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1 Title: The effect of ischemic preconditioning on maximal swimming performance

2

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14

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## 1 Abstract

2

3 The effect of ischemic preconditioning (IPC) on swimming performance was examined. Using a  
4 randomized, crossover design, National-and International-level swimmers ( $n=20$ ; 14 males, 6  
5 females) participated in three trials (Con, IPC-2h, IPC-24h). Lower-body IPC (4 x 5 min bi-lateral  
6 blood-flow restriction at 160-228 mmHg, and 5 min reperfusion) was used 2- (IPC-2h) or 24-h (IPC-  
7 24h) before a self-selected (100 m,  $n=15$ ; 200 m,  $n=5$ ) swimming time-trial (TT). The Con trial used  
8 a sham intervention (15 mmHg) 2h prior to exercise. All trials required a 40-min standardized pre-  
9 competition swimming warm-up (followed by 20-min rest; replicating pre-competition call room  
10 procedures) 1h before TT. Capillary blood (pH, blood gases and lactate concentrations) was taken  
11 immediately pre-and post-IPC, pre-TT and post-TT. No effects on TT for 100 m ( $P=0.995$ ; IPC-2h:  
12  $64.94\pm 8.33$  s; IPC-24h:  $64.67\pm 8.50$  s; Con:  $64.94\pm 8.24$  s), 200 m ( $P=0.405$ ; IPC-2h:  $127.70\pm 10.66$  s;  
13 IPC-24h:  $129.26\pm 12.99$  s; Con:  $130.19\pm 10.27$  s) or combined total time (IPC-2h:  $84.27\pm 31.52$  s; IPC-  
14 24h:  $79.87\pm 29.72$  s; Con:  $80.55\pm 31.35$  s) were observed following IPC. Base excess (IPC-2h: -  
15  $13.37\pm 8.90$  mmol·L<sup>-1</sup>; Con:  $-13.35\pm 7.07$  mmol·L<sup>-1</sup>; IPC-24h:  $-16.53\pm 4.65$  mmol·L<sup>-1</sup>), pH ( $0.22\pm 0.08$ ;  
16 all conditions), bicarbonate (IPC-2h:  $-11.66\pm 3.52$  mmol·L<sup>-1</sup>; Con:  $-11.62\pm 5.59$  mmol·L<sup>-1</sup>; IPC-24h: -  
17  $8.47\pm 9.02$  mmol·L<sup>-1</sup>), total carbon dioxide (IPC-2h:  $-12.90\pm 3.92$  mmol·L<sup>-1</sup>; Con:  $-11.55\pm 7.61$  mmol·L<sup>-1</sup>;  
18  $9.90\pm 8.40$  mmol·L<sup>-1</sup>), percentage oxygen saturation (IPC-2h:  $-0.16\pm 1.86\%$ ; Con:  
19  $+0.20\pm 1.93\%$ ; IPC-24h:  $+0.47\pm 2.10\%$ ) and blood lactate (IPC-2h:  $+12.87\pm 3.62$  mmol·L<sup>-1</sup>; Con:  
20  $+12.41\pm 4.02$  mmol·L<sup>-1</sup>; IPC-24h:  $+13.27\pm 3.81$  mmol·L<sup>-1</sup>) were influenced by swimming TT  
21 ( $P<0.001$ ), but not condition (all  $P>0.05$ ). No effect of IPC was seen when applied 2- or 24-h before  
22 swimming TT on any indices of performance or physiological measures recorded.

23

24 Key words: Time-trial, lactate, blood gases, ergogenic aid

25

## 26 INTRODUCTION

27

28 During international swimming events athletes are required to perform two to three maximal efforts  
29 following months or even years of training and preparation, with marginal differences of <0.5%  
30 separating medal and non-medal positions (e.g. difference between sixth and third place in the men's  
31 and women's 100 m at World Championships; FINA, World Championship results 2017 - 8). In  
32 addition to the benefits of training, previous research has shown the importance of competition warm-  
33 up intensity (24), timing of warm-up (36) and use of active heating and land-based activation  
34 exercises (21, 22) as competition-day strategies to improve subsequent swimming performance.  
35 Ischemic preconditioning (IPC), involving cycles of ischemia and reperfusion achieved through the  
36 application of cuffs to the arms or thighs (11), has also been reported to improve indices of athletic  
37 performance when used between 15 mins and 8h before performance assessments (12).

