upon prior response times to the same dose of with sodium bicarbonate.

METHODS

Experimental Approach to the Problem.

Given that sodium bicarbonate is an allowed ergogenic aid, we wanted to determine the timings of peak pH so that performance times could be individually tailored to a subject. We hoped that this would individualise the response in order to maximise the dose during anaerobic performance.

Subjects. Eleven male active team and individual sports participants volunteered to participate in the study (mean ± SD: age 24.6 ± 6.1y; mass 74.9 ± 5.7kg; height 177.2 ± 6.7cm). All subjects were familiar with high-intensity exercise and on average took part in at least two hours of intermittent team or individual sporting activity per week. Subjects were excluded if they were smokers, taking medication or suffering from any chronic diseases. The subjects were informed of both the benefits

and the potential side effects associated with the study (both verbally and in writing), before providing written informed consent. The study was approved by the institutional Departmental Ethics Committee.

Procedures. The subjects attended the laboratory on four separate occasions, three of these required the participants to perform the RSA protocol (experimental conditions) and one session was allocated to determine each individuals resting blood pH and HCO_3 responsiveness to $NaHCO_3$ ingestion. Testing was undertaken in a randomised placebo-controlled double-blind crossover design. Participants ingested either 300 $mg \cdot kg^{-1}$ (BM) of $NaHCO_3$ (Experimental [E]) or 270 $mg \cdot kg^{-1}$ BM of NaCl (Placebo [P]) taken in 400 ml of water with 50 ml of flavoured cordial, as this has been used in previous studies (Price et al., 2003). Sodium Chloride has been used as a control or placebo substance as it matches the Na^+ content in $NaHCO_3$ (Driller et al., 2013). Flavoured cordial was used to increase the palatability and partially disguise the slight difference in taste between the two substances (Lavender and Bird, 1989). In the control condition (C), no drink was consumed. The use of a placebo during an ergogenic aid intervention has been widely used to control the participants perceptions about the likely outcome from receiving a treatment (Beedie, Coleman and Foad, 2007; Beedie and Foad, 2009). A 7-day wash out period was used to ensure that participants' acid-base status had returned to normal between each trial, as seven days is deemed sufficient enough to remove any ergogenic effect of sodium bicarbonate (Bishop and Claudius, 2005). Participants were asked to refrain from alcohol and any beverages other than water, and maximal exercise 24 h before each trial. This procedure has been used in various RSA protocols to prevent any disturbance in acid-base status arising from extraneous variables (McNaughton et al., 2011, Bishop et al., 2004, Lavender and Bird, 1989).

First Visit. On the first visit the participants reported to the laboratory where a 300 µl resting capillary blood sample was taken aseptically from the fingertip. The participants then consumed 300 $mg \cdot kg^{-1}$ (BM) of $NaHCO_3$ in 400ml of water with 50ml of flavoured cordial. Blood HCO_3^- and pH concentrations were then measured (Radiometer ABL800, Denmark) from finger prick blood samples

at ten minute intervals for 70 min followed by blood sampling every 5 minutes up to 90 min. This procedure was used to determine the participants' individual physiological response to $NaHCO_3$ and their peak blood pH and HCO_3^- concentrations following $NaHCO_3$ ingestion. The dose used in this study has previously been found to improve repeated sprint performance (Bishop et al., 2004, Gaitanos et al., 1990, Lavender and Bird, 1989).

Repeated Sprint Cycling Test. The repeated sprint cycling protocol comprised 10 x 6s sprints with 60s recovery on an SRM cycle ergometer (SRM® Jülich, Germany) set at open ended test, and was designed to replicate the high-intensity sprints that are performed in team sports (Dawson, 2012; Oliver et al., 2006; Bishop et al., 2004). The SRM ergometer indicates peak and mean power (W) and allows for the calculation of total work (kJ). On arrival, the participants consumed either 300 $mg \cdot kg^{-1}$ (BM) of $NaHCO_3$, a placebo containing 270 $mg \cdot kg^{-1}$ BM of NaCl or no supplement. In the E and P conditions, the participants were instructed to consume the entire volume of liquid within a 5 min period. The start time of the RSA test was prescribed on an individual basis and corresponded with each participants' time to reach peak blood pH during the first laboratory visit**.** Prior to experimental testing, participants also performed a 5-minute warm up on the cycle ergometer pedalling at 60W. The handle bar position and seat height position was adjusted according to participants' preference and was standardised for each test thereafter. A cycle ergometer was used since it allows precise recordings of the different exercise intensities and has been used routinely to examine the influence of interventions on RSA in a variety of participants (Spencer et al., 2005).

