

Magnitudes matter more than Beetroot Juice

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Statistics | Technical note | MBI | Beetroot

Headline

A few tweets, re-tweets and emails from colleagues have caught my attention last year, all pointing toward a new study showing improvements in sprinting and high-intensity intermittent running performance after dietary nitrate supplementation (beetroot shots) (1). In the 36 team-sports players (training 5-10h a week) who volunteered for the study, **significant** “improvements” in 5- (2.3%), 10- (1.6%) and 20-m (1.2%) sprint times and a 3.9% “increase” in high-intensity intermittent performance were reported, after no longer than 5 days of supplementation (1)! These somewhat surprising results (at least to me) pushed me to write a blog post questioning the stats and the data analysis, that I published on my personal website (2). The present report is a re-use of the blog content, updated with some additional guidelines for our new Sport Performance and Science Reports platform.

Discussion

To all practitioners who may read both the article (1) and the present manuscript, the topic is obviously highly relevant; we are all looking for various ways to improve our players’ running performance – even better if these improvements can be gained legally (no doping) and without (physical) efforts. If you can convince yourself to commit to drink daily an awful 70-ml beetroot shot for 5 days before an important competition, then you may have found a really cool and lazy way to get faster and fitter!

However, before I began to tell (again) every player at the club (who would systematically pass on beetroot because of its taste) to finally commit themselves to drink this stuff, because it really works, I wished to make sure it would be worth the effort, both for them and me. After a deeper read of the paper, a closer look at the study design, the data analysis and the stat approach, I realized that in fact, beetroot supplementation, within the context of the present study, may not be as promising as it could be understood while only reading the title of the paper. This for at least two important reasons: 1) the somewhat limited magnitude of the “changes”, although significant and 2) the questionable study design/data analysis that doesn’t allow individual responses to be clearly accounted for and analyzed.

1. The magnitude of the “improvement” may not be large enough to be meaningful.

When considering the magnitude of the smallest worthwhile changes for different sprint distances (SWC, i.e., the minimum improvement likely to have an impact on the field, such as that required to be 20 cm ahead of an opponent to win a ball, Table 1) (3), the changes reported in the present study are in fact either smaller (5 m: study 2.3% vs SWC \approx 4%, 10 m: study 1.6% vs SWC \approx 2%) or just similar to (20 m: study 1.2% vs SWC \approx 1%) (3). Even for 20-m time, which magnitudes equals the SWC, chances for the “improvement” to be substantial may be no more than 50% at the individual level (when considering a typical error of the measurement (TE) of the same magnitude than the SWC - while in fact the TE may actually be twice as

large as the SWC for such a distance (3), decreasing further the likelihood of a substantial change) (3). The same reasoning applies to the “increase” in Yo-YoIR1 performance (+3.9%), which SWC is generally twice larger (\approx +8% (4), +7% as 0.2xSD in the present study). In conclusion, the comparison of the reported changes, although significant, to their specific SWC directly questions the practical impact and in turn, the usefulness of beetroot supplementation in the context of the present study. These data illustrate once again that the use of null hypothesis significance testing (NHST) is clearly limited to assess the actual performance benefit of a supplement or an intervention (5, see also the blog on the topic) – in the present case the significant P value likely results from the large sample size ($n=36$) – different conclusions (and probably less misleading in the present case) would be drawn with lower samples (i.e., $n<15$ as typically used in sport/nutrition/exercise interventions).

Since defining the SWC is determinant to MBI (using an inappropriate SWC can lead to erroneous conclusions), I have added here some updated (7) guidelines (Table 1) to derive the SWC, when it comes to analyze both group responses (“is my team getting faster following our last training block?”) and monitoring individual athletes. The spreadsheet to use in each scenario is also provided. Recommended reads (5, 7) including a discussion with daddy Will Hopkins (who I recently managed to convince to change his mind ^^) on the SWC for physiological data **with no direct** link to performance or risk of injury.(8)

2. The data analysis doesn’t allow individual responses to be clearly accounted for/analyzed.

In fact, the authors simply chose to compare the sprints/YoYoIR1 performances following beetroot supplementation to those following the placebo drink (Post beetroot – Post placebo, via paired-samples t-tests)!? While it is not clear why such a limited approach was chosen, the proper way to analyze these data would be to look first at within-group changes, and more importantly, to compare these within-group changes (i.e., between-group differences in the changes - typical crossover design, as ‘post beetroot - pre beetroot’ compared with ‘post placebo - pre placebo’ (18)). This latter approach is way more powerful and allows the understanding of i) the effect of each treatment per se (within-group effect, in relation to the SWC), ii) the variability of the response within each treatment (SD of the change, which has important implications when using supplementation with athletes – some will respond, some not !! – and how many and by which magnitude?), iii) compare the efficacy of the treatments (differences in the magnitude of the changes) and even more importantly, iv) compare the magnitude of the individual responses between each treatment (i.e., which treatment shows the greater variability in response). The importance of assessing individual responsiveness to various treatments including food supplements is often overlooked both in research and on the field (19). In fact, for an optimal prescription at the athlete level, it is compulsory to examine both the direction and magnitude of the effect of a supplement with regard to well-thought minimum thresholds (i.e., SWC); only doing so may

