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New Zealand Blackcurrant extract supplementation does not improve repeated sprint ability

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ABSTRACT

Blackcurrants are an excellent source of antioxidant and anti-inflammatory agents, and recent studies have found them to facilitate performance and recovery in aerobic activities. However, limited research exists in intermittent or anaerobic settings despite known oxidative and inflammatory stresses. Therefore, we examined the effects of New Zealand Blackcurrant (NZBC) on repeated sprint ability (RSA) and recovery parameters. Sixteen recreationally active females were supplemented with either NZBC (1.6mg.kg-1 anthocyanin content; ViBERi, Timaru, New Zealand) or a matched placebo (artificial sweetener) for 7 days in a randomized, double-blind, parallel-group design. On day 7 participants performed the RSA test which consisted of ten 30m shuttle sprints interspersed with a 30 second recovery period. Blood lactate was assessed 1-, 3-, 5-, and 10-minutes post-test. The same protocol was then replicated the following day. NZBC improved mean sprint time from baseline by 2.0% and fastest sprint time by 2.7%. Placebo also improved sprint time by 2.3%. Compared to the placebo group the NZBC group typically performed better in all RSA test outcomes, however the differences were deemed unclear and non-significant. Lactate responses post RSA on average tended to be higher on both days for the NZBC group compared to placebo group (15.1 – 32.5%). A moderate difference (ES: -0.64) was observed between groups post 7-days of supplementation for lactate clearance from 5-minutes to 10-minutes post-test with NZBC leading to a decrease of 23.7%. In conclusion, NZBC supplementation for 7-days does not improve repeated sprint ability when compared to placebo.

1. Introduction

New Zealand Blackcurrant (NZBC) supplementation has received growing attention from the sports science community, alongside a boom in other plant-derived compounds such as capsaicin, menthol and tart cherry juice (Best et al., 2020; Kuehl et al., 2010; Rosenbloom, 2016; Stevens & Best, 2017), often termed functional foods (Knab et al., 2013; Milivojevi et al., 2013). NZBC is a rich source of the flavonoid pigments anthocyanins which are responsible for the characteristically purple color of NZBC and are purported to confer health and performance benefits (Konczak & Zhang, 2004; Milivojevi et al., 2013).

NZBC supplementation has been shown to improve cycling performance (Cook et al., 2017a; Murphy et al., 2017; Willems et al., 2014), volume of high intensity running in repeated sprint protocols (Perkins et al., 2015; Willems et al., 2016), and recovery from exercise (Lyall et al., 2009; Murphy et al., 2017; Willems, Myers, Gault, & Cook, 2014). Mechanistically, NZBC supplementation elicits improvements in fat oxidation, total hemoglobin, lactate clearance, lactate production and vasodilation (Cook et al., 2017a; Cook et al., 2017b; Perkins et al., 2015; Willems et al., 2014). More specifically, flow mediated dilation may be increased following anthocyanin supplementation, with a

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possible increase of nitric oxide availability and a concomitant impairment of NADPH oxidase (Rodriguez-Mateos et al., 2013). Interestingly, these improvements occur across a range of exercise intensities and exercise modalities, suggesting that the beneficial effects of NZBC supplementation whilst far reaching may pertain to energy system predominance. This is further supported by NZBC ability to modulate oxidative responses to exercise (Cook et al., 2017a).

To date research has primarily investigated NZBC supplementation at predominantly aerobic intensities, with the maximum controlled intensity being 110% vVO_{2max} (Perkins et al., 2015). Whilst time trial data have also been presented (Cook et al., 2017a; Murphy et al., 2017), these are also aerobic in nature, with time to completion approximately 6 – 30 minutes (Cook et al., 2017a; Lyall et al., 2009; Murphy et al., 2017). Classical evidence shows that aerobic fitness improves athletes' rate of lactate clearance but not lactate production (Donovan & Brooks, 1982; Sahlin & Henrikkson, 1984), whereas recent evidence shows an increased reliance upon anaerobic metabolism is positively correlated with repeated sprint outcomes (Milioni et al., 2017). NZBC supplementation affects both lactate production and clearance (Willems et al., 2015), suggesting investigation into anaerobic activities and NZBC supplementation is warranted. Such investigation expands NZBC supplementation beyond endurance activities, with only two papers published to date in an intermittent or team setting (Perkins et al., 2015; Willems et al., 2016).

