

1 **Effects of 3-day serial sodium bicarbonate loading on performance and physiological**  
2 **parameters during a simulated basketball test in female university players**

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6  
7 **Abstract**

8 The aim of this study was to investigate the effect of 3-day serial sodium bicarbonate  
9 ingestion on repeated sprint and jump performance. Fifteen female university basketball  
10 players (23.3±3.4 years; 173.1±5.8 cm; 65.8±6.3 kg; 23.6±4.9% body fat) ingested 0.4 g·kg<sup>-1</sup>  
11 of body mass of sodium bicarbonate or placebo for 3 days (split in 3 equal daily doses),  
12 before completing a simulated basketball exercise. Sprint and circuit times, jump heights,  
13 performance decrements and gastrointestinal (GI) side effects were recorded during the test  
14 and blood lactate concentration was measured pre- and post-test. Sodium bicarbonate  
15 supplementation led to significant decreases in mean sprint times (1.34±0.23 vs. 1.70±0.41 s,  
16 p=0.008, 95% CI: -0.54 to -0.10 s) and mean circuit times (30.6±2.0 vs. 31.3±2.0 s, p=0.044)  
17 and significantly greater mean jump height (26.8 (range 25.2-34.2) vs. 26.0 (range 25.6-33.6)  
18 cm, p=0.013) compared to placebo. Performance decrement was significantly less for sprints  
19 with sodium bicarbonate compared to placebo (9.9 (range 3.4-37.0) vs. 24.7 (range 4.1-61.3)  
20 %, p=0.013), but not different for jumps (13.1±4.5 vs. 12.5±3.1%, p=0.321) between  
21 conditions. No differences in GI side effects were noted between conditions. Significantly  
22 greater post-exercise blood lactate concentrations were measured in the sodium bicarbonate  
23 condition compared to the placebo condition (8.2±2.8 vs. 6.6±2.4 mmol.L<sup>-1</sup>, p=0.010). This  
24 study is the first to show that serial loading of sodium bicarbonate is effective for basketball  
25 players to improve repeated sprint and jump performance during competition, or withstand  
26 greater training load during practice sessions without any GI side effects.

27

28 **Key words:** sprint, jump, lactate, performance decrement, gastrointestinal.

## 29 **Introduction**

30 Sodium bicarbonate ( $\text{NaHCO}_3$ ) supplementation has been widely studied as a strategy to  
31 delay metabolic acidosis in the muscles during high-intensity short duration (<10 min)  
32 exercise (McNaughton et al., 2016). Ingestion of  $\text{NaHCO}_3$  results in a greater concentration  
33 of bicarbonate ( $\text{HCO}_3^-$ ) in the blood by 4-8  $\text{mmol}\cdot\text{L}^{-1}$ , which in turn buffers hydrogen ( $\text{H}^+$ )  
34 ions and increases blood alkalosis (Jones et al., 2016). Kemp et al. (2006) suggested that this  
35 alkaline environment in the extracellular fluid increased the efflux of  $\text{H}^+$  out of the working  
36 muscles, hence reducing intracellular metabolic acidosis.

37

38 These chemical changes were associated with better performance during several types of  
39 high-intensity exercise (e.g., Bishop et al., 2003). In particular, significant improvements in  
40 repeated sprint ability (RSA) performance were observed following acute doses of  $\text{NaHCO}_3$   
41 ranging from 0.3-0.4  $\text{g}\cdot\text{kg}^{-1}$  body mass (Bishop et al., 2004; Bishop & Claudius, 2005; Afman  
42 et al., 2014; Miller et al., 2016). However, the extent of improvement in RSA performance  
43 varied in these studies, and some even reported no improvements in specific parameters  
44 (Afman et al., 2014; Miller et al., 2016). These discrepancies could be explained by various  
45 exercise protocols (Afman et al., 2014), dosage (Douroudos et al, 2006), gastrointestinal  
46 problems (Burke & Pyne, 2007) or sub-optimal timings of ingestion/individual variation in  
47 response to supplementation (Sparks et al., 2016).

