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Mary Ann Liebert
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Sugar Habit Hacker: A pilot randomised controlled trial of personalised normative feedback to change sugar consumption

Rimke Bijker[1], Hiranya Khullar[2], Braden Te Ao[2] and Simone N Rodda[1,2]

Abstract

Background: Excessive sugar consumption is a major public health concern, yet effective, scalable interventions remain limited.

Aim: To explore the effects of a brief online intervention of personalised normative feedback (PNF) on sugar consumption, mental well-being, craving, and self-efficacy at one and two months in New Zealanders.

Methods: Random assignment was to PNF on sugar consumption with feedback on mental wellbeing, craving, and self-efficacy scores, and information on strategies for change or a personalised summary of total sugar consumption and scores on measures. The main outcome was change in sugar intake from baseline, assessed using a self-reported Food Frequency Questionnaire (FFQ). Secondary outcomes were change in craving strength, craving frequency, self-efficacy and mental well-being.

Results: A total of 605 participants were recruited over a four-week period. Most participants were female (86%), aged >45 years (56%), and consumed sugar within the recommended 10% daily energy intake limit (72%). Sugar consumption reduced by 10.2% at one-month post-intervention (Cohen's $d = -0.27$; 95% CI [−0.43, −0.11]), and this change was maintained at two months. Improvements were found for all secondary outcomes except mental well-being. There were, however, no significant group-by-time interactions for sugar intake or other outcomes.

Conclusion: PNF shows promise in improving sugar consumption, but outcomes were similar to offering a personalised summary of scores alone. Given rapid recruitment and strong retention, future research should compare these conditions with a true control group that provides no feedback. Further work should also examine the reliability and validity of the FFQ for measuring sugar consumption.

Keywords

Personalised normative feedback, free sugar intake, dietary intervention, digital health intervention, randomised controlled trial

Introduction

Overconsumption of sugar is a growing public health concern. Numerous studies have demonstrated links between excessive sugar intake and dental caries, obesity, type 2 diabetes, cancer, cardiovascular disease, and depression (Huang et al., 2023). In response, the World Health Organisation (WHO) has issued guidelines on sugar consumption, recommending that intake of free sugars should be limited to less than 10% of daily energy intake (DEI), with a further suggestion to reduce intake below 5% DEI for additional health benefits (WHO, 2015). In New Zealand, over half of the population continues to consume more sugar than the recommended daily limit (Kibblewhite et al., 2017). This mirrors global trends, where sugar consumption is commonly reported to exceed dietary

[1]Department of Psychology and Neuroscience, School of Science, AUT University, Auckland, New Zealand
[2]School of Population Health, Faculty of Medical and Health Sciences, University of Auckland, Auckland, New Zealand

Corresponding author:
Simone N Rodda, Department of Psychology and Neuroscience, School of Science, AUT University, Auckland, New Zealand.
Email: simone.rodda@aut.ac.nz

guidelines across age groups (Walton et al., 2023). The widespread excess in sugar intake signals the need for interventions targeting sugar consumption behaviour.

Emerging evidence suggests that self-perceptions and perceived social norms play a significant role in shaping sugar consumption behaviours. An Australian population study found that people who viewed their consumption of sugar-sweetened beverages (SSBs) as habitual or excessive, and recognised associated health risks, were more likely to intend to reduce their intake (Dono et al., 2021). Similarly, among public housing residents in the United States, perceived high consumption of sweets and sugary drinks within one's social network was linked to higher personal sugar intake (Gudzune et al., 2018). University students who believed their chocolate consumption exceeded that of their peers also expressed greater concern about their own behaviour (Aldrovandi et al., 2015). A meta-analysis further demonstrated that exposure to normative information about food portion sizes influenced intake, particularly when the reference group was perceived as similar to the individual (Robinson et al., 2014). Together, these findings indicate that targeting perceived social norms may be a promising approach to reducing sugar consumption.

One approach that leverages the influence of perceived norms is personalised normative feedback (PNF). PNF is an ultra brief intervention which provides people with tailored feedback, usually in graphs or text, about three key elements: (1) their own self-reported behaviour, (2) their perception of their peers' behaviour, and (3) the actual average behaviour within their peer group, representing the descriptive norm (Saxton et al., 2021). In many cases, PNF includes additional components such as feedback on secondary effects of behaviour (e.g., impacts on wellbeing), information about official guidelines, and practical strategies for reducing use. By highlighting the discrepancy between perceived and actual peer behaviour, particularly in relation to the person's own actions, PNF aims to correct misperceptions and motivate change (Dempsey et al., 2018). Meta-analytic evidence shows that PNF, whether delivered on its own or combined with additional interventions such as information provision, has small but favourable effects on reducing alcohol consumption and, to a lesser effect, gambling (Dotson et al., 2015; Saxton et al., 2021). PNF is considered cost-effective, scalable, and adaptable across different settings.