The optimal dose of NZBC supplementation has not currently been reported; however, studies have indicated dose dependent effects (Cook et al., 2017a). Absolute doses have been explored (typically 300mg.day^{-1}), yet many commonly used sports nutrition interventions typically employ relative doses. The exploration of a relative dose encourages personalization of NZBC supplementation strategies and may elucidate a minimal worthwhile dose.

The aim of this study is to examine the effect of 6 and 7-days' supplementation of a relative dose of NZBC on variables pertaining to repeated sprint ability against a dose matched placebo treatment. It was hypothesised that mean sprint time would be lower in the NZBC group, potentially via an attenuation of sprint time decrements in the latter stages of exercise due to lower rates of lactate accumulation and a possible increase in aerobic contribution.

2. Methods

2.1. Participants

Sixteen recreationally active females were recruited for this study. Utilizing a customized spreadsheet (Hopkins, 2010) all participants were allocated to either the blackcurrant or placebo group using minimization of means. Allocation was based on the rank order according to the mean sprint result of the 10 sprints of the repeated sprint ability (RSA) test performed during baseline testing. Three participants in the blackcurrant group (3 out of 8; 37.5%) and one participant in the placebo group (1 out of 8; 12.5%) withdrew from the study owing to injury or illness throughout the supplementation period. Characteristics for the participants that completed the supplementation period and all RSA testing sessions are summarized in Table 1. All participants provided informed voluntary consent and completed a health screen prior to physical testing. This study was approved by the Institute's Human Research Ethics Committee.

Participants attended three sessions within 16 days. The first session acted as a baseline testing session to determine group allocation. Sessions 2 and 3 were test trials conducted on consecutive days, 6- and 7-days post supplementation. Each participant completed all sessions at the same time (6:00 – 8:00 a.m.) and with the same environmental conditions (15.2 ± 1.8°C temperature and 67.0 ± 8.5% relative humidity) to minimize the influence of circadian variation. Testing was conducted indoors at a recreational training facility. Participants were required to wear comfortable running shoes and sportswear.

2.2. Protocol

Utilizing a double-blind parallel group study design, participants were supplemented with either NZBC (1.6mg.kg^{-1} anthocyanin content; ViBERi, Timaru, New Zealand) or a matched placebo (artificial sweetener) for seven days. NZBC and placebo supplementation was administered in opaque gelatine capsules, which were provided to each participant in sealed envelopes, to maintain double blinding. Supplementation commenced six days prior to the first RSA test trial and ended following the completion of the first RSA post-test allowing for a total of seven doses on consecutive days. This design was intended to reflect a weekend tournament in team sports, or a heat and final taking place on consecutive days.

Table 1: Participant characteristics in NZBC and placebo supplement groups. Values are mean ± standard deviation.

	Blackcurrant (n = 5)	Placebo (n = 7)
Age (years)	25 ± 4	31 ± 7
Body mass (kg)	61 ± 9	65 ± 9
Height (cm)	165 ± 5	167 ± 4
Training (sessions/week^{-1})	5 ± 1	8 ± 1

Participants were instructed to consume the supplementation as part of their morning eating regime. Participants were recommended to moderate habitual exercise intensity for the 48 hours prior to exercise and consume their habitual diet. Dietary manipulation or restriction of anthocyanin-rich foods was not part of this instruction, so as to not introduce bias before study commencement. Whilst dietary controls were not stringent, the use of consecutive testing days may serve to further minimise any potential confounding brought about by bioavailability or lack thereof, as anthocyanins remain in circulation for as long as 48 hours post-consumption (Kay, Mazza, & Holub, 2005).

Prior to commencing the RSA test, participants completed a standardised 15 min warm-up consisting of low-intensity shuttle runs, directed dynamic stretching and self-selected static stretching. A pre-test lactate measure was then taken (fingertip (non-preferred ring finger); Lactate Pro 2 LT-1730, Arkray Factory Inc., Japan).