48

49 While most studies used laboratory tests to study the effects of  $\text{NaHCO}_3$  on RSA, these are  
50 largely influenced by pacing strategy (Billaut et al., 2011) and lack ecological validity  
51 (cycling for team sport players, Bishop et al., 2004; Miller et al., 2016). In contrast, Afman et  
52 al. (2014) tested the effectiveness of 0.4  $\text{g}\cdot\text{kg}^{-1}$  body mass  $\text{NaHCO}_3$  ingestion on the  
53 performance of basketball players during a 60-min simulated basketball exercise. The main

54 limitation of this study was the reliance of limited basketball-specific movement patterns  
55 (forward runs/walks, lay-ups and changes of direction). Indeed, basketball incorporates jumps  
56 (35 to 43 per match), and high-intensity shuffles (22 to 58 per match) (Matthew & Delestrat,  
57 2009; Narazaki et al., 2009; Delestrat et al., 2015; Scanlan et al., 2015a, 2015b). While the  
58 metabolic demands of shuffling is not known, Buchheit (2010) showed that adding jumps to a  
59 repeated sprint sequence resulted in greater cardiorespiratory and metabolic demand (+4%  
60 oxygen uptake and +0.8 mmol.L<sup>-1</sup> blood lactate concentration). It is therefore essential to  
61 investigate the effects of NaHCO<sub>3</sub> in simulated basketball by incorporating repeated sprints,  
62 jumps and shuffles. Another discrepancy in the literature is the dose of NaHCO<sub>3</sub> used for  
63 supplementation. While a dose of 0.3 g.kg<sup>-1</sup> body mass is usually recommended (Burke &  
64 Pyne, 2007), higher doses are likely to lead to greater performance improvements  
65 (Douroudos et al., 2006). However, high, acute doses of NaHCO<sub>3</sub> could induce gastro-  
66 intestinal (GI) complaints (Burke & Pyne, 2007; Afman et al., 2014). Consequently, serial  
67 loading (*i.e.* ingesting smaller doses across multiple days before exercise) could be a good  
68 alternative to acute loading. Another advantage of serial loading is that HCO<sub>3</sub><sup>-</sup> levels stay  
69 elevated in the blood for longer after the last ingestion, compared to acute loading  
70 (McNaughton and Thompson, 2001), which could avoid the large inter-individual variability  
71 in response to acute ingestion of HCO<sub>3</sub><sup>-</sup> recently reported in the literature (McNaughton et  
72 al., 2016; Sparks et al., 2016; Gough et al., 2017).

73

74 Within this context, the aim of the present study was to investigate the effects of 3-day serial  
75 NaHCO<sub>3</sub> ingestion on repeated sprint and jump ability and physiological parameters during  
76 simulated basketball exercise in female collegiate basketball players.

77

78

## 79 **Methods**

### 80 *Participants*

81 Fifteen female university basketball players ( $23.3 \pm 3.4$  years;  $173.1 \pm 5.8$  cm;  $65.8 \pm 6.3$  kg;  
82  $23.6 \pm 4.9\%$  body fat) volunteered to take part in the study. The sample included six guards,  
83 five forwards and four centres. At the time of the study, participants were undertaking two 2-  
84 h practice sessions and one match weekly. Participants who had used nutritional supplements  
85 in the past two months or had any metabolic, endocrine or orthopaedic problems were  
86 excluded. Prior to participation, participants were fully informed about all procedures and  
87 gave informed written consent. In addition, approval for the study was granted by the local  
88 ethical committee (DREC 0413\_30).

89

### 90 *Procedures*

#### 91 *Design and overview*

92 The study used a double-blind, cross-over design. Participants first took part in a preliminary  
93 session consisting of anthropometric measurements (height: Harpenden stadiometer, UK,  
94 body mass and body fat: Tanita BC 418 MA Segmental Body Composition Analyser, Tokyo,  
95 Japan) and familiarisation with the simulated basketball exercise. Subsequently, they  
96 performed two test sessions on an indoor basketball court (temperature  $20^{\circ} \pm 2^{\circ}\text{C}$ , humidity:  
97  $45 \pm 4\%$ ) at the same time of day to control for circadian variations and one week apart, each  
98 preceded by supplementation of either  $\text{NaHCO}_3$  or placebo. In the 24-h before the first  
99 session, participants recorded food and fluid consumption in a diary and were required to  
100 replicate this diet before the next test session (Hill & Davies, 2012). Participants were  
101 requested not to consume any caffeine and/or alcohol 24-h before tests (Lavender and Bird,  
102 1989; Wang et al., 1995; Bishop et al., 2004; Stuart et al., 2005). Although caffeine could

103 cause withdrawal in regular caffeine consumers, only 6 of the 15 participants were habitual  
104 users and reported to have a maximum of two daily cups (less than 300-mg caffeine).