38

39 The benefits of IPC to improve athletic performance have been previously observed in time to  
40 exhaustion (e.g. 9), anaerobic specific performance tests (e.g. 14) and repeated sprint ability (e.g. 26).  
41 It has been reported that IPC induces acute vascular adaptations, resulting in local vasodilation and  
42 enhanced blood flow (34). Consequently, enhanced functional sympatholysis may speed and increase  
43 oxygen extraction by means of matching demand with supply (13), facilitating an increased aerobic  
44 contribution during subsequent exercise. Reports suggest that IPC can cause a faster uptake of acetyl  
45 coenzyme A (acetyl-CoA) by mitochondria thus maintaining lactate accumulation at a metabolically  
46 acceptable level due to greater contribution of aerobically generated adenosine triphosphate (ATP) for  
47 exercise (14). Recruitment of higher order motor units via enhanced central motor efferent command  
48 also results from IPC (4), allowing for exercise to be completed beyond the individual's critical  
49 threshold by increasing or maintaining the rate of force development and improving subsequent  
50 performance.

51

52 However, only one study (31) relating to sports performance has differentiated between the  
53 observed early and late phase of IPC reported within the clinical literature, implementing IPC 24h  
54 prior to a 5 km running time trial (TT). Research suggests that there are two phases resulting from  
55 IPC; the early phase which begins soon after reperfusion and lasts 3-4h, whereas the late phase  
56 starts 12–24h after IPC (16) and last 48–96h (27, 33). The release of endogenous substances is  
57 thought to stimulate post-translational modifications in proteins within the early phase, whereas in  
58 the late phase this leads to synthesis of new proteins and altered gene expression (34). Accordingly,  
59 owing to the timing of pre-competition practices and regulations in athletic competitions (e.g., the  
60 use of pre-competition call-rooms within 20 min of competition starting), the late phase of IPC may  
61 offer another practical option, to coincide with competition timings to further optimize swimming  
62 performance on the day of competition.

63

64 With a specific emphasis on swimming performance, IPC may be beneficial for 100 to 400 m  
65 swimming performance due to the resultant increase in contribution of ATP generated from the  
66 aerobic system (28). To date, four studies (7, 14, 17, 20) have identified a positive effect of  
67 implementing IPC prior to swimming performance. For example, Jean-St-Michel et al. (14) reported  
68 that five min of ischemia followed by five min of reperfusion, repeated for four cycles, implemented  
69 45 min prior to 100 m swimming TT improved personal best swimming times by 1.1%. Most  
70 recently, Lisboa et al. (17) applied IPC 1h, 2h and 8h preceding a 50 m TT performance, with  
71 performance improvements of 1.0% and 1.2% in 2h and 8h conditions, respectively. The previous  
72 research relating to IPC and swimming performance has investigated the effects of the early phase of  
73 IPC on performance as application has been <12h prior to performance. However, for short duration  
74 events (i.e. 10-90 s), a recent meta-analysis showed that a longer duration between IPC and exercise  
75 resulted in a higher effect size; suggesting that IPC may be dependent on the timing of the  
76 preconditioning strategy relative to the start of subsequent performance (30). Research is yet to  
77 investigate if the delayed phase of IPC can enhance swimming performance when applied at least 12h  
78 prior to competition, a strategy which may be attractive for coaches and swimmers.

79 Consequently, the purpose of this study was to investigate the impact of IPC on swimming TT  
80 performance 2h (early phase) and 24h (late phase) after eliciting IPC in competitive swimmers.