While there is a need for interventions to reduce sugar consumption at the population level, few studies have explored the use of PNF to address sugar consumption, with existing research primarily focusing on SSBs and samples of school-aged children (Nikniaz et al., 2022). Most studies have focused on changing social norms related to SSBs (Bélanger-Gravel et al., 2022) with very few examining sugar more broadly or consumption outcomes. For example, factorial studies have examined change to intention, appetite and perceptions, but have reported either minimal or non-significant change across groups (Potthoff et al., 2024; Rosas et al., 2017). Beyond SSBs we also found few studies that examined the effect of a brief intervention on total sugar consumption with just one single session intervention delivered by workbook and in-person facilitation (Brittain et al., 2021). This study prompted participants to select a goal aligned with WHO guidelines, develop implementation plans, and self-monitor for 30 days, resulting in large effects ($d = 0.83$) at follow-up evaluation, with medium to large effects on sugar cravings, self-efficacy, well-being and reduction in BMI (Brittain et al., 2021).

Building on this limited evidence base, the present study aimed to evaluate the effectiveness of a brief online intervention that delivered PNF on sugar consumption, information on WHO sugar intake limits, personalised feedback on secondary outcomes, and information on strategies for change. This exploratory randomised controlled trial sought to determine whether PNF resulted in greater reductions in free sugar consumption compared to a control condition that provided total sugar consumption and scores on secondary outcomes but without additional feedback or strategies for change. Outcomes were assessed among New Zealand adults at one- and two-months post-intervention. In accordance with WHO guidelines, free sugars were defined as monosaccharides and disaccharides added to foods and beverages by the manufacturer, cook, or consumer, as well as sugars naturally present in honey, syrups, fruit juices, and fruit juice concentrates (WHO, 2015). A secondary aim was to examine the impact of the intervention on related outcomes, including sugar craving, eating self-efficacy, and mental well-being.

Methods

This was a two-arm, parallel-group, pilot randomised controlled trial comparing a brief online PNF intervention with a minimal feedback control condition. Participants were randomly allocated in a 1:1 ratio. After completing the baseline survey, those in the intervention group immediately received the PNF intervention. Follow-up surveys were conducted at 30 days and again at two months post-baseline. The study received ethical approval from the University of Auckland Human Participants Ethics Committee. Due to its exploratory nature, the study protocol was not prospectively registered. The survey and personalised feedback report were tested for readability and comprehension with five people with lived experience prior to the study commencing.

Participants

Participants were recruited through community flyers, shared noticeboards, and paid social media advertising targeting New Zealand residents, supplemented by outreach to online community platforms and cultural organisations. Advertising was focused around 'are you curious about how much sugar you consume'. Recruitment and data collection were conducted entirely online due to COVID-19 restrictions. Upon completing baseline and follow-up surveys, participants had the opportunity to enter a draw for one of 10 $50 shopping vouchers.

Participants were eligible to participate if they were aged ≥18 years, resided in New Zealand and were willing to complete a questionnaire 30 days after the initial questionnaire. Participants who did not provide contact information were excluded, as they could not be reached for follow-up assessments.

Intervention

The intervention was brief, single-session, and delivered entirely online. Participants completed the online assessment with normative information collected at the start on the following:

- How many teaspoons of sugar do you think you have daily?
- How many teaspoons of sugar do you think other New Zealanders have daily?
- How many teaspoons of sugar do you think other (males/females) in New Zealand have daily?
- How many teaspoons of sugar do you think other New Zealanders in your age group have daily?
- How many teaspoons of sugar do you think the WHO recommends (males/females) to limit daily?

Intervention participants received a two-page personalised written summary of their results which provided their calculated total sugar intake alongside their estimation (Appendix). It then provided normative comparisons with population-level daily sugar intake and with intake by gender and age based on data from the New Zealand Health Survey (Kibblewhite et al., 2017). Information was also provided on the WHO recommendations for daily sugar intake, including the maximum number of teaspoons suggested for additional health benefits. Personalised scores and how to interpret the results were also provided on wellbeing, confidence to resist sugar and strength and frequency of sugar cravings.