105

#### 106 *Supplementation*

107 Participants were administered capsules (MyProtein gelatin caps, Cheshire, UK) containing  
108 either NaHCO<sub>3</sub> (Dr Oetker, Leyland, UK) or calcium carbonate (Sigma-Aldrich Co. LLC.,  
109 Dorset, UK, Stephens et al., 2002) with a daily dose of 0.4 g·kg<sup>-1</sup> body mass for three days  
110 before testing. Indeed, it has been recommended to use higher quantities than the 0.3 g·kg<sup>-1</sup>  
111 body mass commonly administered, while serial loading avoids the GI disturbances usually  
112 reported with such doses ingested acutely (Burke & Pyne, 2007). In addition, capsules were  
113 preferred to powder to mask the taste of the substances ingested and allow blinding of the  
114 participants to the experimental conditions. Capsules were consumed in three equal amounts  
115 throughout the day (during breakfast, lunch and dinner), with the last ingestion at 7pm on the  
116 day before the test. During the supplementation period, participants also reported any  
117 gastrointestinal (GI) side effects on a 10-point Likert scale (Jeukendrup et al., 2000).

118

#### 119 *Basketball simulation protocol: the modified Basketball Exercise Stimulation Test (modified* 120 *BEST)*

121 The BEST was validated by Scanlan et al. (2012, 2014), (Figure 1). We slightly modified this  
122 test, designed for men, to better fit the characteristics of female European basketball players  
123 (circuits lasting 35-s to account for the lower match activity frequencies in women and longer  
124 recovery periods to reflect the different work:rest ratio of 1:4.3 vs. 1:3.6 in women vs. men,  
125 Ben Abdelkrim et al., 2010; Delextrat et al., 2015, and a total number of circuits of 17 to  
126 reflect the duration of a quarter in European basketball). Before each test session participants

127 completed a 10-min warm-up which was typical of their normal pre-game routine involving  
128 jogging, short high-intensity sprints, lay ups and stretching.

129

130 -----Figure 1 here: please refer to appendix-----

131

### 132 ***Outcome measures***

133 During the modified BEST, time to complete the initial sprint of each circuit was recorded  
134 with timing gates (Wireless speedtrap 2, Brower Timing Systems, Draper, Utah, USA), and  
135 the mean of all sprint times (ST) during all circuits was calculated. Subsequently Ideal Time  
136 (IT, s) was calculated as the best average of two sprint efforts (ST2) multiplied by the number  
137 of sprint means (Scanlan et al., 2012), and Total Time (TT, s) was calculated as the sum of  
138 ST2 plus the 17<sup>th</sup> ST (due to the odd number of sprints). Circuit times were recorded with a  
139 digital stopwatch, and the mean circuit time (s) over all circuits calculated. A jump mat  
140 (Ergojump, Globus Inc., Treviso, Italy) was used to record jump height (cm) for every circuit.  
141 The jump performed was a countermovement jump with the hands on hips (Buchheit, 2010).  
142 Finally, sprint and jump performance decrements (Sprint PD and Jump PD) were calculated  
143 by the following equations (Glaister, 2008):

144  $\text{Sprint PD (\%)} = [(\text{TT}/\text{IT}) \times 100] - 100]$

145  $\text{Jump PD (\%)} = [100 - (\text{final jump height}/\text{Initial jump height}) \times 100]$

146

147 Fingertip capillary blood samples were taken at rest, prior to the warm-up, as well as  
148 immediately on completion of the modified BEST (within the first min), with blood lactate  
149 concentration (LA, mmol·L<sup>-1</sup>) measured using a portable analyzer (Lactate Pro, Arkray,  
150 Tokyo, Japan).

