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Precision Nutrition and Continuous Glucose Monitoring in People Without Diabetes: Promise, Evidence and Overreach

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Abstract

Personalising diet by glucose response assumes that repeated responses to the same meal vary less within a person than responses to different meals. Investigators examining that assumption report that it had not been rigorously tested, and that duplicate presented meals produced unreliable individual responses in adults without diabetes. The population in question is also already largely in range: across 4,135 euglycaemic participants, median time in the standard range was 95.8 per cent and median glycaemic variability 14.8 per cent. Diet associations were present but weak, with rank correlations of 0.17 for carbohydrate energy and 0.12 for ultra-processed food. Meta-analysis of monitoring as a behaviour change tool found favourable but modest effects. Reviewers separately describe normal variability being read as a health threat, with anxiety and orthorexic patterns reported.

Keywords: *Continuous glucose monitoring; Precision nutrition; Glycaemic variability; Time in range; Overinterpretation*

Introduction

Continuous glucose monitors provide high-frequency measurement of interstitial glucose under free-living conditions, capturing the magnitude, duration and frequency of fluctuation in a way that intermittent sampling cannot [1,2]. Their use has extended beyond diabetes into wellness and preventive settings [3].

The rationale for personalisation rests on an observation: postprandial responses differ markedly between individuals, and the ranking of foods by their effect on glucose can differ between people [4,5]. If so, advice could be tailored by identifying which foods produce reliably low responses in a given person [4,6].

This review examines whether that inference holds, what the monitor detects in people who do not have diabetes, what interventions built on it achieve, and what has been reported about harms.

Objective

This review sets out to establish four things from the published literature. First, what glucose metrics look like in people without diabetes and how much scope for improvement exists. Second, whether the reproducibility assumption underlying personalisation has been tested. Third, what monitoring achieves as a behaviour change tool. And fourth, what has been reported about psychological harm and about the limits of what the device detects.

Literature Review

What the metrics look like in this population: Analysis of 4,135 participants from euglycaemic community-based cohorts, with mean age 47 plus or minus 12 years, 83 per cent female and mean body mass index 27 plus or minus 6, found median glycaemic variability of 14.8 per cent (IQR 12.6 to 17.6), median time in the standard range of 95.8 per cent (IQR 89.6 to 98.6) and median time in a more stringent range of 75.0 per cent (IQR 64.6 to 82.8) (Figure 1) [7].

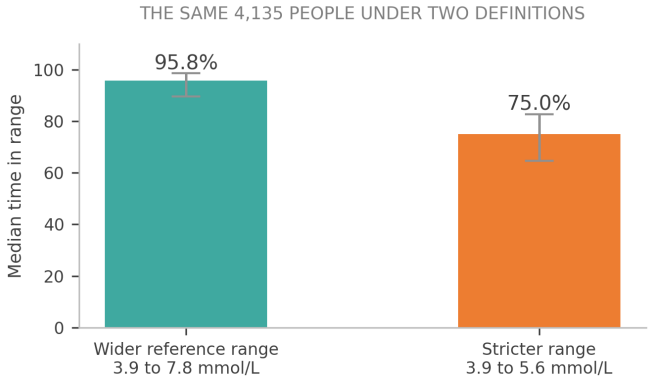

Figure 1: Time in range in 4,135 people without diabetes [7]

What those metrics related to: Greater time in the stringent range was associated with lower glycated haemoglobin, lower ten-year atherosclerotic cardiovascular disease risk and lower insulin resistance, all at p below 0.05. Lower glycaemic variability was associated with lower percentage of energy from carbohydrate (rank correlation 0.17, $p < 0.01$), lower ultra-processed food intake (0.12, $p = 0.01$) and longer overnight fasting duration (−0.10, $p = 0.01$) (Figure 4) [7]. The authors concluded that a stringent target provides sensitivity to detect changes not detected using standard secondary targets [7] (Table 1).