Type of data	Example of data	Type of analysis and spreadsheet of use	Method to derive the SWC	Common SWC value (elite level)
Individual athlete performance	Track and field events	Individual athlete compared with himself over time - Original (9) and updated (with trends) (10) spreadsheets	1/3 of the competition performance coefficient of variation (CV) (the performance monitored should be <u>similar</u> to the competition)	~0.3% (0.03s) for 100-m sprint time ~0.8% (1 min) for marathon (11)
Physical performance in team sports	Counter movement jump (CMJ), sprint times, maximal aerobic speed (MAS)	Group analysis: assessing the average changes in the team performance - Spreadsheet (12)	1) 1/5 of between-athlete SD	~2% (1cm) for CMJ height (13, 14) ~1.3% (0.2 km/h) % for MAS (13) ~8% for Yo-YoIR1 total distance (4)
			2) performance clues, e.g., based on empirical observations of direct performance benefits, such as a distance of 20–50 cm that one soccer player needs to be ahead of the opponent to win a ball	~1% (0.03s) for 20-m sprint time (3)
		Individual analysis: player compared with himself over time - Original (9) and updated (with trends) (10) spreadsheets	1) 1/5 of between-athlete SD	~2% (1cm) for CMJ height (13) ~1.3% (0.2 km/h) % for MAS (13) ~8% for Yo-YoIR1 total distance (4)
			2) performance clues, e.g., based on empirical observations of direct performance benefits, such as a distance of 20–50 cm that one soccer player needs to be ahead of the opponent to win a ball	~1% (0.03s) for 20-m sprint time (3)
Physiological data with no direct link to performance or risk of injury	Heart rate variability, Creatine Kinase, most blood variables	Group analysis: assessing the average changes in the team/group performance - Spreadsheet (12)	1/5 of between-athlete SD	~3% (0.10 ms) for Ln rMSSD (15) ~9% for Creatine Kinase (14)
		Individual analysis: single athlete or player compared with himself over time - Original (9) and updated (with trends) (10) spreadsheets	Changes relative to the individual own SD (repeated measures within the same athlete) – especially when there are large differences between the athletes' SD	Highly athlete-dependent. The choice of the SD fraction/multiple (e.g., 0.5 – 2 xSD) depends on the expected sensitivity (the greater the fraction/multiple, the more conservative the decisions) (8)
Physiological data with relationship with performance or risk of injury	Submaximal HR	Group analysis: assessing the average changes in the team/group performance - Spreadsheet (12)	The actual change in this variable that relates to the smallest important change in performance (so-called Δ/Δ ratios)	1% for submaximal HR (16)
		Individual analysis: single athlete or player compared with himself over time - Original (9) and updated (with trends) (10) spreadsheets	The actual change in this variable that relates to the smallest important change in performance (so-called Δ/Δ ratios)	1% for submaximal HR (16)
Physical activity that has no direct impact on performance	Distance covered during matches in team sports	Group analysis: assessing the average changes in the team/group performance - Spreadsheet (12)	Still debated 1) 0.2 x between-athlete SD until new evidence is shown 2) Interpretation of the magnitude left to the practitioners	Likely depends on both tracking variables and intensity zones (17)
		Individual analysis: single athlete or player compared with himself over time - Original (9) and updated (with trends) (10) spreadsheets	Still debated 1) 0.2 x between-athlete SD until new evidence is shown 2) Interpretation of the magnitude left to the practitioners	Likely depends on both tracking variables and intensity zones.(17)

Fig. 1. Table 1. Suggested methods to derive the smallest worthwhile change (adapted from (5, 7))
Change/differences of 1x, 3x, 6x and 10x SWC can be considered as small, moderate, large and very large, respectively (5). Ln rMSSD: logarithm of the square root of the mean of the sum of the squares of differences between adjacent normal R–R intervals

guarantee a minimal return on investment. Unfortunately, all these relevant information for practitioners are missing in the manuscript.

To conclude, this study (1) provided me with the opportunity to highlight once again the limitation of null hypothesis testing and the associated use of P values (5). In practice, this confirms that practitioners willing to embrace an evidence-based approach when it comes to selecting the most useful food supplements should refrain from making decisions when only P values are reported in a study. A supplement efficacy may be very low despite a significant P value (leading to the adoption of a supplement that is in fact likely hopeless), or conversely, another complement may be dismissed following a non-significant P value despite its likely large effect on health or performance. That being said, I am happy to keep beetroot shots on the supplement table for the moment (for players that can cope with the taste... at least it hasn't been shown to be detrimental). I may, however, not use the present study to advertise the benefit of beetroot to the players – if we want to keep our legitimacy and maintain the trust that the players put on us, I believe it is important to come to them with the right message – and in that case, applying some appropriate stats surely helps!

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