Before the test began the participants were required to assume a standing position on the ergometer to overcome inertia and to standardize the position of the crank at the start (Spencer et al. 2005) after which they rode in the sitting position. A standing stationery start was used as it produces high peak power outputs and a greater degree of sprint consistency compared to a rolling start (Lavender and Bird, 1989). Participants were given a five second verbal countdown to perform the 1st six second sprint, once this sprint was completed the participant was told to immediately stop and assume the resting position, which comprised a seated position, on the ergometer for one min.

The same verbal countdown instructions were provided to the participants 5s prior to commencing each subsequent sprint. Blood pH and blood La^- was recorded after the 1st,5th and 10th sprint using a blood gas analyser (Radiometer ABL800, Denmark) and a blood La^- analyser (Lactate Pro LT 17-10, Akray, Japan; McNaughton et al., 2002).

GI-Symptoms assessment Questionnaire. Due to the gastrointestinal (GI) side effects associated with $NaHCO_3$ ingestion (Carr et al. 2011, Siegler et al., 2012) an assessment of functional GI disorders was undertaken using a GI-Tolerability Assessment Questionnaire (Cameron, McLay-Cooke, Brown, Gray, & Fairbairn, 2010). Participants completed a questionnaire prior to and 60 minutes after ingestion of the test drinks. The questionnaire consists of two questions, the second question consisted of nine 100-mm visual analogue scales (VASs). The VASs were anchored at each end of starting with *no symptom* on the left side and *severe symptom* on the right. Participants were asked to rate the severity of the symptoms by placing a vertical mark on the line. This method was used to measure GI symptoms of nausea, flatulence, stomach cramping, belching, stomach ache, bowel urgency, diarrhoea, vomiting and stomach bloating (Cameron et al., 2010).

Statistical Analysis. Statistical analysis of this study was undertaken using SPSS (Version 20, IBM, Chicago). All values are reported as Mean±SD. In all cases, the level of significance was set at $p < 0.05$ for the dependent variables.

A 2-way (condition x sprint) repeated measures ANOVA was performed on the dependent variables (meeting the assumptions of parametric data) to identify differences in these parameters between the experimental conditions and sprints. Bonferroni post hoc tests were used where appropriate. Total work (kJ) was calculated from the SRM (open ended test) data as was peak power for each sprint test. Blood variables where analysed after the 1st, 5th and 10th sprint. Examination of the severity ratings of the GI side effects between the $NaHCO_3$ and placebo conditions were assessed using a paired samples *t*-tests.

RESULTS

The times to peak pH to determine the optimum loading strategy, are shown in Figure 1. The range of times was 10-90 min, with the mean time being 68.2±21.0min. The correlation between time to peak pH and time to bicarbonate peak time was r=0.95.

Performance Parameters. There was a main effect of condition (F = 10.63; p=0.01, η^2 = 0.515) for total work completed during the repeated-sprint protocol. A comparison of the trials indicated that there were no differences in work completed between the C and P trials (59.6±12.2 kJ vs 63.0±8.3 kJ, p=0.12). However, in the E trial, ingestion of $NaHCO_3$significantly increased total work (69.8 ± 11.7kJ) compared to the control, (p=0.002) and placebo trials (p=0.016).

The mean peak power output for the three trials and during all sprints can be seen in Figure 2. There was no effect of condition (F = 2.74, p=0.089, η^2 =.0.22), but there was an effect of sprint (F = 216.87, p<0.001, η^2 = 0.42). There was also no interaction effects (F = 1.612, p=0.061, η^2 =0.14).

Blood Parameters. There was a significant interaction effect of condition and sprint (F= 6.86, p=0.001, η^2 = 0.41). There was also a significant effect of both condition (F= 24.39, p=0.001, η^2 = 0.71) and time (F= 55.99, p=0.001, η^2 = 0.85). There were no significant differences in resting pH between the three conditions (C =7.40±0.01; P = 7.40±0.02; E =7.41±0.04). Post $NaHCO_3$ ingestion there was a significant (p=0.001) increase in pH in the E trial (7.44±0.03) as compared to both C (7.40±0.01) and P (7.40±0.02) trials ingestion. Pre-ingestion, blood HCO_3^- concentrations were not significant between conditions (C 23.43 ± 1.2 $mmol \cdot L^{-1}$; P 23.1± 0.9 $mmol \cdot L^{-1}$ and E 23.48 ± 0.7 $mmol \cdot L^{-1}$, *F* = 2.06, *p* = 0.16, η^2 = .22). However, $NaHCO_3$ ingestion resulted in a significant increase in the HCO_3^- response to the first sprint, which was absent in the control and placebo conditions (condition x sprint interaction; P =?). Figure 3 shows the blood pH (A) and blood bicarbonate (B) responses in the three trials.

