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**Effects of creatine and sodium bicarbonate co-ingestion on multiple indices of mechanical power output during repeated Wingate tests in trained men**

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## Abstract

This study investigated the effects of creatine and sodium bicarbonate co-ingestion on mechanical power during repeated sprints. Nine well-trained men (age =  $21.6 \pm 0.9$  yr, stature =  $1.82 \pm 0.05$  m, body mass =  $80.1 \pm 12.8$  kg) participated in a double-blind, placebo-controlled, counterbalanced, crossover study using six 10-s repeated Wingate tests. Participants ingested either a placebo ( $0.5 \text{ g}\cdot\text{kg}^{-1}$  of maltodextrin),  $20 \text{ g}\cdot\text{d}^{-1}$  of creatine monohydrate + placebo,  $0.3 \text{ g}\cdot\text{kg}^{-1}$  of sodium bicarbonate + placebo, or co-ingestion + placebo for 7 d, with a 7 d washout between conditions. Participants were randomised into two groups with a differential counterbalanced order. Creatine conditions were ordered first and last. Indices of mechanical power output (W), total work (J) and fatigue index ( $\text{W}\cdot\text{s}^{-1}$ ) were measured during each test and analysed using the magnitude of differences between groups in relation to the smallest worthwhile change in performance. Compared to placebo, both creatine (effect size (ES) = 0.37-0.83) and sodium bicarbonate (ES = 0.22-0.46) reported meaningful improvements on indices of mechanical power output. Co-ingestion provided small meaningful improvements on indices of mechanical power output (W) compared to sodium bicarbonate (ES = 0.28-0.41), but not when compared to creatine (ES = -0.21-0.14). Co-ingestion provided a small meaningful improvement in total work (J) (ES = 0.24) compared to creatine. Fatigue index ( $\text{W}\cdot\text{s}^{-1}$ ) was impaired in all conditions compared to placebo. In conclusion, there was no meaningful additive effect of creatine and sodium bicarbonate co-ingestion on mechanical power during repeated sprints.

**Key words:** meaningful, effect size, smallest worthwhile change

## Introduction

Research has revealed that limitations to energy supply, accumulation of cellular hydrogen ions and acidosis and impairment in muscular excitability and neural drive may explain exercise fatigue (Girard et al., 2011; Hirvonen et al., 1987; Lambert & Flynn, 2002; Spriet et al., 1989). High-intensity exercise of ~10-12.5 s has been reported to diminish ATP and PCr re-synthesis by 14-32% and ~40-70% respectively (Hirvonen et al., 1992; Jones et al., 1985). Resynthesis of PCr has been correlated ( $r^2 = 0.71$ ) with the percentage of mechanical power output recovery during repeated sprint cycling (Bogdanis et al., 1996) and suggests that the ability to sustain mechanical power is related to PCr resynthesis. Under resting conditions arterial blood pH is ~7.4 however during high-intensity exercise can decrease to pH 7.1 due to the formation of cellular hydrogen ions (Cameron et al., 2010). A reduction in blood pH has been correlated ( $r^2 = 0.47$ ) with reductions in isometric leg force (Bergström & Hultman, 1988). Strategies that can increase the rate of phosphocreatine resynthesis and facilitate the efflux of cellular hydrogen ions could be advantageous to athletes participating in repeated high-intensity exercise.

Increases in high-intensity exercise performance have been reported in studies supplementing creatine monohydrate in doses of 15-25 g·d<sup>-1</sup> for 3-7 d (Dawson et al., 1995; Eckerson et al., 2005; Izquierdo et al., 2002; Peyrebrune et al., 1998; Skare et al., 2001; Ziegenfuss et al., 2002). Endogenous creatine and phosphocreatine stores have been shown to increase by ~20% and 20-40% following supplementation, and may explain creatine's ergogenic properties (Harris et al., 1992).

Extracellular buffering agents such as sodium bicarbonate have also been suggested to have performance benefits (McNaughton et al., 2008). Extracellular bicarbonate augments the efflux of cellular hydrogen ions, elevating the pH gradient between intracellular and extracellular environments, preserving a stable electrolyte gradient (Aschenbach et al., 2000; McNaughton et al., 2008). Studies conducted on the effects of sodium bicarbonate supplementation on high-intensity exercise performance are equivocal, with some studies

reporting meaningful increases in mechanical power output of 5.4% (McNaughton et al., 1987), and 4.3% (Bishop et al., 2004) whilst others (Aschenbach et al., 2000; Horswill et al., 1988; Lavender & Bird, 1989; Robergs et al., 2005; Siegler et al., 2008) report no meaningful performance improvements.