81

## 82 **METHOD**

### 83 **EXPERIMENTAL APPROACH TO THE PROBLEM**

84 Twenty National and International-level swimmers participated in a randomized, crossover design  
85 that involved three sessions (Con, IPC-2h, IPC-24h) separated by seven days. Timing of IPC  
86 completed in conditions were implemented in line with previous research complete by Seeger et al.  
87 (31) and Lisboa et al. (17). Occlusion cuffs were applied bi-laterally at the most proximal point of  
88 each thigh and intermittently inflated to an individualized cuff pressure determined from thigh girth  
89 and resting blood pressure for a total of 40 min in IPC-2h and IPC-24h. In Con, cuffs were applied  
90 for the same duration (total 40 min), however cuff pressure was inflated to 15 mmHg. A self-selected  
91 (100 or 200 m) swimming TT (assessing total time, 50 m split times, stroke count; SC, and stroke  
92 rate; SR, time underwater off starts and turns) followed intervention administration and physiological  
93 markers (pH, blood gases and lactate concentrations) were assessed at pre-IPC, post-IPC, pre-TT and  
94 post-TT.

95

### 96 **SUBJECTS**

97 Following ethical approval from Swansea University ethics committee, twenty (6 females, 14 males)  
98 National- and International-level swimmers (age;  $20 \pm 2$  y, mass;  $71.1 \pm 9.6$  kg, stature;  $178.4 \pm 9.6$  cm,  
99 Training experience;  $9.6 \pm 2.7$  y) participated in the study. All subjects had qualified for, and  
100 competed at British swimming National competitions. Subjects were informed of the experimental  
101 procedures, the purpose and possible risks associated with the study, and provided written informed  
102 consent before participation.

103

### 104 **PROCEDURES**

105 After familiarization, participants were required to attend the testing venue on three occasions (Con,  
106 IPC-2h, IPC-24h) in a randomized order.

107 Main trials were performed in an enclosed 50 m swimming pool within the subject's normal training  
108 environment. To minimize the effects of biological rhythms, the timing of measurements was  
109 consistent between trials. To control for varying levels of weekly fatigue, testing was conducted on  
110 the same day of the week in a stable, maintenance phase of training. Subjects were required to refrain  
111 from alcohol and intense physical exercise in the 24h preceding trials and between IPC and swimming  
112 TT performance.

113

114 On arrival for main trials, subjects were required to rest for 10 min to allow for resting blood pressure  
115 to be recorded (Omron Healthcare, Europe; systolic >140 mmHg and/or diastolic >90 mmHg  
116 precluded further study involvement). Once blood pressure was recorded, thigh girth was measured  
117 for determination of cuff pressure and a capillary blood sample was taken. Occlusion cuffs were then  
118 applied to the most proximal point of the thighs, with subjects assuming a supine position. The cuff  
119 (10 cm) contained a pneumatic bag along its inner surface that was connected to a pressure gauge and  
120 manually inflated to either 15 mmHg (Con) or an individualized cuff pressure (IPC-2h, IPC-24h) for a  
121 total of 40 min consisting of four cycles of five min occlusion and five min reperfusion. The  
122 individualized cuff pressures were calculated from Loenneke et al. (18) with values ranging from 160  
123 to 228 mmHg. Cuff pressure was 15 mmHg in the Con condition; based on previous research  
124 showing that 10-20 mmHg (e.g. 1, 14, 26) caused no alteration to the arterial inflow but allowed  
125 increased control over the placebo effect as cuffs were worn in both conditions.

126

127 Following the completion of the IPC protocol, subjects rested accordingly for 24h or 2h; intense  
128 physical activity was restricted during the 24h and all subjects arrived at the swimming pool and  
129 rested for 3h prior to TT regardless of the condition, cuffs were applied during this period for IPC-2h  
130 and Con. A standardized race swimming warm up (40-min) was performed 1h prior to a swimming  
131 TT and a 20-min post-warm-up rest period at the swimming pool replicated pre-competition call room  
132 requirements. This was immediately followed by a maximal swimming TT (100 m:  $n=15$ , 200 m:  
133  $n=5$ ), completed on the subjects' chosen stroke, in accordance with FINA rules. Subjects completed  
134 the TT individually, starting from a block and taking off after an audible starting signal.