Ingestion of $NaHCO_3$ in the E condition (27.66 ± 0.9$mmol \cdot L^{-1}$) significantly increased HCO_3^- concentrations after the 1st, sprint compared to the C and P (F = 113.57, *p*< 0.001, η^2 = .94). Likewise there were higher HCO_3^- concentrations in E after the 5th sprint compared to the control and placebo

(F = 20.11, $p < 0.05$, $\eta^2 = .74$). After the 10th sprint however, there were no significant differences between the three conditions (p=0.34).

Resting blood lactate (La^-) was not significantly different between the three conditions (F = 1.14 p = 0.33, $\eta^2 = .14$). There was no significant difference in blood La^- after the 1st sprint between C, E and P (1.8 ± 0.7, 2.2 ± 1.0, 1.9 ± 0.4 mmol·L^{-1} respectively; F = 0.66 p = 0.65, $\eta^2 = .08$. Blood La^- after the 5th sprint also showed no significant difference between the three conditions (4.6 ± 2.6, 6.2 ± 2.7 and 5.8 ± 2.6, mmol·L^{-1}, C, P, and E, respectively), F= 2.10 P = 0.09, $\eta^2 = .23$. However relative to C (7.1 ± 2.9 mmol·L^1), blood La^- was significantly higher in the E condition (9.8 ± 3.1 mmol·L^{-1}) after the 10th sprint ($p< 0.05$). No significant difference was found between the E and P (8.6 ± 3.1 mmol·L^{-1}; F = 3.6 p = 0.09, $\eta^2 = .34$).

Gastro-Intestinal Parameters. Figure 4 indicates the severity of GI discomfort symptoms pre (A) and 60 min post ingestion (B) of NaHCO3 and placebo. Analysis of the severity of acute GI discomfort indicated no significant difference in nausea (p= 0.38), flatulence (p = 0.45), belching (p = 0.17), bowel urgency (p = 0.14), vomiting (p = 0.35) and stomach bloating (p = 0.95) (Figure 5a). However, there was a significant increase in stomach cramping ($p \leq 0.05$), stomach ache ($p \leq 0.05$) and diarrhoea ($p \leq 0.05$) following $NaHCO_3$ ingestion compared to the placebo. (Figure 5a).

After 60 min post $NaHCO_3$ingestion, Figure 5 (B) shows there was a significant increase in all of the parameters measured.

DISCUSSION

This is the first work that we know of to utilise an individualised timing protocol to investigate the use of $NaHCO_3$ during a repeated sprint protocol. The results indicate that, despite $NaHCO_3$ having a significant and profound effect on gastro-intestinal upset, total work in the RSA protocol was improved. The results revealed that blood HCO_3^- levels increased and high intensity performance significantly improved after the oral consumption of $NaHCO_3$ when ingested in accordance in individual peak loading times. Previous works have demonstrated increases in blood HCO_3^- and pH after $NaHCO_3$ consumption (Seigler et al., 2007; Higgins et al., 2013); however, previous works

utilising set loading times have produced equivocal results (Sale et al., 2011) and it is stipulated that the performance enhancing effects of $NaHCO_3$ are associated with the degree of metabolic alkalosis induced by timing and dosage (Siegler et al., 2010).

Ingestion of $NaHCO_3$ significantly increased total work done by 17.11% compared to the control trial and 10.8% in comparison to the placebo trial. An induced metabolic alkalinity associated with $NaHCO_3$ ingestion, has previously been associated with an improved in high intensity performance parameters (Higgins et al., 2013). Further data supporting augmented repeated sprint performance may lie in the findings from Ducker et al. (2013), who stipulated that acute supplementation of $NaHCO_3$ significantly improved a three set RSA protocol (6 x 20 m sprints in a gymnasium, departing every 25 secs, with 4 minute active recovery between sets). Similarly, Bishop et al. (2004) recorded a 6% in total work done during a single set repeated sprint test (5 x 6 second cycle test, 30 seconds rest). Due to the anaerobic nature of RSA resulting in an accrual of H^+, previous studies have elucidated to an interference with metabolism and consequent muscular fatigue (Spriet et al., 1985). Over the course of a football match, players experience an increase in fatigue, occurring at several points of the match, such as following intense periods, at the beginning of the second half and towards the end of the match, which manifests itself as a decline in work rate (Reilly et al., 2008) and less high intensity running. Although the mechanisms behind the development of fatigue is axiomatically multifactorial, due to intermittent nature of the sport and contributions from both aerobic and anaerobic energy systems, an individual's ability to offset fatigue is a key factor in increasing a player's efficiency at performing during precise movements (Reilly et al., 2008) and manipulating just one contributor to the decline of high intensity activity during team sports could prove highly beneficial.