151

## 152 **Statistical Analyses**

153 Shapiro-Wilk tests revealed that mean sprint and circuit times, TT, jump PD and LA were  
154 normally distributed. Therefore differences in these outcome measures between NaHCO<sub>3</sub> and  
155 placebo conditions were assessed by Student T-tests for paired samples, and values were  
156 expressed as mean±SD with 95% confidence intervals (95%CI). The remaining outcome  
157 measures were not normally distributed, and for these measures, non-parametric Wilcoxon  
158 rank-sum tests were used to evaluate differences between conditions, and data were  
159 expressed as median and range. An alpha level of  $p < 0.05$  was accepted as statistically  
160 significant. Effect sizes were calculated as Cohen's  $d$  (parametric data) and  $r$  (non-parametric  
161 data, calculated as  $z/\sqrt{n}$ ), and interpreted as *small* ( $>0.1$ ), *medium* ( $>0.3$ ) and *large* ( $>0.5$ )  
162 (Cohen, 1988; Rosenthal, 1994). Finally, the test-retest reliability of the modified BEST was  
163 assessed on 8 participants by the Pearson correlation coefficient ( $r$ ), reliability coefficient  
164 (Mueller & Martorell, 1988), and intraclass correlation coefficient (ICC) for relative  
165 reliability and the technical error of measurement (TEM) and coefficient of variation (%CV)  
166 for absolute reliability. All statistical analyses were performed on IBM SPSS version 22  
167 software, except TEM (Microsoft Excel).

168

## 169 **Results**

170 NaHCO<sub>3</sub> supplementation resulted in significant decreases in mean sprint times (-0.36 s,  $t =$   
171 3.106,  $p = 0.008$ ,  $d = 1.08$ , 95% CI for the difference: -0.54 to -0.10, Table 1) and mean circuit  
172 times (-0.7-s,  $t = -2.209$ ,  $p = 0.044$ ,  $d = 0.39$ , Table 1). Variables calculated from the mean sprint  
173 times averaged every two sprints also showed significant differences between conditions,  
174 with lower IT (-1.62 s,  $z = -2.482$ ,  $p = 0.013$ ,  $d = 0.77$ , Table 1), TT (-3.24 s,  $t = -3.106$   $p = 0.008$ ,  
175  $d = 1.09$ , 95% CI for the difference: -4.79 to -0.88 s, Table 1), and sprint PD (-14.8%,  $z =$   
176 2.329,  $p = 0.013$ ,  $d = 0.79$ , Table 1) shown in the NaHCO<sub>3</sub> condition compared to the placebo

177 condition. NaHCO<sub>3</sub> supplementation also resulted in a significantly greater mean jump height  
178 compared to placebo (+0.8 cm,  $z = -2.481$ ,  $p=0.013$ ,  $d=0.78$ , Table 1), with no significant  
179 difference between conditions in jump PD (-0.6%,  $t: 2.109$ ,  $p=0.321$ , Table 1). Reliability  
180 measures for the modified BEST were  $r = 0.78$  to  $0.91$ ,  $R = 0.82$  to  $0.90$ , TEM =  $0.20$  to  $0.32$ ,  
181 %CV =  $3.5$  to  $5.2$ , ICC =  $0.81$  to  $0.93$ .

182

183 -----Insert Table 1 here: please refer to appendix -----

184

185 While no significant difference between conditions was shown in pre-exercise LA  
186 concentrations ( $p=0.283$ ), significantly greater post-exercise LA was evident in  
187 NaHCO<sub>3</sub> condition compared to placebo ( $+1.6$ -mmol.L<sup>-1</sup>,  $t: 2.954$ ,  $p=0.010$ ,  $d=0.49$ , 95% CI  
188 for the difference:  $0.35$  to  $2.21$ , Figure 2).

189

190 -----Insert Figure 2 here: please refer to appendix -----

191

192 No, or very limited, GI adverse effects were reported by participants, with no significant  
193 difference between NaHCO<sub>3</sub> and placebo (median scores of 1 (range 1-3) vs. 1 (range 1-3),  
194 respectively,  $p=0.987$ ).

195

## 196 **Discussion**

197 The results from the present study demonstrate that 3-day serial NaHCO<sub>3</sub> ingestion improved  
198 repeated sprint and jump performance and increased post-exercise LA in female university  
199 basketball players. This is the first study to investigate the effect of serial loading of sodium  
200 bicarbonate supplementation on basketball-specific performance.