135 Rating of perceived exertion was recorded using the Borg (2) scale on completion of the race. From  
136 the TT, SR, SC, 50 m split times, time underwater off the start and turns and total time were  
137 calculated retrospectively from video recordings. Equation 1 was used to determine SR; for each 25  
138 m of the TT SR was calculated, the mean  $\pm$  SD was then calculated for each 50 m. To ensure  
139 acceptable reliability of the SR measurement, intra-observer tests were completed. The analyst  
140 viewed two randomly selected TT performances ten times over a two-week period under the same  
141 conditions. The coefficient of variation (CV) was calculated to identify the measurement error; this  
142 resulted in a low, acceptable percentage of error (CV = 0.2%).

143

144 Equation 1: Stroke rate =  $\frac{\text{Number of complete strokes over 25 m} \times 60}{\text{Time of hand entry 1} - \text{time of hand entry 2}}$

145 (Time of hand entry 1 – time of hand entry 2)

146 Where hand entry 1 is the first-hand entry at the start of 25 m and hand entry 2 is the hand entry at the  
147 end of 25 m, recorded in seconds.

148

149 A capillary blood sample was taken pre-IPC, post-IPC, pre-TT and post-TT to measure blood lactate,  
150 pH, percentage of oxygen saturation (sO<sub>2</sub>%), partial pressure of oxygen (PO<sub>2</sub>), partial pressure of  
151 carbon dioxide (PCO<sub>2</sub>), total carbon dioxide (TCO<sub>2</sub>), bicarbonate (HCO<sub>3</sub>) and Base Excess. This was  
152 analyzed using a portable analyser (ISTAT 1; 300G) and associated cartridges (CG4+; Abbott, point  
153 of care testing, Arbroath, UK). Prior to data collection the analyzer was calibrated according to the  
154 manufacturer's specifications and cartridges were stored as per manufacturer's instructions (2-8°C)  
155 and removed to room temperature ~5 min prior to use. The capillary blood sample was immediately  
156 expelled from the capillary tube into the sample well of the cartridge. Blood gases and pH were  
157 analyzed using these methods which have previously been compared (35) against two auto-calibrated  
158 analyzers (r >0.993). Dascombe et al. (5) also confirmed intra-test reliability of the analyzer; intra-  
159 class correlation coefficients (ICC) for all analytes were observed to be strong following maximal  
160 intensity exercise (ICC = 0.77-0.95; where 0.7-0.9 deemed a strong correlation) and technical error of



161 measurement (TEM) <15% was deemed acceptable (pH; 0.24%, blood lactate; 3.12%, all other  
162 measured blood gas parameters 2.02-8.85%).

163

## 164 STATISTICAL ANALYSES

165 All data is presented as mean  $\pm$  standard deviation (SD). Following confirmation of parametric  
166 assumptions, repeated measures multivariate analysis of variance (MANOVA) with Bonferroni  
167 adjustment assessed between-trial differences for variables with multiple time points per trial (i.e.  
168 blood lactate, pH, sO<sub>2</sub>%, PO<sub>2</sub>, PCO<sub>2</sub>, HCO<sub>3</sub> and Base Excess). One-way ANOVA assessed between-  
169 trial differences for all performance variables from the swimming TT and RPE recorded post-TT.  
170 Statistical analyses were carried out using SPSS version 22.0 (SPSS Chicago, IL) with significance  
171 being accepted at  $P \leq 0.05$ .