The effectiveness of the $NaHCO_3$ ingestion protocol was determined through the evaluation of blood pH and HCO_3^- values, neither values presented significant results pre-ingestion, however, the data corroborated a retardation in the decrease in pH during exercise with a significant increase of 0.03 pH units and HCO_3^- values rose from 23.48 ± 0.7 $mmol \cdot L^{-1}$ to 27.66 ± 0.9$mmol \cdot L^{-1}$ following ingestion,

which were similar to previous studies (Price et al., 2003; Sale et al., 2011). Higher blood HCO_3^- concentrations were also present following the 1st and 5th sprint in the experimental trial compared to placebo and control trials suggesting that there was a significant improvement in the imbalance between the rate of proton release and the rate of proton buffering and removal.

Despite these increases, and proposed augmented transport of H^+ out of the muscle and into the surrounding interstitium, thus allowing for the ions to be buffered by circulating buffers, $NaHCO_3$ ingestion only elicited a significant reaction in the first sprint in comparison to the placebo and control trials; however, a higher yet non-significant PPO was observed in the remaining sprints, except number 6. This is in contrast to studies such as Bishop et al. (2004) who reported significant increases in peak power output in the final three sprints out of a set of 5 after ingesting $NaHCO_3$. Along similar lines, Bishop and Claudius (2005) reported significant improvements in peak power during several sprints in the second half of a prolonged repeated sprint test (2 x 36 minute halves, ~2 minute blocks of 4 second sprint, 100 second active recovery, 20 seconds rest with 2 extra 5 x 2 seconds repeat sprint bouts during each half). The discrepancies in findings between the present studies and the studies that report on an association between induced alkalosis and power production could be a result of differences in sprint times and recovery times used in the protocols, thus perhaps the current test was not able to replicate the full metabolic demand experienced by players during prolonged team sport match play. Furthermore, subjects used in the present study were mostly from an endurance trained background, and both Bishop et al. (2004) and Bishop and Claudius (2005) used team sport trained subjects, therefore, as supplementation would have increased extracellular buffering, the results allude to differences in muscle buffer capacity (βm) between the participants (Edge et al., 2006). According to Bishop and Spencer (2004), endurance athletes were not able to reach high peak power outputs in comparison to team sport trained athletes during RSA protocols. Evidence for an augmented H^+ buffering capacity amongst professional-standard football players is borne out by Rampinini et al. (2009) who observed that βm was positively associated with players' RSA and their playing standard. The likely mechanisms

behind this could be in relation to the high intensities required during training and match play in team sport athletes.

Perhaps contributing to this are the composition of different muscle fibres present in the vastus lateralis of team sport athletes as compared to endurance athletes (Abernethy et al., 1990). Therefore, as supplementation would have increased extracellular buffering, and consequently, the down-regulation of glycogenolysis and glycolysis which typically accompanies blood pH decline would have been blunted, thus allowing these processes to be maintained due to the augmented free adenosine diphosphate, adenosine monophosphate and inorganic phosphate concentrations competing and negating with the pH effect. Consequently the glycogenolytic rate may exceed the maximal pyruvate dehydrogenase rate, and lead to increased intramuscular La^- accumulation and efflux from activated fibres (Hollidge-Horvat et al., 2000). This too would coincide with results in the present study, whereby, albeit non-significant, La^- was 34.8% higher in the experimental trials than the control following the 5^{th} sprint and 6.9% higher than the placebo trial. Following the 10^{th} sprint, a significant difference was found between the placebo and experimental trial, marking a 38% higher La^- concentration resulting from $NaHCO_3$ supplementation compared to the control trial and an non-significant 14% higher score as compared to the placebo trial. Therefore, athletes possessing a higher level of fast twitch fibres, and thus increased ability to recruit high threshold motor units during activities requiring high levels of force, may respond to induced alkalosis more so than their endurance trained counterparts.