201

202 We showed significant improvements in mean sprint and jump performance and TT and IT  
203 following NaHCO<sub>3</sub> supplementation, with medium to large effect sizes. These results are in  
204 accordance with findings from previous studies using short repeated sprint protocols (<10-  
205 min, Zajac et al., 2009; Bishop et al., 2004; Ducker et al., 2013). For example, a significant  
206 improvement (+5.1%) in total work (kJ) performed on a cycle ergometer during five repeated  
207 6-s sprints was shown by Bishop et al. (2004) following NaHCO<sub>3</sub> ingestion in physically  
208 active women. Our greater post-exercise LA with NaHCO<sub>3</sub> could be explained by the fact  
209 that greater sprint speed commonly involves a rise in carbohydrate turnover, which increases  
210 lactate production in the muscle and its efflux into the blood (Saraslanidis et al., 2009). This  
211 suggests that participants were able to increase their speed thanks to a less acidic intracellular  
212 environment brought about by the extracellular buffering of H<sup>+</sup> ions by HCO<sub>3</sub><sup>-</sup>. However,  
213 when longer protocols are used, contrasting results are observed (Bishop & Claudius, 2005;  
214 Afman et al., 2014). Indeed, a recent study using acute NaHCO<sub>3</sub> ingestion pre-exercise  
215 showed better 15-m sprint performance during a simulated basketball exercise test in the  
216 HCO<sub>3</sub><sup>-</sup> group from 45 to 60 min (Afman et al., 2014). In contrast, NaHCO<sub>3</sub> ingestion had no  
217 significant effect on mean sprint times during a 72-min intermittent team-sport exercise in  
218 trained women (Bishop & Claudius, 2005). These contrasting results could be due to the  
219 greater contribution of the oxidative system and lower contribution of the glycolytic system  
220 in longer exercise protocols, while it cannot be excluded that less than optimal ingestion  
221 timings could also be responsible for the absence of significant results. In shorter high-  
222 intensity intermittent efforts, the better performance with NaHCO<sub>3</sub> ingestion has been linked  
223 to increases in blood pH and improvement in *in vivo* muscle buffer capacity (Bishop et al.,  
224 2003). Kemp et al. (2006) suggested that metabolic acidosis was reduced after NaHCO<sub>3</sub>  
225 ingestion, thanks to increased alkalosis in the extracellular fluid, leading to a greater efflux of

226 H<sup>+</sup> out of the muscle. Blood parameters were not measured in the present study, which limits  
227 the extent of our understanding of the mechanisms involved.

228

229 The novel aspect of the present study was the incorporation of basketball-specific movement  
230 patterns (jumps and lateral shuffles) in our protocol, to replicated more closely the metabolic  
231 and cardiovascular demands of basketball (Buchheit, 2010). Present results showed that  
232 NaHCO<sub>3</sub> supplementation resulted in significant improvements in mean jump height,  
233 showing the effectiveness of this nutritional strategy on basketball-specific effort. This  
234 finding is crucial as jumps are involved in a lot of technical actions in basketball, such as lay-  
235 ups or rebounds, which can be decisive in the outcome of a match (Delextrat et al., 2015).  
236 Our findings showed that jump PD was not affected by NaHCO<sub>3</sub> ingestion, which is  
237 somewhat surprising. One possible explanation is that only sprint, jump and overall circuit  
238 performance were measured, which might have encouraged participants to pace themselves  
239 in the tasks that were not specifically measured, and hence hindered the positive influence of  
240 NaHCO<sub>3</sub> on some of the outcome variables.

241

242 Several studies have shown the benefits of serial loading of NaHCO<sub>3</sub> (doses ranging from  
243 0.3-0.5 g·kg<sup>-1</sup> body mass), compared to a placebo on high-intensity cycling tests ranging from  
244 30-s to 4-min (McNaughton et al., 1999; McNaughton & Thompson, 2001; Douroudos et al.,  
245 2006; Driller et al., 2012). The present study is the first to show the benefits of NaHCO<sub>3</sub>  
246 serial loading on repeated sprint and jump exercise. We used a 3-day serial loading of 0.4  
247 g·kg<sup>-1</sup> NaHCO<sub>3</sub>, split into three equal doses in the three days preceding testing, as  
248 recommended by Burke and Pyne (2007). The benefit of serial compared to acute loading is  
249 the lower likelihood of adverse GI side effects (Driller et al., 2012), with similar effects on  
250 performance observed with both methods in the literature (Mc Naughton & Thompson, 2001;