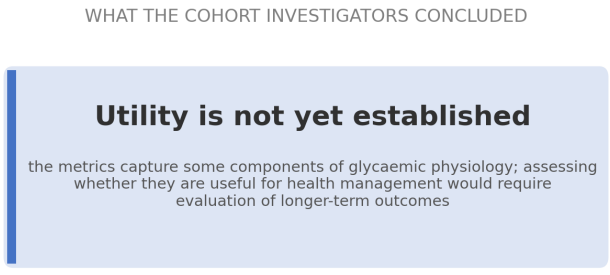

Figure 4: How strongly diet related to variability [7]

Table 1: Glucose metrics across 4,135 euglycaemic participants [7]

Metric	Median	Interquartile range
Glycaemic variability	14.8%	12.6 to 17.6
Time in standard range	95.8%	89.6 to 98.6
Time in stringent range	75.0%	64.6 to 82.8

The assumption underneath personalisation: Investigators state that a fundamental assumption of precision dietary advice is that glucose responses to the same meal on repeated occasions within an individual are much less variable than that person's responses to different meals, and that this assumption had not been rigorously tested (Figure 2) [8]. Testing it using duplicate presented meals across four dietary patterns in adults without diabetes, they reported unreliable individual glycaemic responses [8,9].

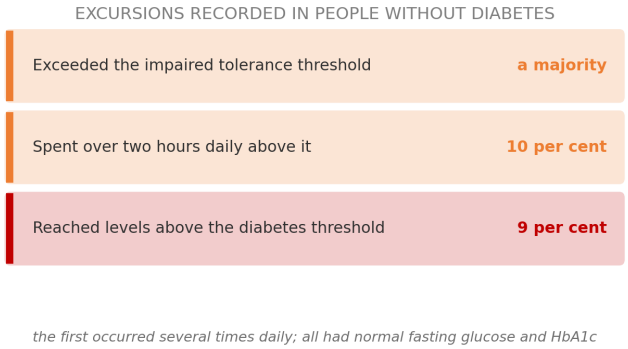

Figure 2: The assumption personalisation rests on [8]

What monitoring achieves as an intervention: A systematic review and meta-analysis of randomised trials examined whether monitor-based feedback supports behaviour change in adults with and without diabetes, searching five databases through January 2024. It found favourable though modest effects on glycaemic control, with time in range increased by 7.4 per cent (95% CI 2.0 to 12.8, $p < 0.008$) compared with control, which the authors note surpasses a stated 5 per cent threshold for clinical significance, and glycated haemoglobin fell by 0.28 per cent (95% CI 0.15 to 0.42) (Figure 3). Heterogeneity was high for both, at 80.5 and 88 per cent respectively. No significant change in time above range was observed, which the authors attribute partly to inconsistent thresholds and fewer studies reporting it [10].

Who those trials actually studied: Of the 25 trials, 17, or 68 per cent, were conducted in adults with type 2 diabetes, with three each in type 1 diabetes, gestational diabetes and obesity. Only four of the 25 evaluated the effect on dietary change and five on physical activity, despite behaviour change being the stated mechanism. Eleven of the 25, or 44 per cent, reported conflicts of interest affiliated with monitor manufacturers, which the reviewing authors state should be considered when interpreting the results.

What the device does not detect: A prospective observational pilot compared 14 normoglycaemic participants with obesity against 14 without, monitored for five consecutive days. Fasting serum insulin and insulin resistance were significantly higher in the group with obesity ($p < 0.05$), while glycaemic variability was similar between the groups (Figure 6) [11]. A metabolic difference present on laboratory measurement was therefore not distinguished by the monitor.

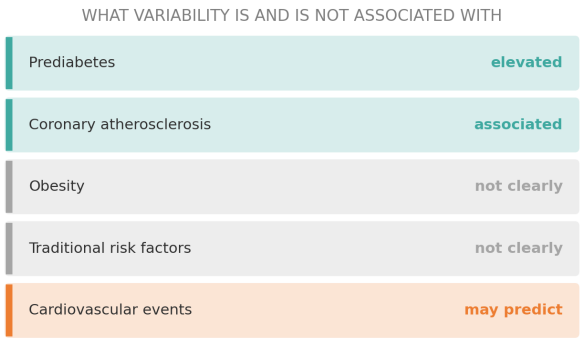

Figure 3: Effect on time in range against the stated threshold [10]

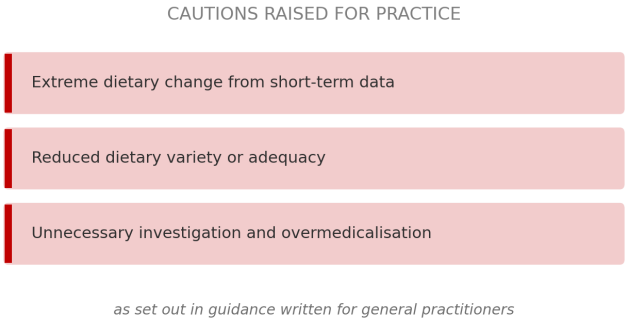

Figure 6: Normoglycaemic participants with and without obesity [11]