Previous studies have suggested that acid base disturbances can have adverse effects on gastrointestinal comfort (Burke & Pyne. 2007; Carr et al., 2011; Saunders et al., 2014) which can have consequent implications for athletic performance (McNaughton, 1992). In the present study, abdominal distress was shown to be significantly more prominent in the $NaHCO_3$ trial than the placebo, resulting in an increase in stomach cramping, stomach ache and diarrhoea in the participants immediately after consumption, and following 60 minutes post-ingestions there was a larger increase in symptoms which may have impacted on performance.

The present study found sodium bicarbonate ingestion significantly increased total work, (kJ) compared the control and placebo conditions. Relative to the control and placebo, $NaHCO_3$ ingestion resulted in an elevated blood buffering capacity pre-exercise and throughout the protocol. However the significant improvements in PPO occurred in the early stages of the protocol, potentially when homeostasis is in a state of flux (i.e. blood pH, HCO_3^-) (Price et al., 2003). The work supports previous work in the area (McNaughton et al., 2011; Bishop et al., 2004; Lavender and Bird, 1989) and we believe that sodium bicarbonate is a useful tool in team and individual sports where RSA is an important requirement. Furthermore, training using $NaHCO_3^-$ for these sports may also be beneficial for future performance (McNaughton et al. 2011; Tan et al. 2010; Edge et al. 2006). The ingestion protocol used in this study increased GI distress amongst the subjects which subsequently may have effected performance (Hobson et al., 2013; Carr et al., 2011; Siegler et al., 2010; Cameron et al., 2010). Splitting the acute or applying a different loading strategy may be a practical way of reducing GI distress without reducing the ergogenic benefit of induced alkalosis (Hobson et al., 2013; Siegler et al., 2010).

PRACTICAL APPLICATIONS

- Athletes and coaches should ensure that, if they use sodium bicarbonate as a performance or training aid, then ingestion and performance timing should be individually applied based on known responses.
- Researchers using sodium bicarbonates in laboratory studies should likewise ensure that participants have been previously tested to determine their response times to a given doseage.

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Figure 1

Mean ± SD pH measurements to determine the time to peak pH. Arrows indicate subjects' time to peak with numbers indicating the number of subjects peaking at that time.

Figure 2

Mean SD Peak Power outputs across the 10 sprints in the three conditions.

* Significantly different ($p<0.05$) to both Control and Placebo conditions

Figure 3

Mean ± SD blood pH (A) and bicarbonate (B) in the three trials and across sprints 1, 5 and 10.

***** Denotes bicarbonate is significantly different ($p<0.05$) from control and placebo

Figure 4.

Mean ± SD severity of GI discomfort symptoms pre (A) and 60 min post ingestion (B) of $NaHCO_3$ and placebo.

* significantly difference from placebo ($p \leq 0.5$) and ** $p < 0.001$. .

Edge Hill University

Professor Lars R. Mc Naughton
Department of Sport and Physical Activity

13 February 2015

Dear Editor,

My colleagues and I would like to submit the manuscript “The effects of novel ingestion of sodium bicarbonate on repeated sprint ability” to the Journal of Strength and Conditioning Research (JSCR). We state that: “The manuscript is original work and not previously published, not is being considered for publication elsewhere until a decision is made as to its acceptability by the JSCR Editorial Review Board”.

We believe the work is novel, given the ingestion regime and that it adds to the current research in the field of ergogenic aids!

We look forward to hearing from you in due course,

Yours Sincerely,

Professor in Sport and Exercise Physiology
PhD, MSc, MBA, BEd, FACSM, FBASES, FESSA, FECSS, FHEA

Title Page (Showing Author Information)

