

Does gradual ingestion of a carbohydrate energy gel during endurance exercise result in different physiological and perceptual responses compared with single bolus ingestion?

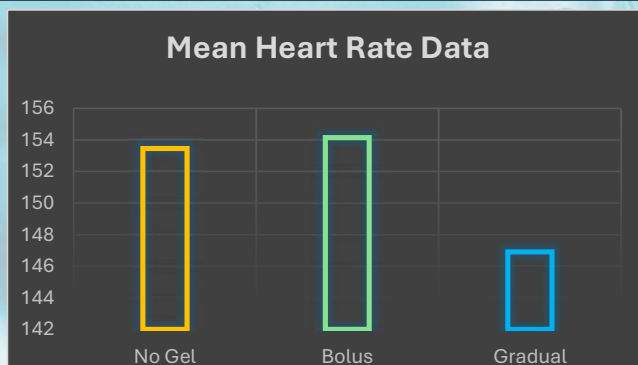
Matt Anthony (2026)

BACKGROUND: Carbohydrate intake during endurance exercise is essential for maintaining performance, delaying fatigue, and supporting physiological function¹. However, the method of ingestion may influence gastrointestinal tolerance and athlete response. Many athletes report discomfort when consuming large bolus doses, which may negatively impact performance and pacing. This study compared bolus versus distributed carbohydrate intake to assess their effects on physiological, perceptual, performance, and gastrointestinal responses².

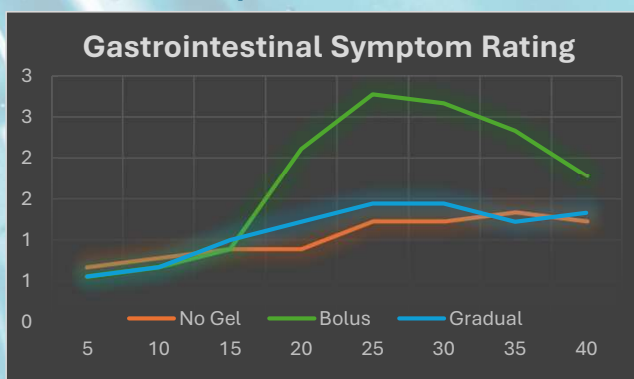
AIM: To investigate the effects of three carbohydrate strategies (control, bolus gel ingestion, and distributed intake) on heart rate, pacing, perceived exertion, and gastrointestinal symptoms during exercise.

METHOD: Nine trained athletes completed three run sessions under different nutritional conditions: no carbohydrate (control), a bolus gel at 20 minutes, and a distributed gel intake between 15–25 minutes. Heart rate, pacing, cadence (RPM), rating of perceived exertion (RPE), and gastrointestinal symptoms (GSRS) were recorded at regular intervals. Each session was set at an identical pace for each athlete at 80% threshold, set by a Cooper Test³. Data were analysed using repeated measures ANOVA with A Pairwise comparisons with Bonferroni adjustment.

KEY RESULTS: Bolus gel ingestion significantly increased gastrointestinal symptoms compared to both control and distributed conditions with a **mean difference = 0.694, p = 0.021**. No significant differences were observed for heart rate or pacing, although a trend towards lower heart rate was seen in the distributed condition **mean difference = 6.542, p = 0.070**. Variability in pacing and perceptual responses was greater in the bolus condition, while cadence remained stable across all trials.



Distributed carbohydrate intake improves tolerance without compromising performance



INSPIRATION: These findings suggest that carbohydrate delivery method influences response stability and tolerance more than overall physiological or performance outcomes. Bolus intake appears to increase variability and gastrointestinal discomfort, whereas distributed intake promotes a more stable and tolerable response profile.

PRACTICAL APPLICATION: Athletes may benefit from consuming carbohydrate in smaller, more frequent doses rather than as a single bolus. This approach may reduce gastrointestinal discomfort and support more consistent physiological and perceptual responses during endurance exercise, with the delivery method potentially reusable/refillable.

LIMITATIONS: The small sample size ($n = 9$) limits statistical power and generalisability. Subjective measures such as RPE and GSRS may introduce variability, and environmental or pacing factors were not fully controlled⁴. Future studies should include larger sample sizes and incorporate additional physiological measures (e.g., blood glucose or lactate).

CONCLUSION: Bolus gel intake increased gastrointestinal discomfort, whereas distributed intake maintained tolerance and showed a trend towards reduced physiological strain. Carbohydrate timing did not significantly affect performance, suggesting that how athletes fuel may be more important for comfort than performance outcomes.



Prifysgol Cymru
Y Drindod Dewi Sant
University of Wales
Trinity Saint David

Recent European and UK environmental policy has placed increasing emphasis on the reduction of avoidable single-use plastics, particularly short-life items that are difficult to recycle and prone to littering^{5,6,7}.

While sports nutrition products are not currently the primary focus of legislative bans, energy gels closely align with the characteristics of single-use plastics targeted by these policies: they are typically used once, frequently contaminated after use, and rarely recycled through conventional waste streams. This study will help with product development to help drive single-use plastic reduction.

References

1. Jeukendrup, A. (2014) "A Step Towards Personalized Sports Nutrition: Carbohydrate Intake During Exercise," *Sports medicine (Auckland)*, 44(Suppl 1), pp. 25–33. Available at: <https://doi.org/10.1007/s40279-014-0148-z>.
2. Costa, R. J. S., Snipe, R. M. J., Kitic, C. M., & Gibson, P. R. (2017). Systematic review: exercise-induced gastrointestinal syndrome—implications for health and intestinal disease. *Alimentary Pharmacology & Therapeutics*, 46(3), 246–265. <https://doi.org/10.1111/apt.14157>.
3. Coquart, J., Tabben, M., Farooq, A. et al. Submaximal, Perceptually Regulated Exercise Testing Predicts Maximal Oxygen Uptake: A Meta-Analysis Study. *Sports Med* 46, 885–897 (2016). <https://doi.org/10.1007/s40279-015-0465-x>
4. Chang M, Büchel D, Reinecke K, Lehmann T, Baumeister J. Ecological validity in exercise neuroscience research: A systematic investigation. *Eur J Neurosci*. 2022 Jan;55(2):487-509. doi: 10.1111/ejn.15595. Epub 2022 Jan 12. PMID: 34997653.
5. European Parliament (2024), New EU rules to reduce, reuse and recycle packaging | News | European Parliament, Found at: https://www.europarl.europa.eu/pdfs/news/expert/2024/4/press_release/20240419IPR20589/20240419IPR20589_en.pdf [Accessed on 25th Jan 2026]
6. Department for Environment, Food & Rural Affairs (DEFRA). (2023). Policy paper: Single-use plastics and waste reduction in England. UK Government.
7. UK Government. (2023). Bans and restrictions on polluting single-use plastics. HM Government