What has been reported about harm: A narrative review notes that by making previously invisible physiological fluctuation constantly visible, monitoring carries a risk of overinterpretation, and that sustained self-monitoring can carry psychological burdens that remain incompletely characterised, particularly in users without diabetes. Normal, non-pathological variability can be misperceived as a health threat, potentially fostering anxiety, hypervigilance around food choices and orthorexic eating patterns (Figure 5). The same authors state that monitor-guided dietary restriction is not recommended without specialist psychological input in individuals with a personal or family history of disordered eating [3].

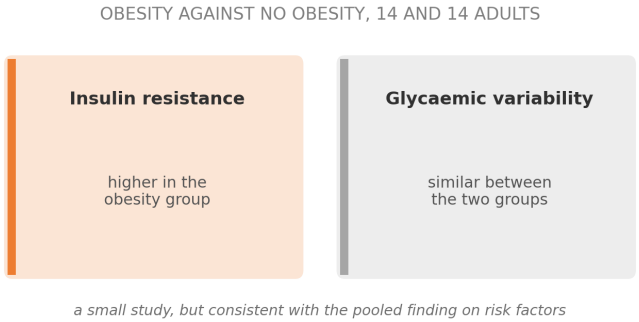

Figure 5: A reported risk of continuous self-monitoring [3]

The case made for the approach: The same review sets out the hypothesis that monitor-guided metabolic phenotyping combined with personalised dietary optimisation constitutes a mechanistically coherent preventive strategy, describing it explicitly as hypothesis-generating and pending confirmation in prospective outcome trials [3]. Machine learning trained on personal monitor data, microbiome profiling and lifestyle parameters has been reported to predict individual postprandial responses and generate personalised recommendations [3,4] (Table 2).

Table 2: What the evidence supports for each element of the argument

Claim	Status in the reviewed evidence
Responses differ between people	Consistently reported [4,5]
Responses reproduce within a person	Reported as unreliable [8,9]
Feedback changes behaviour	Favourable but modest [10]
Detects metabolic dysfunction	Not in one normoglycaemic pilot [11]
Improves clinical outcomes	Awaiting prospective trials [3]

Trials of personalised approaches: Randomised comparison of a postprandial response-targeting diet against a Mediterranean diet has been conducted for glycaemic control in prediabetes [12], and a randomised trial has compared a low-fat diet with a precision nutrition-based diet for weight loss, with glycaemic variability and glycated haemoglobin among its outcomes [13]. These are the designs that would establish whether personalisation outperforms conventional advice [12,13].

Where the personalisation idea originated: Prediction of glycaemic responses from personal and microbiome data was first reported in a widely cited study [4], and a separate assessment examined a personalised prediction approach in individuals without diabetes [17]. Distinct patterns of glucose dysregulation have been described in non-diabetic participants [18]. The wider personalised nutrition literature sets out the genomic and microbiome rationale [14,15,16], and the glycaemic index methodology that preceded it established both its clinical interest and its measurement difficulties [6].

Reproducibility was already questioned before monitors: Interindividual variability and intra-individual reproducibility of glycaemic index values were examined for a single commercial product [28], and the reliability of index values with their methodological and biological sources of variability estimated directly [29]. The concern that within-person responses may not reproduce is therefore older than the technology now used to generate them [28,29,8].

Reference values in people without diabetes: Multicentre prospective work has characterised monitoring profiles in healthy non-diabetic participants [19], and earlier work described continuous profiles under everyday conditions and after defined meals [20]. Glycaemic variability has been compared between people with type 2 diabetes and healthy individuals [30]. International consensus statements set targets and interpretation for monitoring data, developed for populations with diabetes [2,21].

How the extension to wellness is being debated: Reviews have asked whether use by people without diabetes is an idea whose time has come [23], whether it represents hype or hope [31], and whether the wellness application warrants more scepticism than it has received [32]. Possible applications in health care, wellness and sport have been catalogued [22], methodological considerations for non-clinical populations set out [33], and behaviour modification in prediabetes considered separately [24]. Effectiveness and acceptability in type 2 diabetes, where the evidence base is strongest, has been reviewed for comparison [25,26], alongside work on alternate glycaemic markers in screening [34] and on the energetics that any dietary intervention must contend with [27] (Table 3).