The RSA test consisted of ten 30-m shuttle sprints (15-m + 15-m), each with a single change of direction of 180° interspersed with a 30-second recovery period (Padulo et al., 2016). The test required participants to begin on the start line with their self-selected front foot placed behind a marker in a split stance. The start marker was placed 0.5-m behind a set of wireless timing light gates (SpeedLight V2 timing gates, Swift Performance Equipment, Queensland, Australia) to avoid participants prematurely breaking the infrared beam. Participants then sprinted as fast as possible to the 15-m turning line, touching the line with one foot, turning and sprinting back through the gate at the start line. Participants then decelerated to a walking pace to the baseline (5-m) and back to the start line ready for the next sprint in 30 seconds. Recovery time was monitored via a hand operated stopwatch when the participant returned past the start line. Remaining recovery time was verbally indicated to the participants by the research practitioner at 10 seconds then 3, 2, 1 and zero seconds. At time zero a "Go" command was verbally provided. Verbal encouragement was provided by the research practitioner to the participants throughout the RSA test to motivate maximal effort.

The outcomes derived from the RSA test were mean sprint time of the 10 sprints, fastest sprint time from the 10 sprints, slowest sprint time from the 10 sprints and a fatigue index. The fatigue index was considered as a % decrement in performance, calculated according to Oliver (2009):

$$\%\ decrement = \left(\frac{(mean\ sprint\ time\ -\ fastest\ sprint\ time)}{fastest\ sprint\ time}\right) \times 100$$

Following completion of the RSA-test at testing sessions two and three, post lactate measures were taken. Participants remained seated throughout the collection period (~15 min), with samples taken at 1 minute, 3 minutes, 5 minutes, and 10 minutes post completion of the RSA-test. During this post-test period, only water was permitted. No food or other beverages were permitted.

Subjective responses in the form of rating of perceived exertion (RPE) were recorded during the recovery period at the completion of each shuttle sprint at all testing sessions.

2.3. Statistical Analyses

Utilizing the comparative methods of Hopkins (2006) and using a spreadsheet for the analysis of post only trials, comparisons were made between trials for repeated sprint ability outcomes and blood lactate responses for each supplementation group. These analyses allowed for Cohen effect sizes, 90% confidence intervals (CI), *p* values and qualitative inferences to be presented, which is considered a meaningful practice for statistical use in sports medicine and the exercise sciences (Hopkins et al., 2009). Specifically, differences between trials are expressed as a percentage via analysis of log-transformed values using natural logarithms. To make inferences about the true values of the percentage differences and effect sizes between trial metrics, the uncertainty in the percentage differences and effect sizes are expressed as 90% confidence intervals and as likelihoods that the true value of the difference is substantial (Batterham & Hopkins, 2006). A difference is deemed unclear if its confidence interval of the effect statistic overlaps substantially positive and negative values and the threshold for the smallest worthwhile effect, otherwise, when a result is above the threshold for the smallest worthwhile effect the results are given as: 0 – 0.2 trivial; 0.2 – 0.6 small; 0.6 – 1.2 moderate; 1.2 – 2.0 large; 2.0 – 4.0 very large. An effect size of 0.2 was chosen to be the smallest worthwhile difference in the means in standardized (Cohen) units as it gives chances that the true effect would at least be small. A *p* value of <0.05 was considered significant. Chances of benefit or impairment induced by the supplement were assessed as follows: <1%, almost certainly not; 1 - 5%, very unlikely; 5 - 25%, unlikely; 25 - 75%, possible; 75 - 95%, likely; 95 - 99%, very likely; >99%, almost certain.

Further statistical analyses compared the change scores in repeated sprint ability outcomes and blood lactate responses between the NZBC and placebo supplement groups. Mean nett effects, *p* values and nett differences of training were calculated using a spreadsheet for the analysis of pre-post parallel groups' trials (Hopkins, 2006). Inferential statistics were based on interpretation of magnitude of effects (differences) (Batterham & Hopkins, 2006). The likelihoods of the effect were interpreted using the Cohen scale of magnitudes with 0.2 being chosen as the smallest worthwhile difference in the means. A difference was deemed unclear if the confidence interval of the effect statistic substantially overlapped positive and negative values, and the threshold for the smallest worthwhile effect.

3. Results

Upon completion of the final trial participants were asked if they thought they had consumed either NZBC or placebo, with 40% (2 out of 5 participants) of the NZBC group and 71% (5 out of 7 participants) of the placebo group guessing correctly. This indicated successful blinding in the NZBC group but not the placebo group.