Although studies have reported meaningful improvements in high-intensity exercise performance following creatine and sodium bicarbonate supplementation, only two studies have examined the effects of co-ingestion. Mero et al. (2004) reported a 1.5% improvement in the second of two 100 m swimming sprints compared to a placebo. Barber et al. (2013) reported a 3.2% and 1.9% improvement in mean mechanical power output compared to placebo and creatine conditions during six 10-s repeated Wingate tests. Both studies failed to compare co-ingestion against sodium bicarbonate alone.

The aim of this study was to investigate the effects of creatine and sodium bicarbonate co-ingestion on multiple indices of mechanical power during repeated Wingate tests and compare conditions. It was hypothesised that co-ingestion would improve performance beyond the smallest worthwhile change and that the magnitude of improvement would be greater after co-ingestion of creatine and sodium bicarbonate.

## **Methods**

### **Participants**

Nine well-trained males (mean  $\pm$  SD: age = 21.6  $\pm$  0.9 yr, stature = 1.82  $\pm$  0.05 m, body mass = 80.1  $\pm$  12.8 kg) volunteered for the study which was granted institutional ethical approval. Twelve participants were originally recruited however three failed to complete the study. Sample size was calculated using the standard error of measurement and smallest worthwhile change in performance (Hopkins, 2006); a sample of at least 10 participants was required. All participants provided informed consent. No supplements had been taken by any participants prior to the study and none of the participants were vegetarian.

## Experimental Design

The study employed a double-blind, placebo-controlled, crossover, counterbalanced design. Conditions containing creatine were ordered first and last to minimise creatine loading and to provide washout (~35 d) (Hultman et al., 1996). Prior to testing, participants ( $n = 12$ ) were originally randomised using simple randomisation by an individual external to the study (Figure 1) to ensure randomisation under a counterbalanced design. Unfortunately, we experienced drop-out making groups uneven therefore only trials 3 and 4 were randomised due to the requirement for creatine conditions to be ordered either first or last. Participants underwent familiarization prior to testing.

## Procedures

### Supplementation.

Participants completed 7 d of supplementation of the following conditions: (a) creatine and sodium bicarbonate, (b) creatine, (c) sodium bicarbonate and (d) placebo. Seven days separated each condition and supplementation was not ingested on the day of each trial. Co-ingestion of creatine and sodium bicarbonate contained  $20 \text{ g}\cdot\text{d}^{-1}$  of creatine monohydrate (Myprotein Inc., Northwich, UK),  $0.3 \text{ g}\cdot\text{kg}^{-1}$  of sodium bicarbonate (Buy Whole Foods Online, Canterbury, UK) and  $0.5 \text{ g}\cdot\text{kg}^{-1}$  of maltodextrin (Myprotein Inc., Northwich, UK). Creatine alone consisted of  $20 \text{ g}\cdot\text{d}^{-1}$  of creatine monohydrate and  $0.5 \text{ g}\cdot\text{kg}^{-1}$  of maltodextrin, sodium bicarbonate alone consisted of  $0.3 \text{ g}\cdot\text{kg}^{-1}$  of sodium bicarbonate and  $0.5 \text{ g}\cdot\text{kg}^{-1}$  of maltodextrin, and the placebo contained  $0.5 \text{ g}\cdot\text{kg}^{-1}$  of maltodextrin only. The addition of  $0.5 \text{ g}\cdot\text{kg}^{-1}$  of maltodextrin to all conditions was added to maintain volume consistency and to facilitate creatine uptake (Green et al., 1996). A split-dose strategy was employed to reduce side effects from sodium bicarbonate supplementation (Burke & Pyne, 2007). Supplements were split into four equal dose to be consumed at 9 am, 12 pm, 5 pm and 9 pm. Participants were also instructed to ingest each supplement sachet with 330 ml of water diluted with 40 ml of orange cordial. The degree of compliance reported was  $86 \pm 7\%$  for co-ingestion of creatine and sodium bicarbonate,  $89 \pm 7\%$  for creatine alone,  $90 \pm 7\%$  for

sodium bicarbonate alone and  $93 \pm 4\%$  for the placebo. Participants were instructed to maintain their habitual diet and abstain from strenuous exercise, caffeine and alcohol 24 h prior to each trial.

### **Performance trials.**

All exercise trials were conducted using an externally-verified, electromagnetically-braked cycle ergometer (Lode Excalibur Sport, Groningen, Netherlands). Prior to the study, mechanical power output was assessed using a dynamic external verifier (Calibrator 2000, Lode, Groningen, Netherlands). A 2.6% difference in mechanical power output between the ergometer and the calibrator was reported by the external verifier. The coefficient of variation for mechanical power output between the ergometer and the calibrator was 1%.

Participants' riding position on the cycle ergometer (Lode Excalibur Sport, Lode, Groningen, Netherlands) remained consistent for each trial along with the time of day. Body mass (kg) was measured upon arrival and the ergometer load adjusted to account for changes in body mass following creatine supplementation (Hultman et al., 1996).

