

Energy Per Kilogram (EPK): A Physiology-Aware Framework for Human Energy Availability and Dietary Adherence

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Abstract

Energy Per Kilogram (EPK) proposes that dietary intake should be interpreted alongside body mass, activity, recovery and the burden of sustaining an eating pattern. This revised conceptual paper distinguishes the intake ratio from sports energy availability and from the wearable-informed programme. Published human evidence supports compensatory appetite responses and context-dependent effects of restriction, but also documents sustained weight loss and improvements during supported restriction. We integrate stress, sleep, body composition and energy-estimation findings, and specify tests that could support or reject EPK's practical value. No universal calorie-per-kilogram minimum, device accuracy advantage or 15% growth requirement is established. Quantitative MSc claims from earlier versions are not used as evidence because the original project is not available for verification. No new participant results are presented.

Scope and evidence selection

This is a targeted narrative synthesis and hypothesis paper, updated through 2 October 2026. Sources were selected from the existing EPK evidence library, primary publications and the recent companion reviews. Selection was question-led and not systematic; no pooled effect, formal risk-of-bias score or new participant dataset is reported. Bibliographic records and available abstracts/full texts were used. Abstract-only access limits appraisal of allocation, missing data, confounding and adverse events. Supporting, contrary and null findings are retained.

1. The research problem and the framework

The central EPK question is whether energy planning can support daily function while reducing the burden of repeated unsuccessful restriction. Hunger, fatigue, recovery, dietary tolerability and body composition are distinct outcomes. A programme that changes body mass without improving those outcomes should not automatically be described as restoring physiological function. Equally, an improvement in wellbeing does not establish improved mitochondrial efficiency or fat loss.

EPK is defined as mean dietary energy intake in kcal/day divided by body mass in kg. It is an intake-to-total-mass ratio, not a direct measure of energy balance, ATP production or nutritional sufficiency. Sports energy availability instead subtracts exercise expenditure from intake and divides by fat-free mass. Those quantities must be recorded separately; sports thresholds cannot be transferred numerically to EPK. [1]

A smaller ratio can arise from a larger denominator rather than inadequate intake. For example, two people consuming the same energy but with different adiposity will have different EPK values. Dividing by total mass does not account fully for organ size, lean tissue, age or activity. Tissue-specific metabolic rates reinforce the need for these covariates. [2]

The author's MSc experience remains part of the framework's developmental background. The thesis, complete methods and analysis files were not available for this revision. Earlier sample sizes, deficit percentages, significance claims and causal interpretations attributed to that project are therefore omitted from the present evidence synthesis. This is not a reanalysis or a retrospective validation of the MSc findings.

2. Restriction, adaptation and the meaning of diet failure

Persistent appetite-related hormonal changes after weight loss and model-based estimates of appetite feedback provide plausible reasons why maintaining a deficit can become difficult. They do not show that every participant will regain weight or that a particular EPK value controls appetite. [3] [4]

The Biggest Loser follow-up documented substantial regain and persistent metabolic adaptation in a small selected cohort; participants remained lighter on average than before the competition. Fat-free mass is not identical to muscle. This study cannot supply a universal failure rate for ordinary dietary treatment. [5]

Commercial-programme studies require attention to the denominator. Lowe et al. sampled successful programme completers, so maintenance among those respondents cannot estimate success among all starters. Conversely, the eight-year Look AHEAD trial documents sustained losses in many participants receiving intensive support. Attrition, regain and failure to meet a prespecified target must be reported separately. [6] [7]

The defensible anti-restriction proposition is that avoidable hunger, distress and impaired function deserve measurement and mitigation. It is not that all calorie deficits are ineffective or harmful. EPK must demonstrate a better balance of benefit, burden and sustainability in a defined population.

3. Stress, sleep and function

A short factorial experiment separated calorie restriction from the act of monitoring intake: restriction increased cortisol output, whereas monitoring increased perceived stress. This suggests measuring both exposure and experience. It does not demonstrate abdominal-fat gain or long-term harm caused by dieting. [8]

Sleep responses are heterogeneous. CALERIE 2 found improvements in some wellbeing outcomes during supported restriction; a brief severe-restriction experiment changed sleep architecture without establishing more awakenings. These findings prevent sleep disturbance from being treated as a diagnostic calorie gauge. [9] [10]

In trained women, controlled low energy availability impaired cycling performance despite unchanged measured muscle mitochondrial respiratory capacity. Functional impairment and mitochondrial failure cannot be used interchangeably. [11]