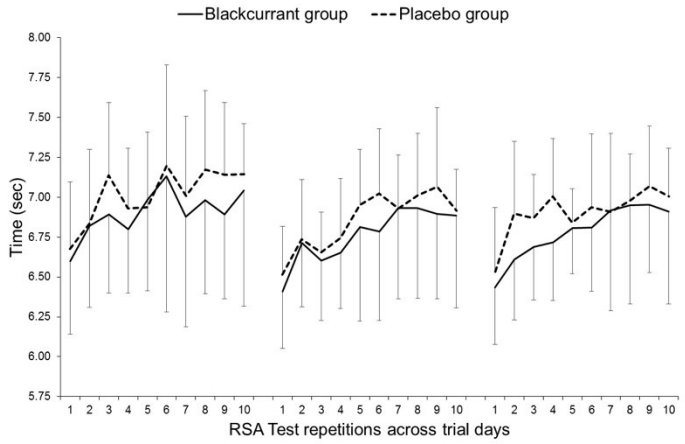

Figure 1: Mean ± SD Sprint time for all 10 sprints for all 3 trials (Baseline, 6-days of supplementation and 7-days of supplementation; left to right respectively).

3.1. Repeated Sprint Ability (RSA) outcomes

Mean sprint times for all sprint repetitions on all trial days are presented in Figure 1. The effect of NZBC supplementation on RSA test outcomes are shown in Table 2. Compared with baseline, after 6-days of supplementation the NZBC group participants improved their mean sprint time by 2.0% (CI = -3.6 to -0.3%) and their fastest sprint time by 2.7% (CI = -4.3 to -1.0%).

Of the five participants in the blackcurrant group, four demonstrated an improved mean sprint time (see Figure 2) whereas all demonstrated improved faster sprint times (-2.7%, CI = -4.3 to -1.0%; $p = 0.027$). No additional substantial differences in mean sprint time, fastest sprint time or any other RSA test outcomes were observed from 7-days of NZBC supplementation. Similarly, compared with baseline, after 6-days of supplementation the placebo group participants improved their mean sprint time by 2.3% (CI = -4.8 to 0.4%). Of the seven participants in the placebo group, five demonstrated an improved mean sprint time (see Figure 3). Compared to the placebo group the NZBC group typically performed better in all RSA test outcomes on all trial days (see Table 2). However, the differences in outcomes between groups were unclear and not significantly different.

3.2. Blood Lactate Responses

Substantial decreases (smallest worthwhile effect as a standardized Cohen's effect size of 0.20) in blood lactate responses as a result of NZBC supplementation was possible to likely probable (see Figure 3). *Small* to *moderate* decreases (effect size range -0.24 to -0.93) were observed between 6-days and 7-days of supplementation for blood lactate responses at 1 minute post-test (-11%, CI = -23.2 to 3.1%), 3 minutes post-test (-13.0%, CI = -30.7 to 9.2%), 5 minutes post-test (-19.8%, CI = -39.1 to 5.6%) and 10 minutes post-test (-22.1%, CI = -39.3 to 0.1%). Similar decreases between days were observed for the placebo group leading to *unclear* differences when comparing lactate responses between NZBC and placebo groups (see Table 3). Lactate responses on average tended to be higher on both days for the blackcurrant group compared to placebo group (see Figure 4).

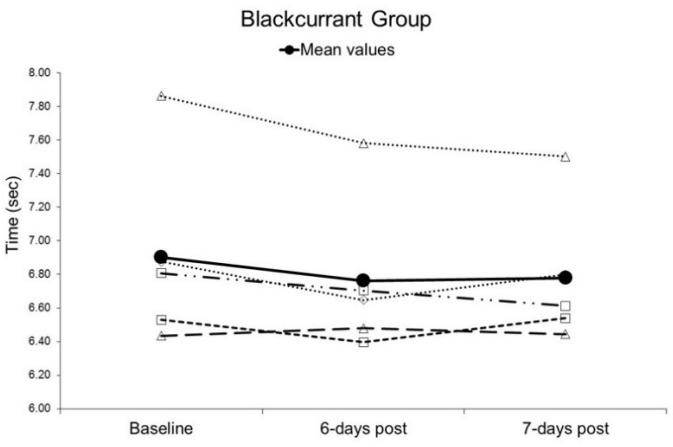

Figure 2: Individual and mean data for RSA mean sprint time in the Blackcurrant group before (Baseline), after 6 days (6-days post) and after 7 days (7-days post) of supplementation.