172

## 173 RESULTS

174

175 Exercise significantly affected blood parameters; following swimming TT, pH decreased by  
176  $0.22 \pm 0.08$  in all conditions ( $P < 0.001$ ;  $\eta^2 = 0.866$ ) (Figure 1). Blood lactate increased pre-to post-TT  
177 ( $P < 0.001$ ;  $\eta^2 = 0.923$ ) by  $12.87 \pm 3.62$  mmol·L<sup>-1</sup>,  $12.41 \pm 4.02$  mmol·L<sup>-1</sup> and  $13.27 \pm 3.81$  mmol·L<sup>-1</sup> in  
178 IPC-2h, Con and IPC-24h, respectively (Figure 1). Base excess (IPC-2h:  $-13.37 \pm 8.90$  mmol·L<sup>-1</sup>; Con:  
179  $-13.35 \pm 7.07$  mmol·L<sup>-1</sup>; IPC-24h:  $-16.53 \pm 4.65$  mmol·L<sup>-1</sup>;  $P < 0.001$ ;  $\eta^2 = 0.857$ ), HCO<sub>3</sub> (IPC-2h: -  
180  $11.66 \pm 3.52$  mmol·L<sup>-1</sup>; Con:  $-11.62 \pm 5.59$  mmol·L<sup>-1</sup>; IPC-24h:  $-8.47 \pm 9.02$  mmol·L<sup>-1</sup>;  $P < 0.001$ ;  $\eta^2 =$   
181  $0.849$ ), TCO<sub>2</sub> (IPC-2h:  $-12.90 \pm 3.92$  mmol·L<sup>-1</sup>; Con:  $-11.55 \pm 7.61$  mmol·L<sup>-1</sup>; IPC-24h:  $9.90 \pm 8.40$   
182 mmol·L<sup>-1</sup>;  $P < 0.001$ ;  $\eta^2 = 0.939$ ) and sO<sub>2</sub>% (IPC-2h:  $-0.16 \pm 1.86$  %; Con:  $+0.20 \pm 1.93$  %; IPC-24h:  
183  $+0.47 \pm 2.10$  %;  $P < 0.001$ ;  $\eta^2 = 0.130$ ) were significantly different pre-TT to post-TT. However, there  
184 were no differences between trials in any of the blood parameters ( $P > 0.05$ ).

185

186

\*\*\*\*\* INSERT FIGURE 1 NEAR HERE \*\*\*\*\*

187

188 Trial did not affect performance for 100 m ( $P=0.995$ ; IPC-2h:  $64.94\pm 8.33$  s; IPC-24h:  $64.67\pm 8.50$  s;  
189 Con:  $64.94\pm 8.24$  s), 200 m ( $P=0.405$ ; IPC-2h:  $127.70\pm 10.66$  s; IPC-24h:  $129.26\pm 12.99$  s; Con:  
190  $130.19\pm 10.27$ ) or combined total time (IPC-2h:  $84.27\pm 31.52$  s; IPC-24h:  $79.87\pm 29.72$  s; Con:  
191  $80.55\pm 31.35$  s). No significant effects between conditions for any of the performance variables were  
192 observed; being, total time ( $P=0.723$ ), split time for the first 50 m ( $P=0.968$ ), split time for the second  
193 50 m ( $P=0.874$ ), start time ( $P=0.817$ ), turn time at 50 m ( $P=0.924$ ), SC for first 50 m ( $P=0.559$ ), SC  
194 for second 50 m ( $P=0.570$ ), SR for first 50 m ( $P=0.726$ ), SR for second 50 m ( $P=0.988$ ) and RPE  
195 ( $P=0.723$ ) (Table 1).

196

197 \*\*\*\*\* INSERT TABLE 1 NEAR HERE \*\*\*\*\*

## 198 **DISCUSSION**

199

200 In this study IPC did not affect 100 or 200 m swimming performance in National-level swimmers  
201 when applied 2h or 24h prior to performance assessment. These findings, particularly for IPC-2h,  
202 oppose previous research that found IPC applied acutely improved subsequent swimming  
203 performance (7, 14, 17, 20). Consistent with previous research (31), no change in swimming  
204 performance was identified when IPC was applied 24h before the TT. Likewise, no differences were  
205 identified in physiological markers following IPC-2h or IPC-24h. Therefore, IPC applied 2h or 24h  
206 had no influence, either positive or negative, on swimming performance or physiological markers.