251 Driller et al., 2012). Participants in the present study reported no GI distress, suggesting the  
252 practical benefits of this loading method. Another advantage of serial vs. acute loading of  
253  $\text{NaHCO}_3$  is the fact that following serial loading, bicarbonate, pH and excess base changes in  
254 the blood are maintained after the supplementation has stopped (McNaughton et al., 1999;  
255 McNaughton and Thompson, 2001; Douroudos et al., 2006). McNaughton et al. (1999)  
256 suggested that the blood may store the extra  $\text{HCO}_3^-$  provided and use it to improve  
257 performance on a subsequent day. This is a major difference to acute loading, where a single  
258 dose is taken, but very large inter-individual variations in the time to alkalotic peak of either  
259 blood  $\text{pH}$  or  $\text{HCO}_3^-$  (10-180-min) were recently reported, highlighting the need for individual  
260 supplementation timings and blood measures (Miller et al., 2016; Sparks et al., 2016; Gough  
261 et al., 2017). Finally Driller et al. (2012) suggested a different mechanism of action of serial  
262 vs. acute loading after showing an improvement in 30-s cycle performance with serial loading  
263 of  $\text{NaHCO}_3$  without any improvement in buffering capacity, through a better perfusion of  
264 muscles thanks to the sodium ions ( $\text{Na}^+$ ), leading to improved oxygen delivery (Mitchell et  
265 al., 1990). This is an interesting mechanism to consider, and further studies should be  
266 conducted combining a control trial along with a placebo.

267

268 Factors to be considered when assessing the effectiveness of  $\text{NaHCO}_3$  ingestion on repeated  
269 sprint performance include sex and training status. Women are usually characterised by  
270 greater resistance to fatigue (smaller PD) during repeated sprints (Laurent et al., 2010;  
271 Mageean et al., 2011). It appears that lower blood pressure, greater oxidative and lower  
272 glycolytic capacity, and neuromuscular factors could underpin these responses (Braun &  
273 Horton, 2001; Yoon et al., 2007). This greater resistance to fatigue suggests that females  
274 might not benefit from buffer systems as much as men. However, our results show that sprint  
275 PD was significantly lower in  $\text{NaHCO}_3$  compared to placebo (9.9 vs. 24.7%, medium effect

276 size), suggesting that women could still benefit from this type of supplementation. Another  
277 factor to consider is participants' training status. Indeed, Joyce et al. (2011) compared the  
278 effect of acute and serial NaHCO<sub>3</sub> loading in well-trained swimmers and did not find any  
279 significant effect of either strategy on performance. They suggested that this population  
280 might already have a well-developed buffering capacity due to the specificity of their  
281 training, which may have masked the potential benefits of NaHCO<sub>3</sub>.

282

283 In conclusion, 3-day serial NaHCO<sub>3</sub> ingestion enhanced repeated sprint and jump  
284 performance during simulated basketball exercise in female collegiate basketball players  
285 compared to placebo. These findings were accompanied by greater post-exercise blood  
286 lactate concentrations with NaHCO<sub>3</sub> supplementation and no adverse GI side-effects.  
287 Consequently, serial HCO<sub>3</sub><sup>-</sup> loading may be an effective strategy administered before  
288 competition to increase performance, or before training to withstand greater training loads in  
289 female basketball players. Further studies should investigate if these observed benefits  
290 translate to basketball exercise conducted across entire match durations, as well as identifying  
291 the optimal dose-response of NaHCO<sub>3</sub> supplementation alone, or combined with other  
292 buffers, such as beta-alanine.

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302

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304

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306 testing, RR and AD in the statistical analysis and all authors contributed to the write-up.

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472 **Table 1.** Performance and physiological characteristics during the modified Basketball  
 473 Exercise Simulated Test (BEST) in the bicarbonate and placebo conditions.