Each trial began with a warm up at 50 RPM against a resistance of 0.5 kg for 5 min, with one 5 s sprint against a resistance of 7.5% of the participant's body-mass after 2.5 min. Participants then completed six 10-s sprints using a standardised resistance equating to 7.5% body mass. One min of active recovery at 50 RPM was provided between each test. Participants were asked to cycle at a cadence of 50 RPM until the start signal to ensure the inertia of the system was not overcome by standardising the angular momentum of the flywheel (Winter & Fowler, 2009). No verbal encouragement or feedback was provided (Currell & Jeukendrup, 2008). Peak mechanical power (W), mean mechanical power (W), relative peak mechanical power ( $W \cdot kg^{-1}$ ), relative mean mechanical power ( $W \cdot kg^{-1}$ ), total work (J) and fatigue index ( $W \cdot s^{-1}$ ) (peak mechanical power – minimum mechanical power / time, lower = beneficial to performance) were recorded during each test using Lode Ergometer Manager (Lode BV, Groningen, The Netherlands).



Prior to the study a test-retest reliability study was conducted on four participants (age =  $24.4 \pm 5.1$  yr, stature =  $1.76 \pm 0.05$  m, body mass =  $89.8 \pm 12.0$  kg) who undertook the experimental protocol on two occasions separated by 7 d. There was no significant differences in peak mechanical power ( $t(3) = 0.906$ ,  $p = 0.432$ ), mean mechanical power ( $t(3) = 0.531$ ,  $p = 0.632$ ), relative peak mechanical power ( $t(3) = 0.086$ ,  $p = 0.937$ ), relative mean mechanical power ( $t(3) = 0.336$ ,  $p = 0.759$ ), total work ( $t(3) = -1.108$ ,  $p = 0.349$ ) or fatigue index ( $t(3) = -0.019$ ,  $p = 0.986$ ) between test 1 and 2. Two-way mixed model intraclass correlation coefficient calculated via absolute agreement for test 1 and test 2 was  $r = 0.901$ ,  $p = 0.047$  for peak mechanical power,  $r = 0.982$ ,  $p = 0.05$  for mean mechanical power,  $r = 0.972$ ,  $p = 0.011$  for relative peak mechanical power,  $r = 0.991$ ,  $p = 0.02$  for relative mean mechanical power,  $r = 0.998$ ,  $p = 0.02$  for total work and  $r = 0.598$ ,  $p = 0.277$  for fatigue index with the coefficient of variation being 6.4% for peak mechanical power, 3.5% for mean mechanical power, 5.7% for relative peak mechanical power, 2.6% for relative mean mechanical power, 1% for total work and 19.9% for fatigue index.

### **Statistical analyses**

We used the guidelines of Batterham & Hopkins (2006) to assess the magnitude of differences between groups in relation to the smallest worthwhile change. All data were log-transformed for analysis to reduce bias arising from non-uniformity error. The standardised difference score (effect size) was calculated using Cohen's  $d$  (difference between groups divided by pooled standard deviation) and assessed according to established criteria;  $\geq 0.2$  small,  $\geq 0.5$  moderate and  $\geq 0.8$  large effect (Cohen, 1988). For between-group comparisons, the chance that the true difference was detrimental, similar or beneficial was assessed using a publically available spreadsheet ([www.sportsci.org/resource/stats/xCompare2groups.xls](http://www.sportsci.org/resource/stats/xCompare2groups.xls)). The chance that the true value was beneficial was assessed against the smallest worthwhile change (0.5 multiplied by the typical error of each measurement) using established criteria,  $\leq 1\%$  almost certainly not, 1 – 5% very unlikely, 5 – 25% unlikely, 25 – 75% possible, 75 – 95% likely, 95 – 99% very likely,

≥ 99% almost certain. Performance was deemed unclear if the confidence intervals spanned over positive and negative thresholds for the smallest worthwhile change.

## Results

All data were normally distributed and equal variances were assumed. Descriptive statistics for peak mechanical power, mean mechanical power, relative peak mechanical power, relative mean mechanical power, total work and fatigue index for each experimental condition can be seen in Table 1 and magnitude-based inferences in Table 2. When compared to the placebo, sodium bicarbonate provided small to moderate beneficial effects (ES = 0.22-0.65) however magnitude-based statistics determined the effect on performance as unclear. Creatine and co-ingestion provided small to large performance benefits compared to the placebo (ES = 0.37-0.83; ES = 0.46-0.83 respectively), however similar to that of sodium bicarbonate, magnitude-based statistics deemed the effect of each condition on performance of mean mechanical power, relative peak mechanical power, relative mean mechanical power and total work as unclear. Creatine and co-ingestion conditions provided a likely performance benefit compared to the placebo for peak mechanical power.