The effects of novel ingestion of sodium bicarbonate on repeated sprint ability

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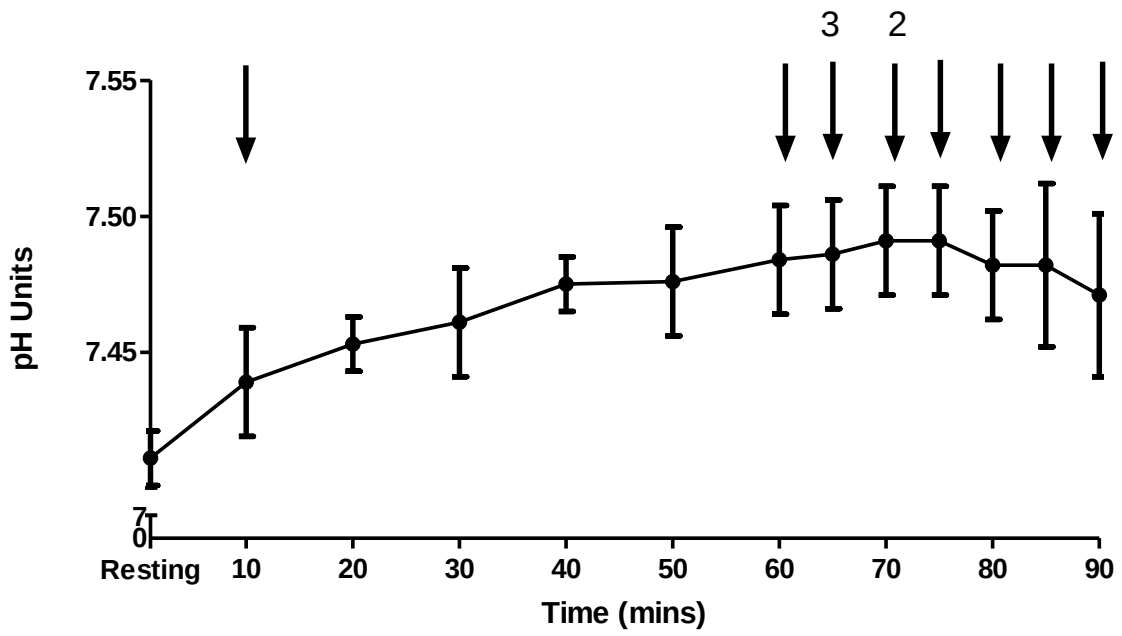
Figure 1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2
7.55
7.50
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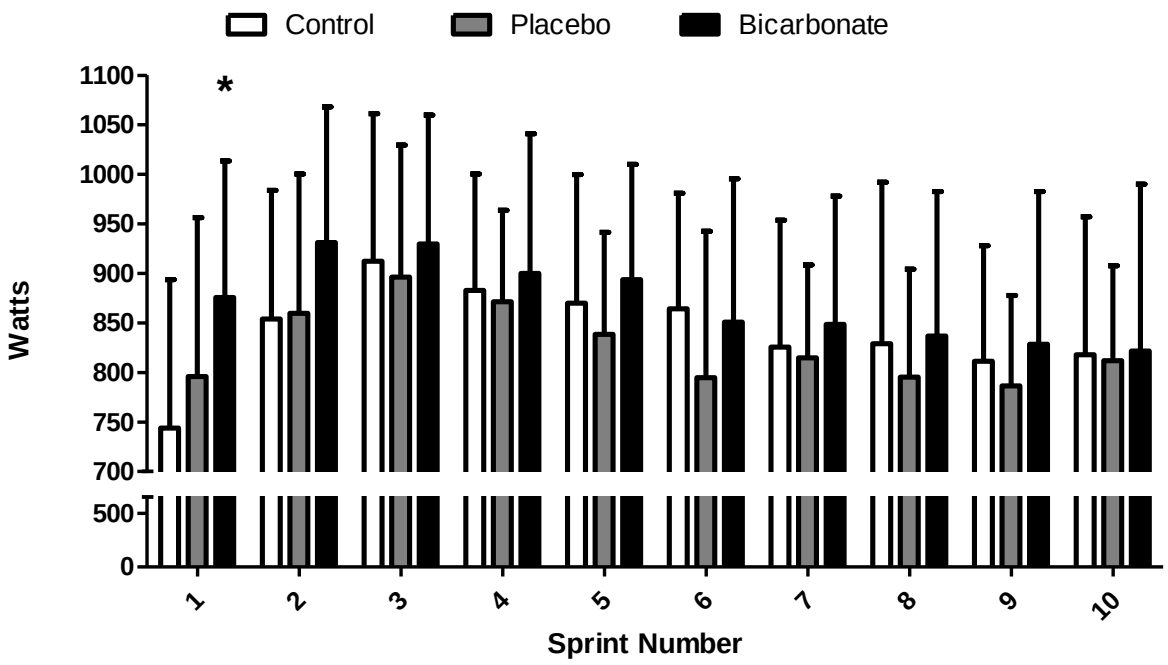
Resting
10
20
30
40
50
60
70
80
90
Time (mins)