	Sodium bicarbonate	Placebo
	Mean±SD <sup>#</sup>	Mean±SD <sup>#</sup>
Mean sprint time (s)	1.34±0.23**	1.70±0.41
Mean circuit time (s)	30.58±2.03*	31.3±1.96
Mean jump height (cm)	26.8(25.2-34.2)*	26.0(25.6-33.6)
Ideal Sprint Time (s)	10.22(8.81-12.87)*	11.84(9.50-17.01)
Total Sprint Time (s)	12.07±2.06**	15.31±2.66
Sprint performance decrement (%)	9.9(3.4-37.0)*	24.7(4.1-61.3)
Jump height decrement (%)	13.1±4.5	12.5±3.1

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475 <sup>#</sup>: median (range): for non-parametric data (mean jump height and sprint performance  
 476 decrement)

477 **\*: significantly better (shorter time, smaller decrement or greater jump height) than the  
 478 placebo condition, p<0.05.**

479 **\*\* : significantly better (shorter time, smaller decrement or greater jump height) than  
 480 the placebo condition, p<0.01.**

481

482 **Figure captions**

483 **Figure 1.** The layout of the basketball exercise simulation test (BEST).

484 **Figure 2.** Blood lactate concentrations before and immediately on completion of the  
485 modified Basketball Exercise Simulated Test (BEST) in the sodium bicarbonate (black) and  
486 placebo (black) conditions.

487 **\*: significantly different from the placebo condition,  $p < 0.05$ .**

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507 **Figure 1.** The layout of the basketball exercise simulation test (BEST).