4. Energy targets, diet composition and boundary conditions

The developer describes an EPK programme using wearable-estimated total daily expenditure, a fallback estimate when data are absent, and an initial five-day learning period. It offers a target intended to match the estimated baseline and an optional performance target approximately 15% above it, within a low-fat/high-carbohydrate eating pattern. These are programme specifications, not validated physiological thresholds. The intake ratio and the programme are distinct research objects. Device errors, missing data, the fallback equation and subsequent update rules must be specified before a reproducible trial. [12]

Accelerometry can add explanatory information beyond demographic and body-composition inputs, while wearable calorie estimates can still contain appreciable individual error. More observations are not equivalent to more accurate kcal/day estimates. A device's total daily estimate must not receive a second full resting-expenditure allowance. [13] [14]

The EPK review category of low fat is 20% of dietary energy or less, stated as an operational definition rather than a universal boundary. Energy intake, achieved fat percentage, grams of carbohydrate and protein, fibre, food sources and essential-fat adequacy should all be recorded. Controlled feeding distinguishes fat oxidation from net fat loss, while human overfeeding shows that fatty-acid type can affect tissue partitioning. [15] [16]

A 25 kcal/kg/day figure in hospital nutrition is a context-specific planning reference, not a universal minimum resting metabolic rate. Age, growth and clinical state matter. Whole-life expenditure data do not support a single trajectory inferred from raw kcal/kg alone. [17] [18]

5. A staged evaluation

Because the ratio is determined entirely by intake and mass, it cannot contain information absent from those inputs. Its usefulness is a question of practical summarisation and predictive performance. Compare a prespecified EPK model with flexible models of intake, mass, fat-free mass and activity, including nonlinear terms where justified. Use the same held-out validation procedure, report calibration and uncertainty, and prefer the simpler model if performance is similar. A favourable comparison with a deliberately weak linear model would not establish a new biological quantity.

Begin with an independently reviewed protocol, a frozen algorithm and a feasible comparator. A pragmatic package trial asks whether EPK helps participants; a matched-diet comparison of wearable versus formula-based targets asks a narrower estimation-strategy question. Neither automatically isolates carbohydrate percentage or the performance increment.

A proposed 60-person, two-arm feasibility study would test recruitment, retention, data completeness, tolerability and delivery over approximately 12 weeks. Sixty is a planning proposal, not an effectiveness power calculation. At 80% retention, the approximate 95% Wilson interval is 68-88% overall; arm-specific estimates would be less precise. Progression criteria and adverse-event review should be agreed before recruitment. [19]

For a later two-arm trial with one continuous primary endpoint, equal allocation, two-sided alpha 0.05, 80% power and 20% attrition, normal-approximation calculations give total recruitment of about 158, 248 or 438 for standardised differences of 0.5, 0.4 or 0.3. These illustrative figures use $n \text{ per arm} = 2(z_{0.975} + z_{0.80})^2/d^2$, rounded up before attrition. They are not EPK effect estimates. Final sizing needs a justified meaningful difference, outcome variance, analysis plan and statistical review; repeated days are not independent participants.

Preregister the trial before first consent, obtain appropriate ethics and sponsor arrangements, and prespecify intention-to-treat analysis and missing-data sensitivity analyses. Report all outcomes and harms, including results that do not support EPK. A public working paper or hypothesis article does not replace registration or approval. [20]

Conclusion

EPK is a testable approach to energy planning and assessment of dietary burden. Current evidence justifies direct investigation of function and adherence, but does not validate its ratio, operational targets or proposed superiority. The practical objective is adequate, sustainable fuelling; its achievement requires measurement rather than assumption.

Version and disclosure

Version 1.2 consolidates repetitive legacy discussion, removes unsupported MSc numerical claims, corrects universal interpretations of dieting and metabolic adaptation, integrates current programme specifications and recent evidence, and replaces inherited citation clusters with claim-specific references. This version supersedes v1.1.1 for the current text; the earlier PDF and DOI remain an archive of that release. Reference numbering has been rebuilt for this version and must not be transferred from earlier editions.

The author develops EPK and has an intellectual and potential commercial interest in its evaluation. AI-assisted editorial drafting and source checking were used. This independent working paper has not undergone external peer review. No new human intervention or participant analysis is reported. Copyright 2026 Billy Craig. Author-owned text is licensed CC BY-ND 4.0; third-party material retains its own rights.

References

References are numbered in order of first citation. Companion EPK working papers provide context, not independent validation.