In addition to the written report, participants were provided a one-page summary of strategies for change with links to downloadable support resources that had been used in another study (Brittain et al., 2021; Rodda et al., 2020). The one-page summary was not personalised or adapted to the individual needs. It was provided to all participants in the intervention group in the same format and included (i) recommended sugar limits, (ii) guidelines for implementation planning and (iii) self-help resource on strategies to limit sugar reduction.

Control condition. Participants in the control group received a one-page written summary of their results which provided their calculated total sugar intake and personalised scores on measures of wellbeing, confidence to resist sugar, and strength and frequency of sugar cravings.

Randomisation and blinding

Participants were automatically assigned to the intervention or control group at the end of the baseline survey using Qualtrics' built-in randomiser with a simple allocation procedure. Researchers were therefore blinded to group allocation during the study but not during analysis.

Outcomes

Sugar consumption was measured using the Food Frequency Questionnaire (FFQ) (Cade et al., 2002). The FFQ has been used in numerous studies to assess sugar intake (Newens and Walton, 2016) and has been adapted for assessing sugar consumption across multiple cultural contexts (Kanehara et al., 2019; Kiwanuka et al., 2006; Mumena and Kutbi, 2022; Norimah, 2012; Yi et al., 2023; Zheng et al., 2023), including New Zealand (Boniface, 2014; Brittain et al., 2021). The current study assessed the frequency of consumption of 27 dietary products high in free sugar, based on New Zealand-specific data (Gemming et al., 2014; Hamilton et al., 2007; Kibblewhite et al., 2017). For ease of comprehension and recall, dietary products were grouped into the categories breakfast foods, beverages, snack foods, desserts, and additives. Participants selected the frequency of consumption over the past month (ranging from "never" to "6+ times per day") for each dietary product. The estimated free sugar content for each dietary product was derived from the New Zealand FOODfiles and Australian AUSNUT databases (Sivakumaran et al., 2018; Sobolewski et al., 2010). Daily sugar consumption was calculated by averaging responses for each dietary product and multiplying by the median sugar content per serving.

Secondary outcomes were those related to sugar consumption. The craving experience questionnaire measured craving strength (CEQ-S) and craving frequency (CEQ-F), with total scores ranging from 0 to 100 (May et al., 2014) and the Weight Efficacy Lifestyle Questionnaire Short-Form measured confidence to resist sugar, with total scores ranging from 0 to 80 (Ames et al., 2015). Higher scores indicated higher craving strength, frequency, and confidence to resist sugar. The introduction to the questionnaires was adapted to clarify the items related specifically to sugary products. Additionally, the WHO Well-Being Index measured mental well-being with total scores ranging from 0 to 100 and higher scores indicating better well-being (Topp et al., 2015).

All outcomes and current weight were assessed at baseline, 30 days, and two months using online surveys created with Qualtrics XM web software. In addition to the primary and secondary outcomes, the baseline survey collected sociodemographic variables, including age, gender, ethnicity, education level, and height. At the end of each follow-up survey, all participants received the same information as the control group which was a brief summary of their current sugar consumption and scores on the various measures.

Treatment fidelity

To ensure that the intervention was delivered as intended and received by participants we included two components. At the end of the intervention, participants were invited to complete a short quiz assessing their recall of information from their personalised report, including sugar intake and the WHO-recommended limits by gender. The quiz also assessed whether participants were surprised by the results and whether they intended to change their sugar consumption. Furthermore, the post-baseline survey contained three questions to assess how much time participants in the intervention group had spent on the feedback report, implementation planning, and the self-help resource on strategies to limit sugar consumption.

Statistical analysis

Descriptive statistics for baseline characteristics were presented as counts and percentages or medians and interquartile ranges (IQRs), as appropriate. Comparisons between groups on baseline characteristics were conducted using Kruskal–Wallis rank test for continuous variables and Pearson chi-squared test for categorical variables. Dietary data from the FFQ were winsorised before computing changes from baseline. Daily sugar consumption was also summarised by dietary product category (breakfast foods, beverages, snack foods, and desserts) across time points to explore patterns of consumption over time.

Changes in sugar intake, mental wellbeing, self-efficacy, and craving were analysed using linear mixed-effects models. Models included random intercepts at the participant level and accounted for repeated measures using a first-order autoregressive covariance structure. All models were adjusted for the *a priori* specified covariates of age, gender, ethnicity, and BMI, as well as the respective baseline outcome value. Residuals were approximately normally distributed, supporting the validity of model-based estimates. Within-group changes from baseline to follow-up were assessed using estimated marginal means, and interaction terms tested whether these changes differed between groups over time. All analyses followed the intention-to-treat principle. Retention and participant characteristics at follow-up assessments where similar across groups (Appendix), therefore, missing data were assumed to be missing at random and no imputation was performed. Statistical significance was determined using two-sided tests with α set at 0.05. Two sensitivity analyses were conducted. The first sensitivity analysis was a complete case analysis, restricted to participants who completed both follow-up assessments, to assess the robustness of the results. The second sensitivity analysis only included participants whose baseline sugar consumption was $\geq$10% DEI, representing a subgroup for whom behaviour change is more relevant.