Creatine and co-ingestion conditions were unlikely different for peak mechanical power (ES = 0.11; 90% CI -0.97 to 1.18), mean mechanical power (ES = 0.14; 90% CI -0.18 to 0.45), relative peak mechanical power (ES = -0.21; 90% CI -0.81 to 0.38) and relative mean mechanical power (ES = 0.04; 90% CI -1.04 to 1.11). Co-ingestion provided a small performance benefit over creatine alone in total work completed over the six sprints (ES = 0.24; 90% CI -0.55 to 1.01) (Figure 2). Figure 3 suggests that the greatest performance enhancement in relative peak mechanical power occurred in sprints 3 (ES = 1.05 Large effect) and 4 (ES = 0.84 Large effect). It is likely that there was no clear performance benefit in the first and last sprint. Figure 4 demonstrates that 7 out of 9 (78%) participants improved more than the smallest worthwhile change in sprint 1 and that 5 out of 9 (55%) participants improved more than the smallest worthwhile change in sprint 6. In all sprints, 4% of changes

in peak mechanical power were beneficially large, 35% moderate, 39% small, 15% trivial, 4% detrimentally small and 4% detrimentally moderate effects.

## **Discussion**

The main findings from the study was that there was no additive effect of combining creatine and sodium bicarbonate supplementation compared to creatine supplementation alone. Creatine supplementation induced meaningful improvements in peak mechanical power (+11%, ES = 0.48 Moderate effect; 90% CI 0.03 to 1.12), mean mechanical power (+2.5%, ES = 0.37 Small effect; 90% CI -0.10 to 0.84), relative peak mechanical power (+8.2%, ES = 0.81 Large effect; 90% CI 0.39 to 1.23), relative mean mechanical power (+4.8%, ES = 0.44 Small effect; 90% CI 0.03 to 0.85) and total work (+3.7%, ES = 0.66 Moderate effect; 90% CI -0.17 to 1.43) compared to placebo. These findings are consistent with previous studies (Dawson et al., 1995; Eckerson et al., 2005; Izquierdo et al., 2002; Peyrebrune et al., 1998; Skare et al., 2001; Ziegenfuss et al., 2002) but contrast research elsewhere (Ahmun et al., 2005; Cooke et al., 1995). These inconsistencies might be to variable dietary creatine (Syrotuik & Bell, 2004) and insufficient carbohydrate to assist creatine uptake (Green et al., 1996).

Sodium bicarbonate alone reported meaningful improvements in peak mechanical power (+8%, ES = 0.28 Small effect; 90% CI -0.28 to 0.85), mean mechanical power (+2.9%, ES = 0.22 Small effect; 90% CI -0.19 to 0.63), relative peak mechanical power (+3.9%, ES = 0.46 Small effect; 90% CI -0.46 to 1.39), relative mean mechanical power (+3.8%, ES = 0.28 Small effect; 90% CI -0.13 to 0.69) and total work (+3.9%, ES = 0.65 Moderate effect; 90% CI 0.18 to 1.42) when compared to placebo. These findings reflect previous studies that reported meaningful improvements in mechanical power output (Bishop et al., 2004; McNaughton et al., 1987) however contradicts studies that reported no meaningful improvements (Aschenbach et al., 2000; Horswill et al., 1988; Lavender & Bird, 1989; Robergs et al., 2005; Siegler et al., 2008). Dosing protocol inconsistencies might explain these differences.

There was no meaningful additive effect of co-ingestion on mechanical power output compared to creatine alone. Mero et al. (2004) reported a 0.9 s (1.5%) improvement in the second of two 100 m swimming sprints compared to a placebo. Barber et al. (2013) reported meaningful improvements of 3.2% in relative mean mechanical power output compared to placebo and creatine only conditions. The present study reported similar improvements in peak mechanical power (+9.7%, ES = 0.46 Small effect; 90% CI -0.04 to 0.96), mean mechanical power (+4.6%, ES = 0.46 Small effect; 90% CI 0.06 to 0.87), relative peak mechanical power (+6.4%, ES = 0.60 Moderate effect; 90% CI 0.19 to 1.01), relative mean mechanical power (+5.7%, ES = 0.45 Small effect; 90% CI -0.01 to 0.90) and total work (+4.3%, ES = 0.83 Large effect; 90% CI -0.02 to 1.60) when co-ingestion was compared to the placebo. When co-ingestion was compared to creatine alone, we failed to observe meaningful performance improvements in peak mechanical power (-1.7%, ES = 0.10 Trivial effect; 90% CI -0.97 to 1.18), mean mechanical power (+2.7%, ES = 0.14 Trivial effect; 90% CI -0.18 to 0.45), relative peak mechanical power (-1.9%, ES = -0.21 Small detrimental effect; 90% CI -0.81 to 0.38) or relative mean mechanical power (+0.9%, ES = 0.04 Trivial effect; 90% CI -1.04 to 1.11). We did observe a small meaningful performance improvement in total work (+1.3%, ES = 0.24 Small effect; 90% CI -0.55 to 1.01) when co-ingestion was compared to creatine alone.