1. Mountjoy et al. (2023). IOC consensus statement on Relative Energy Deficiency in Sport.
<https://doi.org/10.1136/bjsports-2023-106994>
2. Wang et al. (2011). Evaluation of specific metabolic rates of major organs and tissues: comparison between men and women.
<https://pubmed.ncbi.nlm.nih.gov/21484913/>
3. Long-term persistence of hormonal adaptations to weight loss
<https://pubmed.ncbi.nlm.nih.gov/22029981/>
4. How Strongly Does Appetite Counter Weight Loss? Quantification of the Feedback Control of Human Energy Intake
<https://pubmed.ncbi.nlm.nih.gov/27804272/>
5. Fothergill E et al. (2016). Persistent metabolic adaptation 6 years after The Biggest Loser competition. *Obesity* 24:1612-1619.
<https://pmc.ncbi.nlm.nih.gov/articles/PMC4989512/>
6. Lowe et al. (2001). Weight-loss maintenance in overweight individuals one to five years following successful completion of a commercial weight loss program.
<https://pubmed.ncbi.nlm.nih.gov/11319628/>
7. Look AHEAD Research Group (2014). Eight-year weight losses with an intensive lifestyle intervention: the Look AHEAD study.
<https://pubmed.ncbi.nlm.nih.gov/24307184/>
8. Tomiyama et al. (2010). Low calorie dieting increases cortisol.
<https://pubmed.ncbi.nlm.nih.gov/20368473/>

9. Martin et al. (2016). Effect of Calorie Restriction on Mood, Quality of Life, Sleep, and Sexual Function in Healthy Nonobese Adults: The CALERIE 2 Randomized Clinical Trial.
<https://pmc.ncbi.nlm.nih.gov/articles/PMC4905696/>
10. Collet et al. (2016). The Sleep/Wake Cycle is Directly Modulated by Changes in Energy Balance.
<https://pmc.ncbi.nlm.nih.gov/articles/PMC4989258/>
11. The whole-body and skeletal muscle metabolic response to 14 days of highly controlled low energy availability in endurance-trained females
<https://pubmed.ncbi.nlm.nih.gov/39530548/>
12. Craig B (2026). Wearable-Informed Energy Baselines for EPK. Working paper, v1.0. Companion review; not independent validation.
<https://doi.org/10.5281/zenodo.23097644>
13. Dougherty RJ et al. (2022). Validation of accelerometer placement to capture energy expenditure using doubly labeled water. *Applied Physiology, Nutrition, and Metabolism*. doi:10.1139/apnm-2022-0192.
<https://pubmed.ncbi.nlm.nih.gov/35939837/>
14. Murakami H et al. (2019). Accuracy of 12 Wearable Devices for Estimating Physical Activity Energy Expenditure Using a Metabolic Chamber and the Doubly Labeled Water Method: Validation Study. *JMIR mHealth and uHealth* 7:e13938.
<https://pmc.ncbi.nlm.nih.gov/articles/PMC6696858/>
15. Hall et al. (2015). Calorie for Calorie, Dietary Fat Restriction Results in More Body Fat Loss than Carbohydrate Restriction in People with Obesity.
<https://pubmed.ncbi.nlm.nih.gov/26278052/>
16. Rosqvist et al. (2014). Overfeeding polyunsaturated and saturated fat causes distinct effects on liver and visceral fat accumulation in humans.
<https://pubmed.ncbi.nlm.nih.gov/24550191/>
17. ESPEN guideline on hospital nutrition - recommendation 15
<https://www.clinicalnutritionjournal.com/article/S0261-5614%2821%2900456-8/fulltext>
18. Pontzer et al. (2021). Daily energy expenditure through the human life course.
<https://pubmed.ncbi.nlm.nih.gov/34385400/>
19. Eldridge SM et al. (2016). CONSORT 2010 statement: extension to randomised pilot and feasibility trials. *BMJ* 355:i5239.
<https://www.bmj.com/content/355/bmj.i5239>
20. International Committee of Medical Journal Editors. Recommendations: Clinical Trials. Prospective registration requirements.
<https://icmje.org/recommendations/browse/publishing-and-editorial-issues/clinical-trial-registration.html>

Version history

v1.2 - 2 October 2026: scientific and editorial revision, refreshed reference mapping and integrated recent evidence. Unverified MSc quantitative claims are excluded from the evidential basis.

v1.1.1 - 11 September 2026: earlier licensing release. Archived DOI: 10.5281/zenodo.22709850. Earlier versions remain available through Zenodo.

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