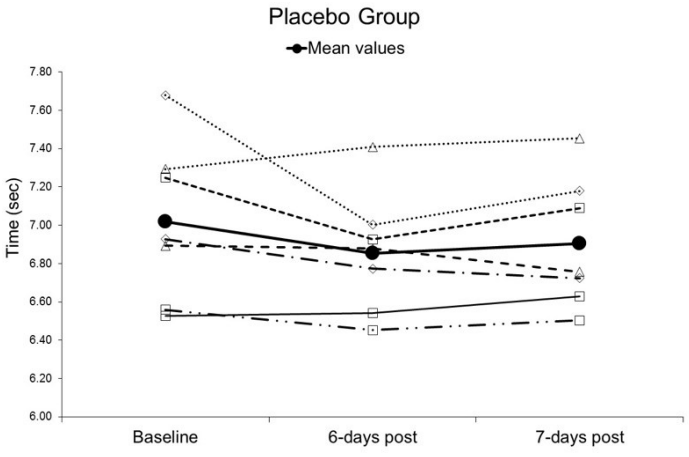

Figure 3: Individual and mean data for RSA mean sprint time in the Placebo group before (Baseline), after 6 days (6-days post) and after 7 days (7-days post) of supplementation.

Table 2: RSA outcomes (Mean ± SD) and corresponding mean changes (%) for NZBC and placebo groups, and nett difference (%, ± 90% confidence limits) of these changes.

				Change in Measure (%)			
		NZBC	Placebo	Comparisons	NZBC	Placebo	% Difference, ± 90% CL
MST (s)	Baseline	6.90 ± 0.67	7.02 ± 0.42	6-d vs. BL	-2.0	-2.3	0.3, ± 2.9
	6-days	6.76 ± 0.47	6.85 ± 0.32	7-d vs. BL	-1.7	-1.6	-0.1, ± 2.7
	7-days	6.78 ± 0.42	6.90 ± 0.34	7-d vs. 6-d	0.3	0.7	-0.4, ± 1.9
FST (s)	Baseline	6.58 ± 0.47	6.65 ± 0.42	6-d vs. BL	-2.7	-3.0	0.3, ± 2.7
	6-days	6.40 ± 0.36	6.45 ± 0.26	7-d vs. BL	-2.3	-1.9	-0.4, ± 2.8
	7-days	6.43 ± 0.36	6.53 ± 0.40	7-d vs. 6-d	0.4	1.1	-0.7, ± 2.4
SST (s)	Baseline	7.23 ± 0.78	7.48 ± 0.48	6-d vs. BL	-2.7	-3.9	1.2, ± 5.1
	6-days	7.02 ± 0.54	7.19 ± 0.42	7-d vs. BL	-2.3	-4.1	1.9, ± 4.8
	7-days	7.05 ± 0.55	7.17 ± 0.39	7-d vs. 6-d	0.5	-0.3	0.7, ± 2.3
FI (%)	Baseline	4.8 ± 2.8	5.5 ± 1.4	6-d vs. BL	18.1	9.7	7.6, ± 28.9
	6-days	5.5 ± 2.5	6.3 ± 2.4	7-d vs. BL	11.5	0.0	11.5, ± 33.5
	7-days	5.4 ± 3.3	5.8 ± 2.6	7-d vs. 6-d	-5.5	-8.9	3.7, ± 38.2

Note: MST: Mean Sprint time; FST: Fastest Sprint time; SST: Slowest Sprint time; FI: Fatigue Index; NZBC: New Zealand Blackcurrant.

Table 3: Blood lactate responses (Mean ± SD) and corresponding mean changes (%) for NZBC and placebo groups, and nett difference (%, ± 90% CL) of these changes.

				Change in Measure (%)			
		NZBC	Placebo	Comparisons	NZBC	Placebo	% Difference, ± 90% CL
Pre-test	6-days	1.1 ± 0.2	1.3 ± 0.2	7-d vs. 6-d	45.9	-4.5	52.7, ± 70.0
	7-days	1.7 ± 0.6	1.5 ± 1.0				
1min Post	6-days	12.1 ± 3.9	9.8 ± 4.4	7-d vs. 6-d	-11.0	-26.7	21.4, ± 21.6
	7-days	10.8 ± 3.4	7.2 ± 3.8				
3min Post	6-days	12.1 ± 4.2	9.8 ± 4.4	7-d vs. 6-d	-13.0	-24.4	15.1, ± 35.6
	7-days	10.5 ± 3.9	7.7 ± 4.4				
5min Post	6-days	12.3 ± 2.3	10.5 ± 5.4	7-d vs. 6-d	-19.8	-39.5	32.5, ± 38.6
	7-days	10.4 ± 3.7	6.8 ± 3.6				
10min Post	6-days	10.1 ± 3.4	8.6 ± 4.3	7-d vs. 6-d	-22.1	-33.5	17.2, ± 36.0
	7-days	7.7 ± 2.2	6.5 ± 3.6				

Note: NZBC: New Zealand Blackcurrant.