There are several possible explanations which could explain these disparities. There might have been insufficient washout between creatine-containing conditions in the present study, causing a carryover effect that might have masked effects in both the placebo and sodium bicarbonate trials. Sodium bicarbonate dosage in the present study might have been insufficient when compared to other studies, Barber et al. (2013). Douroudos et al. (2006) reported significant increases in blood bicarbonate concentration in a dose-response relationship with loading regimens of 0.3 g·kg<sup>-1</sup> and 0.5 g·kg<sup>-1</sup>. During the present study, some participants ( $n = 3$ ) experienced gastrointestinal discomfort that is consistent with other studies containing sodium bicarbonate (McNaughton et al., 2008). Furthermore, the optimal

dosing regimen of sodium bicarbonate for clear performance benefits needs to be determined.

To our knowledge the present study was the first to directly compare co-ingestion against both supplements ingested independently. When co-ingestion was compared to sodium bicarbonate alone, we found no meaningful performance improvement in peak mechanical power (+1.9%, ES = 0.08 Trivial effect; 90% CI -0.66 to 0.82) or total work (+1.1%, ES = 0.18; Trivial effect; 90% CI -0.60 to 0.95), however we found small meaningful performance improvements in mean mechanical power (+2%, ES = 0.28 Small effect; 90% CI -0.47 to 1.01), relative peak mechanical power (+2.6%, ES = 0.48 Small effect; 90% CI -0.29 to 1.20) and relative mean mechanical power (+1.9%, ES = 0.41 Small effect; 90% CI -0.35 to 1.14).

The most surprising outcome of the present study was that all conditions reported a likely detrimental effect on fatigue index. Fatigue index data in the present study should be interpreted cautiously; we observed a coefficient of variation of 19.9% in our reliability study, which appears to be a consistent finding (Hughes et al., 2006; McGawley & Bishop, 2006; Oliver et al., 2006). A limitation to the present study was the failure to measure blood measurements of pH, bicarbonate, lactate and intramuscular phosphocreatine. As a result, the carryover effect of initial creatine loading on other conditions and mechanisms of action are unknown. There were differences in supplement powder mass between conditions however no participants reported observing these differences.

In conclusion, 20 g·d<sup>-1</sup> of creatine monohydrate and 0.3 g·kg<sup>-1</sup> of sodium bicarbonate ingested independently for 7 d provided meaningful improvements on multiple indices of mechanical power output. Magnitude-based statistics determined the majority of these improvements to be unclear, however. There was no meaningful effect of co-ingestion compared to creatine on mechanical power output indices, but a small meaningful improvement on total work for all sprints. Compared to ingesting sodium bicarbonate alone, co-ingestion induced small, meaningful performance benefits.

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CG collected the data, conducted the data analysis and wrote the manuscript. DR conceptualised the study and developed the research question, created the research design, assisted with data analysis and interpretation, provided feedback and edited the manuscript. MR provided feedback and edited the manuscript and AR provided support in data collection, assisted with data analysis and interpretation and provided feedback. All authors approved the final version of the paper.