Figure 2


Control
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Bicarbonate
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1050
1000
950
900
850
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750
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*
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4
5
6
7
8
9
10
Sprint Number

Figure 3

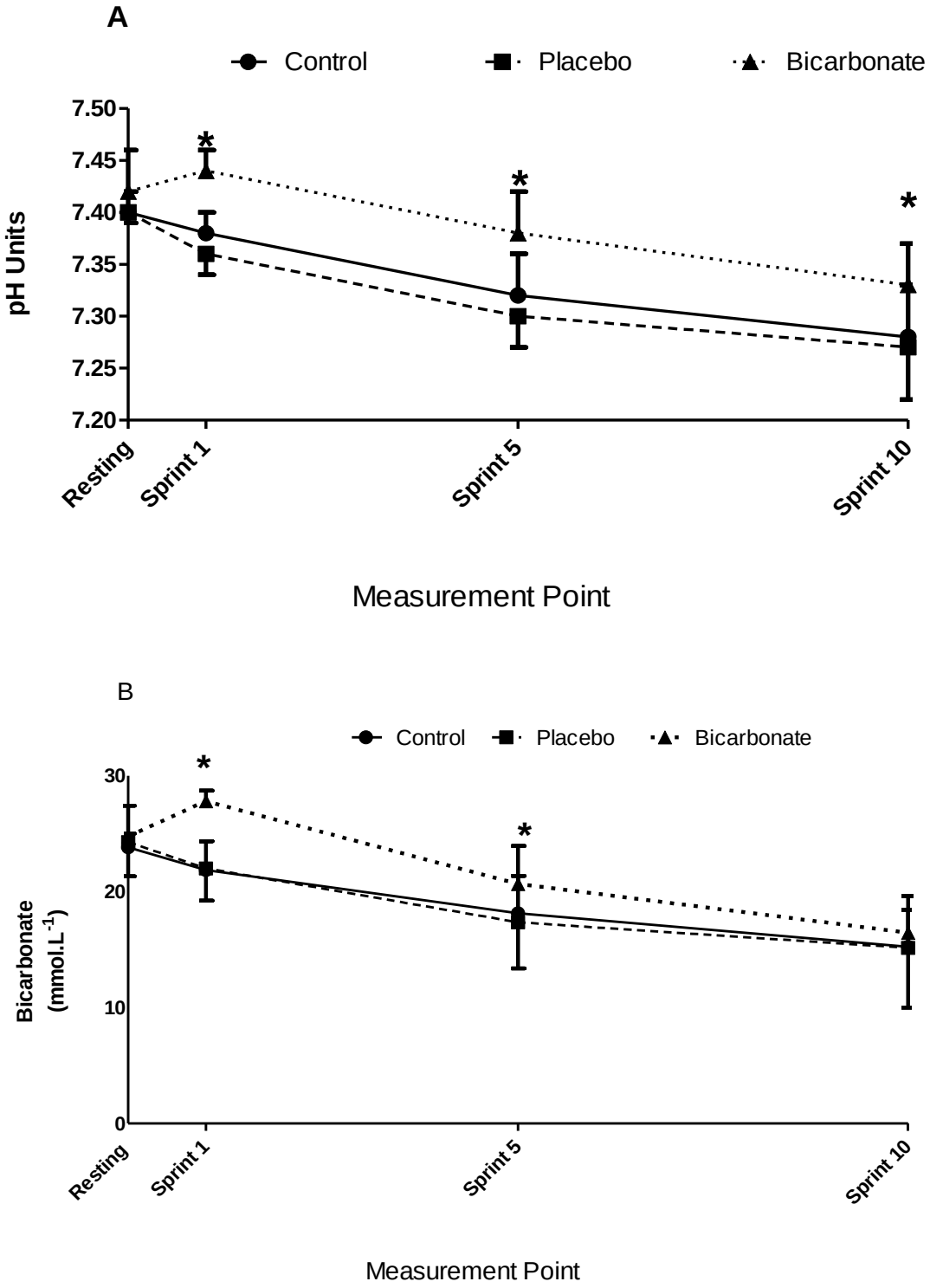
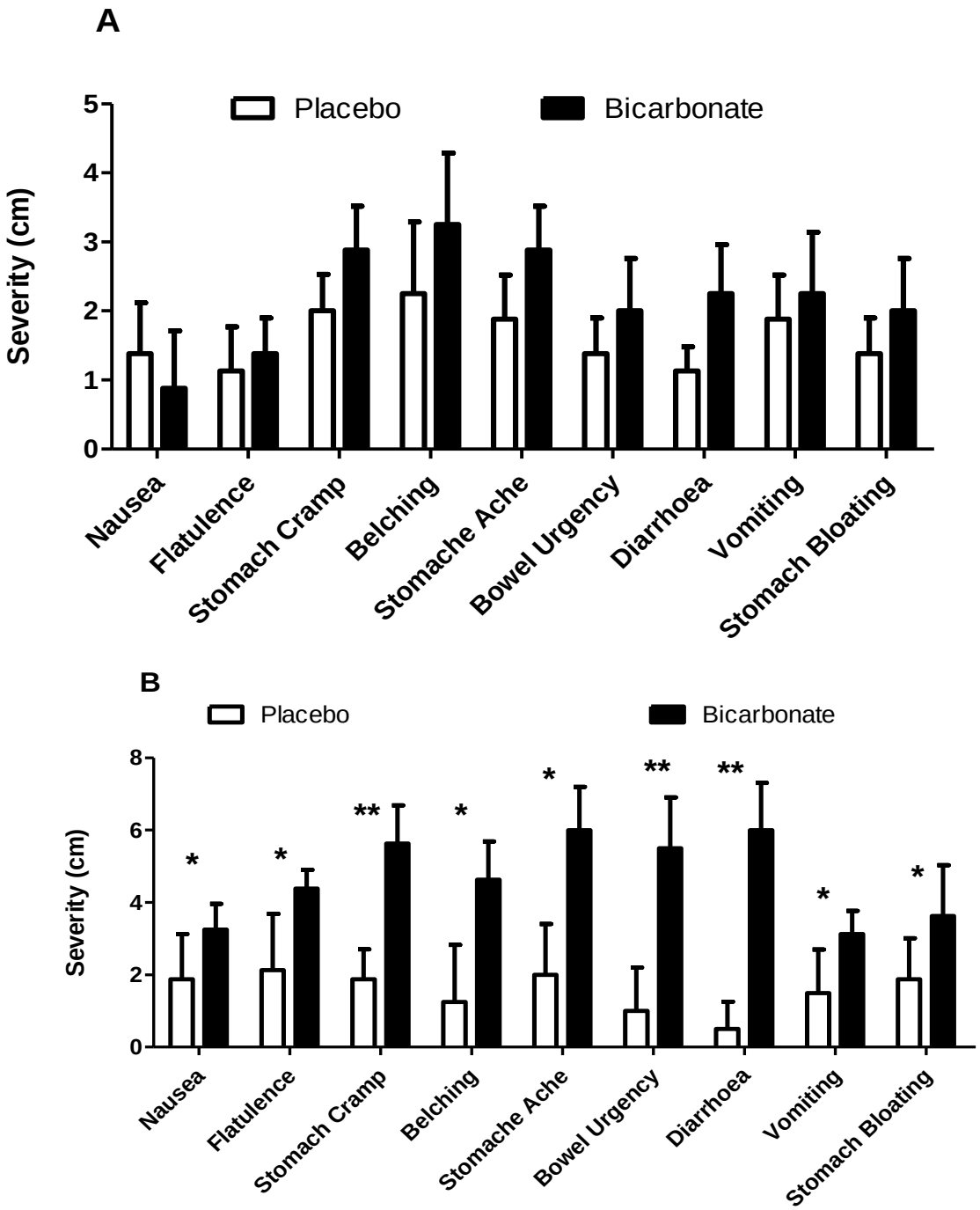

A
Control
Placebo
Bicarbonate
pH Units
7.50
7.45
7.40
7.35
7.30
7.25
7.20
*
*
*
Resting
Sprint 1
Sprint 5
Sprint 10
Measurement Point
B
Control
Placebo
Bicarbonate
Bicarbonate (mmol.L-1)
30
20
10
0
*
*
Resting
Sprint 1
Sprint 5
Sprint 10
Measurement Point

Figure 4.


A
Placebo
Bicarbonate
Severity (cm)
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1
2
3
4
5
Nausea
Flatulence
Stomach Cramp
Belching
Stomache Ache
Bowel Urgency
Diarrhoea
Vomiting
Stomach Bloating
B
Placebo
Bicarbonate
Severity (cm)
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Nausea
Flatulence
Stomach Cramp
Belching
Stomache Ache
Bowel Urgency
Diarrhoea
Vomiting
Stomach Bloating

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