207 For short duration events (i.e. 10-90 s), a recent meta-analysis showed that a longer duration between  
208 IPC and exercise resulted in a higher effect size; suggesting that IPC may be dependent on the timing  
209 of the preconditioning strategy relative to the start of subsequent performance (30). Previous research  
210 in swimming has implemented IPC between 10 min and 8h (7, 14, 17, 20) before performance  
211 assessment and found beneficial effects; findings which contradict those reported here when IPC was  
212 applied 2h before exercise. Several methodological differences between the present study and  
213 previous literature may explain this lack of agreement in findings. Specifically, there is little  
214 consensus regarding optimal cuff pressures used in IPC as a range of pressures have been reported

215 (i.e., 200-230 mmHg or 15-50>SBP) which are universally applied across all individuals within  
216 studies. A standardized cuff pressure may not cause the same percentage of blood flow restriction in  
217 every individual, especially considering the volume and type of tissue surrounding the blood vessels  
218 which may influence the pressure exerted on the vasculature (19). Therefore, the percentage of blood  
219 flow restriction may affect the success of IPC as a pre-competition strategy (10). Recent research by  
220 Loenneke et al. (18) recommended the use of individualized cuff pressure calculated from thigh girth  
221 and resting blood pressure, which was adopted in the current study. However, individual blood flow  
222 restriction was not confirmed using a Doppler due to practicality, which offers a limitation to the  
223 current study as blood flow restriction was calculated in alignment with results from previous research  
224 (18), rather than according to a measured pressure. A protocol to individualise cuff pressure needs to  
225 be determined, identifying the differences between a standard cuff pressures and the use of thigh girth  
226 and blood pressure to calculate individual pressures in comparison to Doppler assessment. The  
227 results of these three methods to determine cuff pressure need to be identified and the resultant effect  
228 on performance tested to establish recommendations for practical use.

229  
230 To explain the current results, another methodological difference should be considered regarding the  
231 location of the cuff, with application previously reported on the lower or upper body. The present  
232 study applied occlusion cuffs to the thighs which contrasts previous research in swimming whereby  
233 cuffs were applied to the upper body (7, 14, 17, 20). Although limited research still exists on the  
234 working mechanism of IPC and athletic performance, it has been suggested that IPC induces a  
235 systemic change in blood flow through a change in sympathetic activity. Due to the nature of  
236 swimming and controlled breathing, which can result in exercise induced arterial hypoxemia,  
237 decreased pH (3, 32) and consequently a significant contributor of fatigue (25), a systemic increase in  
238 blood flow and oxygen delivery could be speculated to improve performance, reducing hypoxemia  
239 and metabolic acidosis. However, in the current study no differences were identified between  
240 conditions in the physiological measures. Alternative research has suggested that IPC may also cause  
241 local changes in the muscle at the site of the cuff (e.g. increase oxygen uptake or change in  
242 mitochondrial activity) which may contribute to an increase muscle oxygenation (13, 15, 29).

243 In swimming, the contribution of propulsive force is approximately 90% for the upper extremities (6,  
244 23), therefore, the local changes achieved by application of the cuffs to the upper limbs, may increase  
245 effectiveness of limb IPC to improve swimming performance. In comparison to previous results  
246 applying cuffs to the thighs to induce a systemic response, this may help to explain the inconsistency  
247 in the current results, highlighting this as an area warranting further investigation to determine the  
248 impact of systemic versus local blood flow restriction on athletic performance.

249 To date, one study has examined the use of IPC applied 24h prior to performance to determine if the  
250 late phase of IPC, originally used in a clinical setting, may also improve athletic performance. The  
251 current study replicated research completed by Seeger et al. (31) but within swimming, with the only  
252 other methodological difference being individualizing of cuff pressures. Similarly, no difference in  
253 performance time between conditions was identified. However, results from the current study were  
254 not consistent with previous research investigating IPC in swimming as previously a benefit has been  
255 identified in the early phase (10 min – 2h) within the literature which was not consistent in our study.  
256 Therefore, methodological differences could have influenced these findings as stated above regarding  
257 cuff location, consequently IPC applied 24h prior to performance should be further investigated in  
258 swimming while ensuring that cuffs are applied to the upper body.