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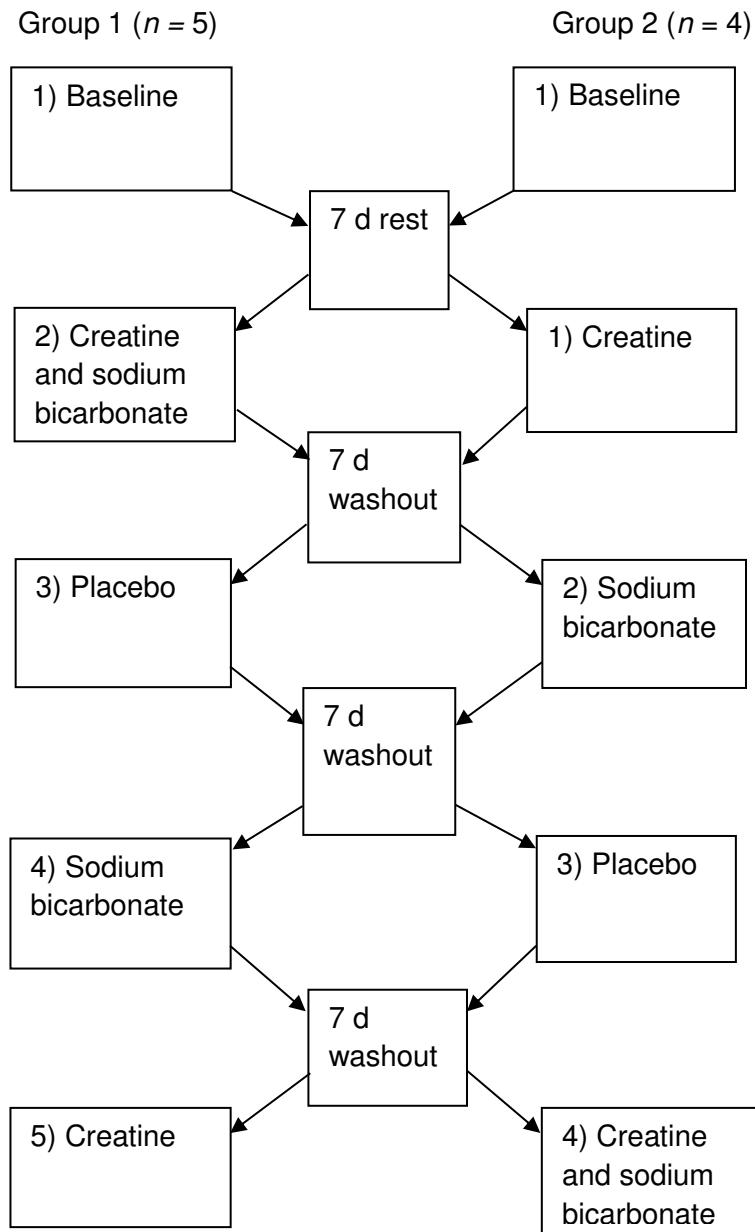
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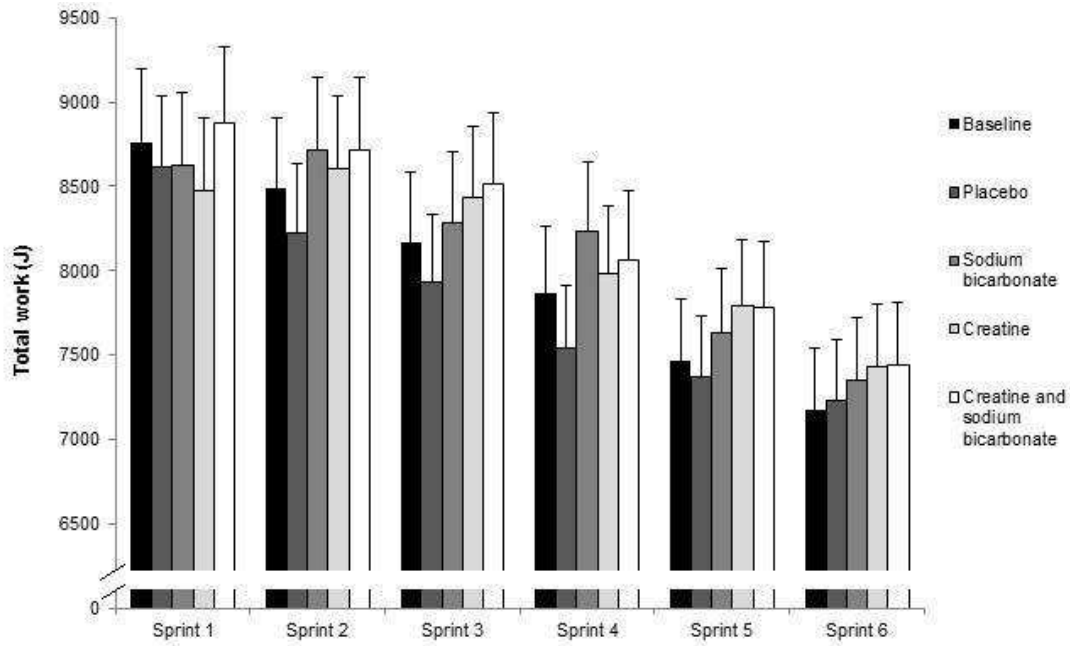
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“Effects of Creatine and Sodium Bicarbonate Co-Ingestion on Multiple Indices of Mechanical Power