Finally, to facilitate interpretation of the practical significance of the findings, we estimated the magnitude of the pre–post change within each group on sugar consumption. Cohen's d and percentage change from baseline were calculated at each follow-up time point based on model estimates. Values of 0.2, 0.5, and 0.8 were interpreted as small, medium and large effect sizes, respectively (Ferguson, 2009). Statistical analyses were performed using Stata version 19.5 (StataCorp, College Station, TX).

Results

Participants

Study recruitment ran from 14 August to 31 August 2021, with study enrolment being open from 15 August to 14 September 2021. A total of 792 individuals completed the baseline survey. Of these, 183 were excluded because they did not provide contact details ($n = 180$), they self-allocated to the intervention group by retaking the questionnaire ($n = 2$) or requested study withdrawal ($n = 1$). The remaining 605 participants were randomly assigned to either the control group ($n = 303$) or the intervention group ($n = 302$). A total of 548 completed the post-intervention assessment (279 control, 269 intervention) and 378 completed the two-month follow-up assessment (187 control, 190 intervention). Loss to follow-up was the primary reason for attrition. All 605 randomised participants were included for analysis (Figure 1).

The majority of the sample were female (86%) and aged >45 years (56%). Almost two-thirds had above normal range BMI (62%), including overweight (32%) and obesity (30%). Most participants had daily sugar intake within the recommended 10% DEI limit (72%), and many met the more stringent 5% target suggested for additional health benefits (40%) (Appendix). Snack foods and beverages were the main contributors to total sugar intake. Estimated total sugar consumption for each of the normative comparisons are shown in the Appendix.

Median time spent completing the assessment and intervention was 16 min (IQR 10) for the intervention group and 13 min (IQR 7) for the control group. The majority of participants (69%) in the intervention group completed the fidelity tests. Almost all these participants correctly