259  
260 In conclusion, the current study demonstrated swimming TT performance of 100 or 200 m was not  
261 influenced when it was preceded 2h or 24h by four cycles of IPC, at an individualized cuff pressure.  
262 Speculatively, this may have been due to the difference in cuff placement on the lower limbs as  
263 opposed to upper limbs as in previous IPC and swimming research. Therefore, the use of IPC 24h  
264 prior to swimming TT performance should be investigated with cuffs applied to the upper limbs to  
265 identify if the late phase of IPC can also improve performance, as this would have greater practical  
266 application completing the IPC protocol 24h before competition rather than in close proximity to the  
267 start of an athletic event.

268

## 269 PRACTICAL APPLICATIONS

270

271 Despite this study concluding swimming performance was not influenced by IPC applied at 2h or 24h,  
272 there are several practical points of relevance for application in sport. These results provide baseline  
273 data for the use of IPC in swimming when cuffs are applied to the thighs, identifying that this strategy  
274 had no detrimental effect on physiological responses. Most prominently, the combination of previous  
275 research and the current study suggest recommendations for application of the cuffs to the upper body  
276 to improve swimming performance.

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280 of the present study do not constitute endorsement by the NSCA.

281

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371

372 **FIGURES AND TABLES**

373

374 **Figure 1:** Change in blood markers from pre-ischemic preconditioning (IPC) to post-IPC and Pre-  
 375 time trial (TT) to post-TT

376

377 **Table 1:** Performance variables from the swimming time trial (100 and 200 m combined) for the three  
 378 conditions



<b>Condition</b>	<b>SC 50</b>	<b>SC 100</b>	<b>SR 50 (SPM)</b>	<b>SR 100 (SPM)</b>	<b>Start (s)</b>	<b>Turn 50 (s)</b>
<b>Con</b>	19.3±2.4	22.2±3.2	45.3±8.0	42.5±7.1	4.9±1.4	4.2±1.6
<b>Confidence Interval</b>	18.1-20.5	20.6-23.8	41.3-49.3	39.0-46.0	4.2-5.5	3.4-5.0
<b>IPC-2h</b>	18.8±2.6	21.3 ±3.2	43.9±8.1	42.3±7.4	4.9±1.4	4.2±1.7
<b>Confidence Interval</b>	17.5-20.0	19.7-22.8	40.1-47.7	38.9-45.8	4.3-5.6	3.4-5.0
<b>IPC-24h</b>	18.4±2.6	21.1±3.7	43.4±8.7	42.1±6.3	5.1±1.1	4.4±1.7
<b>Confidence Interval</b>	17.1-19.7	19.2-23.0	38.9-47.8	38.8-45.5	4.6-5.7	3.5-5.3

\*SC50 = stroke count for the first 50 m, SC 100 = stroke count for the second 50 m, SR 50 = stroke rate for first 50 m, SR 100 = stroke rate for second 50 m, start = time from dive start to first stroke, Turn 50 = turn time at 50 m. Confidence intervals reported at ninety-five-percent.

<b>Condition</b>	<b>SC 50</b>	<b>SC 100</b>	<b>SR 50 (SPM)</b>	<b>SR 100 (SPM)</b>	<b>Start (s)</b>	<b>Turn 50 (s)</b>
<b>Con</b>	19.3±2.4	22.2±3.2	45.3±8.0	42.5±7.1	4.9±1.4	4.2±1.6
<b>Confidence Interval</b>	18.1-20.5	20.6-23.8	41.3-49.3	39.0-46.0	4.2-5.5	3.4-5.0
<b>IPC-2h</b>	18.8±2.6	21.3 ±3.2	43.9±8.1	42.3±7.4	4.9±1.4	4.2±1.7
<b>Confidence Interval</b>	17.5-20.0	19.7-22.8	40.1-47.7	38.9-45.8	4.3-5.6	3.4-5.0
<b>IPC-24h</b>	18.4±2.6	21.1±3.7	43.4±8.7	42.1±6.3	5.1±1.1	4.4±1.7
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\*SC50 = stroke count for the first 50 m, SC 100 = stroke count for the second 50 m, SR 50 = stroke rate for first 50 m, SR 100 = stroke rate for second 50 m, start = time from dive start to first stroke, Turn 50 = turn time at 50 m. Confidence intervals reported at ninety-five-percent.