Output During Repeated Wingate Tests in Trained Men” by Griffen C, Rogerson D, Ranchordas M, Ruddock A  
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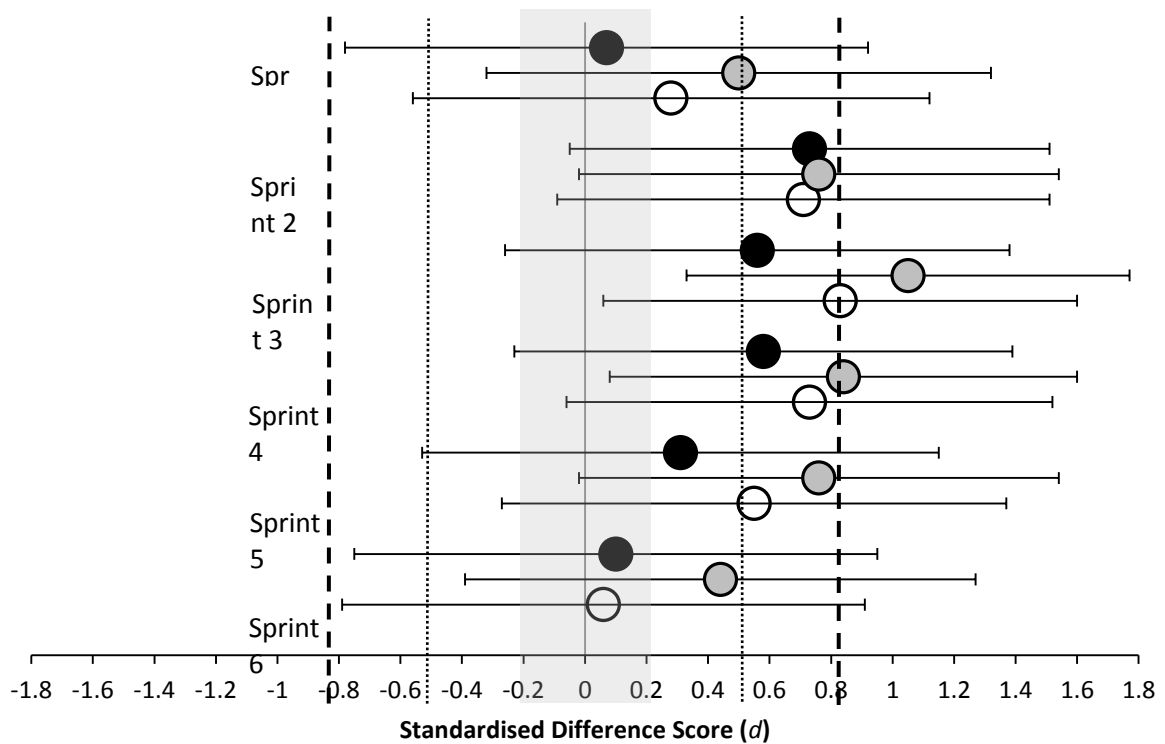
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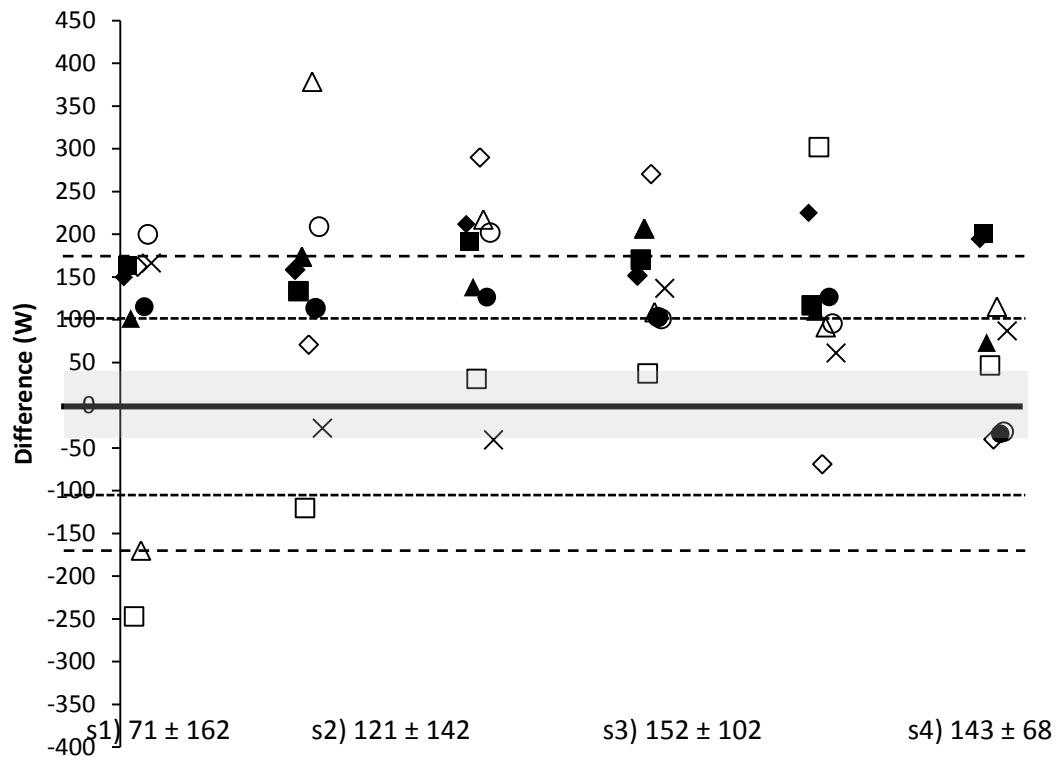
**Figure 1:** Schematic of experimental design.