3.3. Subjective responses

RPE responses are shown in Figure 5. As expected RPE increased gradually between sprints from sprint 1 to sprint 10 irrespective of trial day or group, with non-significant differences between trials and between groups for RPE.

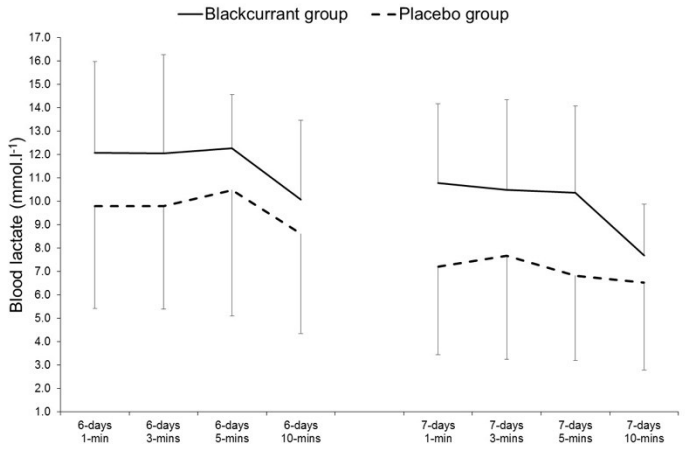

Figure 4: Blood lactate responses post RSA test after 6-days and 7-days of supplementation (Mean ± SD).

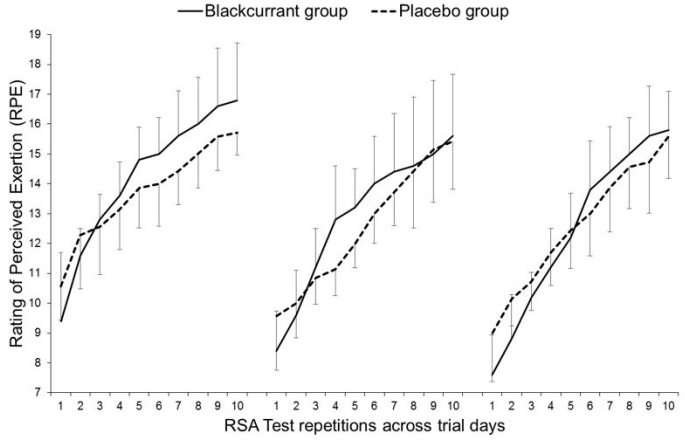

Figure 5: Mean ± SD of RPE scores post sprint for all 10 sprints for all three trials (Baseline, 6-days of supplementation and 7-days of supplementation; left to right respectively).

4. Discussion

Our work produced three key findings. Firstly, that NZBC supplementation tends to promote higher lactate accumulation during repeated sprint activity, irrespective of time point (Figure 3). Secondly, NZBC supplemented athletes consistently displayed faster MST and FST than placebo supplemented athletes, although the magnitude of change between groups is similar (Figure 1; Table 2). Thirdly, NZBC supplementation produces a statistically significant reduction of circulating lactate during recovery (between 5- and 10-minutes post-exercise) in a subsequent testing session (Figure 3).

We are the second group to show that supplementing with NZBC may elicit higher lactate values during exercise. Typically following NZBC supplementation lactate production is either lower (Willems et al., 2015), or shows no change (Cook et al., 2017a; Cook et al., 2017b; Murphy et al., 2017; Willems et al., 2014; Willems et al., 2016), possibly due to increased fat oxidation (Cook et al., 2017a). We tasked participants with performing each sprint at a maximal effort, with a combined mean sprint duration of 6.97 ±0.46 sec; this contrasts starkly with prior research which has examined exercise durations of 6-28 minutes, and 40-80% peak power output (Cook et al., 2017a; Cook et al., 2017b; Murphy et al., 2017; Willems et al., 2014; Willems et al., 2016). Even in previous NZBC repeated sprint/ team sport research (Willems et al., 2016), a large aerobic contribution likely exists due to the prolonged nature of the testing session (>90 minutes) and variability of running speeds. An increased fat oxidation for these activities would concomitantly lower glycolytic contributions and thus lactate production, which may be advantageous during prolonged exercise, but may involuntarily impair single and repeated efforts of high-intensity work (Stellingwerff et al., 2006).