Table 3: What is and is not established about monitoring outside diabetes

Question	What the evidence supports
Do responses differ between people?	Yes, consistently [4,5]
Do they reproduce within a person?	Reported unreliable [8,9]
Is there room to improve range?	Median 95.8% already in range [7]
Does diet explain variability?	Weakly; correlations 0.10 to 0.17 [7]
Are harms characterised?	Described, incompletely studied [3]

Method

Search strategy: PubMed and the archives of the major nutrition, diabetes and digital health journals were searched for studies of continuous glucose monitoring in populations without diabetes. Search terms combined continuous glucose monitoring and precision nutrition with healthy adults, glycaemic variability, time in range, reproducibility and behaviour change. Reference lists of the euglycaemic cohort analysis [7] and the behaviour change meta-analysis [10] were screened by hand for primary sources.

Eligibility: Studies were included if they reported glucose metrics, reproducibility of responses, or intervention outcomes in adults without diabetes. Hypothesis-generating reviews are cited as such, and where authors describe their own proposal as awaiting confirmation that description is reported alongside it.

Data extraction and handling: Population, glycaemic status, the metric applied and the reported estimate were extracted as published. Whether a study population had diabetes, prediabetes or neither is stated in every case, because effects established in diabetes are frequently cited in support of use in people without it and the populations differ in how much scope for change exists. This review reports published findings and does not constitute dietary, monitoring or device guidance for any individual, and offers no eating plan, glucose target or restriction protocol. No pooling or re-analysis was performed. Figures 1 to 6 and Tables 1 to 3 reproduce published values only. This is a narrative synthesis of published literature and was not registered as a systematic review.

Concluding Remarks

The reproducibility finding is the one that bears on everything else. Personalisation requires that a person's response to a given meal be a stable property of that person, and investigators who tested it with duplicate presented meals reported unreliable individual responses [8,9]. If the same meal does not produce the same result in the same person, a recommendation derived from a single measurement is derived from noise as well as signal.

That the assumption had not been rigorously tested before is itself notable [8]. Between-person variation is real and repeatedly demonstrated [4,5]; the inferential step from that observation to individual dietary advice requires within-person stability, and that step was taken widely before it was examined.

The population data set a further limit. Median time in the standard range was 95.8 per cent in 4,135 euglycaemic participants [7]. In people without diabetes there is relatively little time out of range available to recover, and an intervention offering improvement is operating in a narrow band, whatever the stringent-range analysis adds [7].

The diet associations were present and modest. Rank correlations of 0.17 for carbohydrate energy, 0.12 for ultra-processed food and minus 0.10 for overnight fasting duration are real associations in a large sample and account for a small share of variance [7]. They support the direction of general dietary advice more comfortably than they support individualised prescription.

The pilot comparing normoglycaemic participants with and without obesity is a useful corrective in the other direction. Insulin resistance differed significantly between groups while glycaemic variability did not [11]. A device marketed on its ability to reveal hidden metabolic dysfunction did not, in that small sample, distinguish a group with measurably greater insulin resistance.

The harm signal deserves to be reported rather than treated as a footnote, and it is the reviewers advocating the approach who raise it. Normal variability read as a threat, anxiety, hypervigilance around food and orthorexic patterns, with an explicit statement that monitor-guided restriction is not recommended without specialist psychological input where there is a history of disordered eating [3]. A device sold to people who are well reaches a population in which that history is undisclosed and unscreened.

Three limitations belong with these conclusions. The euglycaemic cohorts are 83 per cent female with a mean body mass index of 27, and volunteer cohorts of this kind are not representative of the general population [7]. The reproducibility

work is recent and its conclusions have not been widely replicated, so it should be read as a serious challenge to the assumption rather than as settling it [8,9]. And the behaviour change meta-analysis pools studies in people with and without diabetes, whose scope for glycaemic improvement differs substantially, so the pooled effect describes neither group precisely [10].

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Conflict of Interest

The authors declare no competing interests.

Ethics Statement

This article reviews previously published studies only. No new patient data were collected and no participants were recruited, so ethical approval was not required.

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