**Figure 2:** Total work (sprints 1-6) for baseline, placebo, creatine, sodium bicarbonate and creatine and sodium bicarbonate conditions.



**Figure 3:** Relative peak mechanical power standardised effect size ( $d$ ) and 90% confidence interval for supplementation versus placebo. Black filled circles = sodium bicarbonate; grey filled circle = creatine; open circle = creatine and sodium bicarbonate.



**Figure 4:** Individual differences in peak mechanical power production between creatine and placebo conditions. Values are sprint number, mean average and standard deviation. Small, moderate and large effects are  $\pm 40$ ,  $99$  and  $159$  W respectively.



**Table 1:** Average peak mechanical power, mean mechanical power, relative peak mechanical power, relative mean mechanical power and fatigue index (mean  $\pm$  SD) during six 10-s repeated Wingate tests between baseline, placebo, sodium bicarbonate, creatine and co-ingestion of creatine and sodium bicarbonate conditions.

	<b>Baseline</b>	<b>Placebo</b>	<b>Sodium bicarbonate</b>	<b>Creatine</b>	<b>Creatine and sodium bicarbonate</b>
Peak mechanical power (W)	1117 $\pm$ 232	1122 $\pm$ 313	1220 $\pm$ 285	1264 $\pm$ 260	1243 $\pm$ 262
Mean mechanical power (W)	819 $\pm$ 152	803 $\pm$ 154	827 $\pm$ 147	824 $\pm$ 140	844 $\pm$ 140
Relative peak mechanical power (W $\cdot$ kg <sup>-1</sup> )	14.8 $\pm$ 2.1	14.6 $\pm$ 2.0	15.2 $\pm$ 2.2	15.9 $\pm$ 2.4	15.6 $\pm$ 2.2
Relative mean mechanical power (W $\cdot$ kg <sup>-1</sup> )	10.4 $\pm$ 1.4	10.0 $\pm$ 1.5	10.4 $\pm$ 1.3	10.5 $\pm$ 1.7	10.6 $\pm$ 1.4
Total work (J)	7988 $\pm$ 552	7818 $\pm$ 488	8140 $\pm$ 498	8120 $\pm$ 421	8233 $\pm$ 515
Fatigue index (W $\cdot$ s <sup>-1</sup> )	126 $\pm$ 38	123 $\pm$ 33	137 $\pm$ 47	150 $\pm$ 41	141 $\pm$ 40

**Table 2:** Standardised difference (*d*), (90% confidence interval), % chances of detrimental, similar and beneficial effect; quantitative descriptor of difference for supplement vs. placebo trial.

	<b>Sodium bicarbonate</b>	<b>Creatine</b>	<b>Creatine and sodium bicarbonate</b>
Peak mechanical power (W)	0.28 Small (-0.28 to 0.85) 10/21/69 Unclear	0.58 Moderate (0.03 to 1.12) 4/10/86 Likely beneficial	0.46 Small (-0.04 to 0.96) 6/14/80 Likely beneficial
Mean mechanical power (W)	0.22 Small (-0.19 to 0.63) 27/17/56 Unclear	0.37 Small (-0.10 to 0.84) 21/15/64 Unclear	0.46 Small (0.06 to 0.87) 15/13/71 Unclear
Relative peak mechanical power ( $W \cdot kg^{-1}$ )	0.46 Small (-0.46 to 1.39) 10/29/61 Unclear	0.81 Large (0.39 to 1.23) 2/10/88 Unclear	0.60 Moderate (0.19 to 1.01) 5/18/77 Unclear
Relative mean mechanical power ( $W \cdot kg^{-1}$ )	0.28 Small (-0.13 to 0.69) 39/16/45 Unclear	0.44 Small (0.03 to 0.85) 14/12/74 Unclear	0.45 Small (-0.01 to 0.90) 12/11/77 Unclear
Total work (J)	0.65 Moderate (0.18 to 1.42) 30/5/66 Unclear	0.66 Moderate (-0.17 to 1.43) 24/5/71 Unclear	0.83 Large (-0.02 to 1.60) 33/5/62 Unclear
Fatigue index ( $W \cdot s^{-1}$ )	0.41 Small (-0.11 to 0.92) 6/55/39 Possibly detrimental	0.83 Large (0.53 to 1.13) 0/11/89 Likely detrimental	0.74 Moderate (0.46 to 1.01) 1/39/60 Possibly detrimental