An increase in fat oxidation would also lower RER during exercise and recovery, which has been shown to differentiate between athletes' training status (Hetlelid et al., 2015). Well-trained athletes exhibit *very likely* larger levels of fat oxidation at quicker running speeds, despite comparable levels of carbohydrate oxidation during interval training (Hetlelid et al., 2015). Such an increase in fat oxidation may have benefitted our participants when most glycogen depleted (Gollnick et al., 1973), hence the faster rate of lactate clearance seen on Day 7. However, this would not have been beneficial during RSA testing, as carbohydrate metabolism may also have been impaired. Whilst statistically significant, this faster clearance is likely of limited practical importance or consequence.

There are several pertinent limitations to address in the present study. First being the recreational level of the participants. Despite matched rank allocation following baseline testing we did not quantify participants' fitness levels beyond their RSA. This is perhaps responsible for the similar magnitude of change seen between groups over the course of the study, whereby both groups improved by the same percentage and stabilized, despite the NZBC group being faster at each time point. Whilst differences in absolute time exist between groups, both groups demonstrated an initial improvement followed by a lesser improvement or plateau in MST and FST performance. A washout period and crossover design would ascertain whether this is in fact a consistent response in as much as the participants cannot run any faster, or if NZBC is simply a better placebo, than a placebo. Secondly, whilst dietary protocols to minimise confounding anthocyanin containing foods do exist and are mechanistically sound, they lack ecological validity due to their broadly restrictive nature (Bell et al., 2015; Cook et al., 2017). We acknowledge that athletes' habitual diets certainly have the potential to affect RSA (and in this case MST and FST), most likely through substrate availability, employing

such a dietary protocol may further limit study completion due to adherence or attrition beyond the levels already reported. Thirdly, testing was conducted early in the morning, which may have circadian implications with respect to the circulating hormonal milieu and affected substrate oxidation (Parr, Heilbronn, & Hawley, 2020) and performance of all participants, irrespective of NZBC supplementation. This timing was due to facility availability, but readers should be encouraged that high intensity work could still be performed at this time of day, given some recreational athletes may be time-poor and thus early morning training is a necessity. We would also like to acknowledge the high-rate of participant attrition; participants attributed this to injury or illness not caused by participation, but occurring throughout the supplementation period. Other factors such as timing or testing, supplementation protocol, and family commitments (Abel et al., 2001) may have further compounded the reported reasons for participant withdrawal.

The metabolic climate of NZBC supplemented athletes suggests a need for further NZBC research in intermittent and team sports athletes, preferably with a trained comparator group, employing a replicated crossover design or in an extended tournament setting. In aerobic disciplines, future research should focus on exercise tasks in the severe domain (Burnley & Jones, 2016), where an increased lactate production, as observed in the present study, may improve performance via priming (Ingham et al., 2013). When assessing female participants, menstrual cycle phase should also be considered and where possible controlled for too, due to potential oestrogen-mediated antioxidant and glycogen sparing effects (McNulty et al., 2020).

5. Conclusion

The examined dose in the present study was insufficient to demonstrate previously documented responses to NZBC supplementation. At 1.6mg/kg, ~100mg anthocyanins were provided, this is similar to the loading protocol used by Murphy et al. (2017) who provided seven days of 105mg anthocyanins prior to an acute dose of 300mg which improved repeated cycling performance. A chronic, low dose of anthocyanins may confer cardiovascular benefits comparable to the vascular effects observed by Cook et al. (2017a) and George et al. (2012), but is unlikely to improve repeated sprint performance, in the absence of an acute dose of ≥300mg anthocyanins.

Conflict of Interest

The authors declare no conflict of interests.

Acknowledgment

The authors would like to acknowledge Lillian Morton for her involvement with the initial conceptualization of the research question and design. Data were collected by PM and CM; data interpretation and manuscript preparation were undertaken by RB, PM and GL. All authors approved the final version of the paper.

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