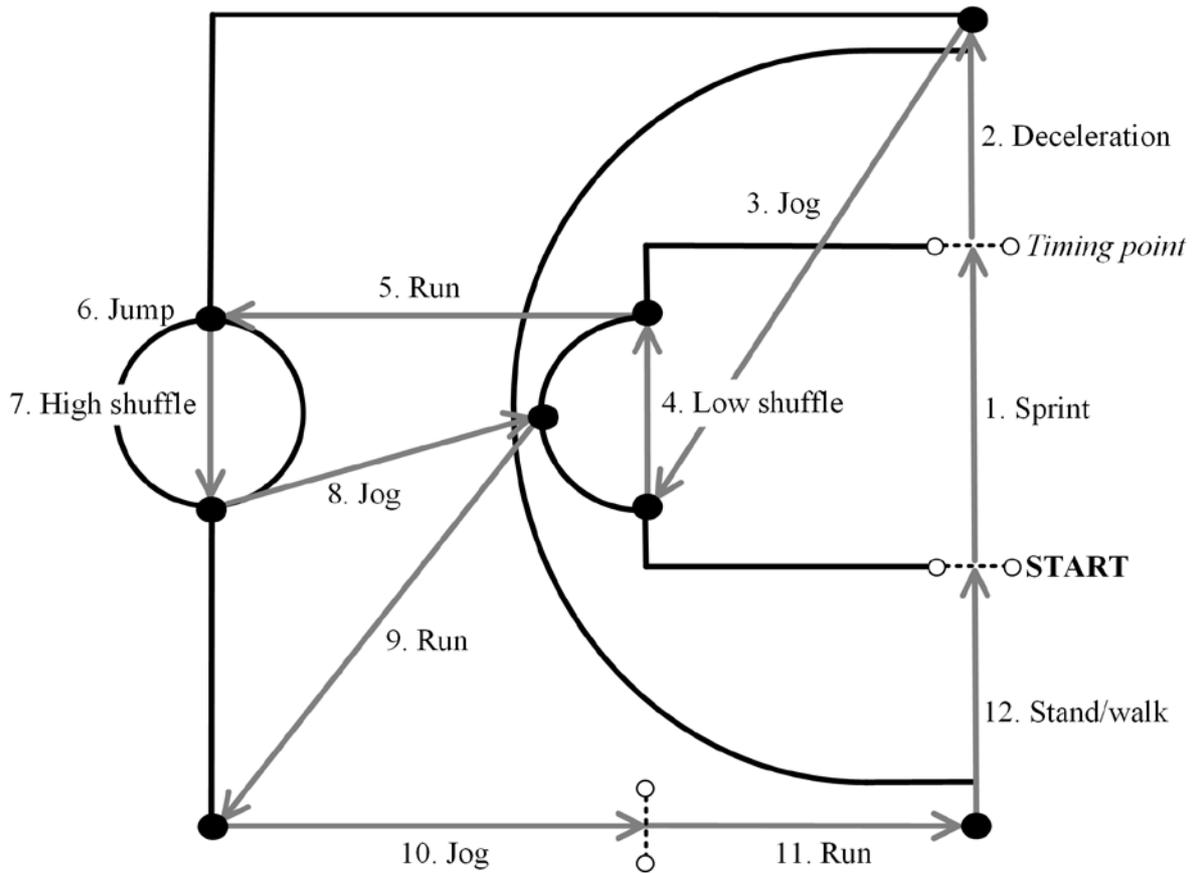
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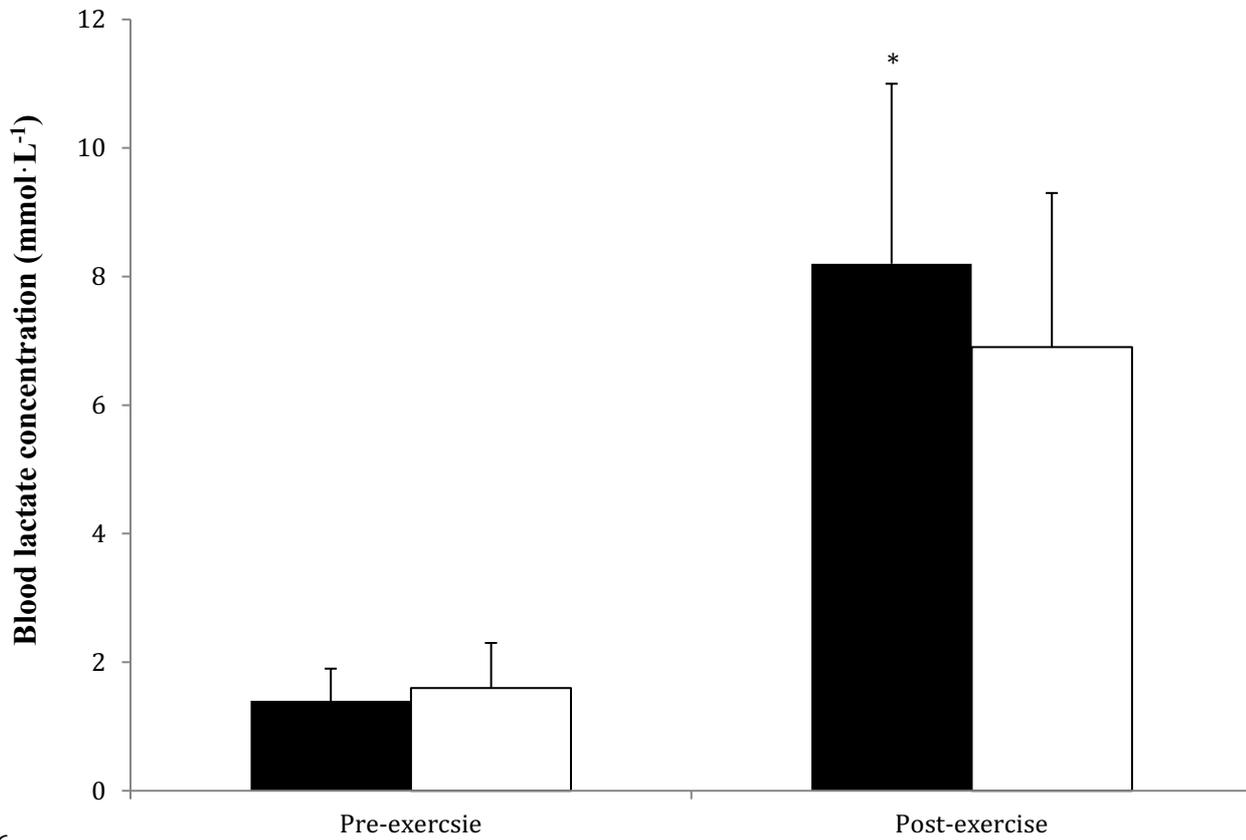
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522 **Figure 2.** Blood lactate concentrations before and immediately on completion of the  
523 modified Basketball Exercise Simulated Test (BEST) in the sodium bicarbonate (black) and  
524 placebo (white) conditions.

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527 **\*: significantly different from the placebo condition,  $p < 0.05$ .**

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