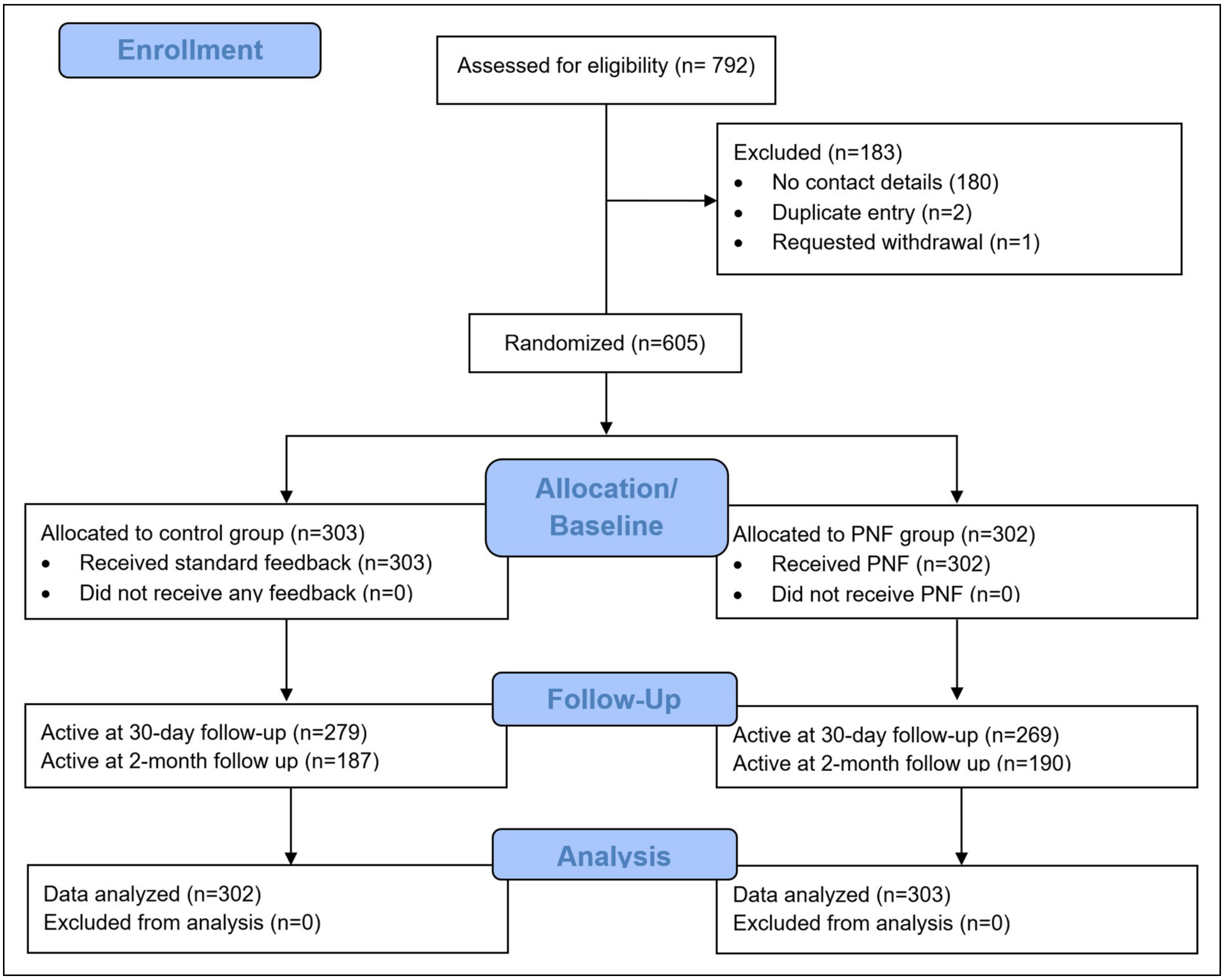

Figure 1. Flowchart.

remembered their personal consumption (97%) and WHO recommendations for sugar consumption (93%), indicating that participants had paid attention to the PNF content of the report. Furthermore, about half of the participants (46%) were surprised by the amount of sugar they consumed, and three-quarters (74%) wanted to change their consumption after seeing the results. Self-reported engagement with the feedback report was no time at all (16.4%), not very much time (41.1%), moderate amount of time (38.1%), and considerable amount of time (4.1%). Twenty-one participants said they did not receive the intervention. Similar proportions reported spending at least some time on the implementation planning materials (65.0%) or self-help sugar reduction guidelines (72.7%). All participants were included in the analysis, regardless of responses to the treatment fidelity tests.

Effects of intervention and time

In the intervention group, median sugar consumption was 37 g/day (IQR 42) at baseline, which reduced to 27 g/day (IQR 35) at one-month post-intervention and maintained at 26 g/day (IQR 31) at two-months follow-up. In the control group, consumption changed from 32 g/day (IQR 39) to 29 g/day (IQR 32) and decreased further to 27 g/day (IQR 28) one and two months later, respectively. Snack foods and beverages remained the largest sugar source throughout, despite notable decreases over time (Appendix). In the intervention group, reductions over time were observed across all sugar categories apart from beverages, which returned to near-baseline levels at two-months follow up.

Linear mixed-effect modelling showed that overall sugar consumption decreased significantly over time ($p < .001$), with no significant main effect of intervention ($p = .511$) or interaction ($p = .479$). Compared to baseline, the intervention group reduced intake by 4.23 g/day post-intervention (95% CI [−6.28, −2.19]), corresponding to a 10.2% decrease from baseline, with a small within-group effect size (Cohen’s $d = -0.27$; 95% CI [−0.43, −0.11]). At two-month follow-up, reductions were 4.67 g/day (95% CI [−7.10, −2.25]), corresponding to a 11.3% decrease and a similar small effect size

(Cohen's $d = -0.27$; 95% CI [−0.43, −0.11]). The control group showed reductions of 3.61 g/day (95% CI [−5.61, −1.60]) and 6.48 g/day (95% CI [−8.92, −4.05]) post-intervention and at two-month follow-up, respectively, corresponding to a 9.4% (Cohen's $d = -0.18$; 95% CI [−0.36, −0.04]) and 16.5% (Cohen's $d = -0.32$; 95% CI [−0.48, −0.16]) decrease. Further inspection of within-group changes showed a marginal quadratics trend in sugar consumption over time ($p = .058$), suggesting the maintenance of the change over time in those who received PNF.

Similarly, significant main effects of time were observed for craving strength, craving frequency, and self-efficacy (all $p < .001$), but not for mental well-being. There were no main effects of the intervention or group-by-time interaction for any of the secondary outcomes. Examination of within-group changes revealed significant quadratic trends for all secondary outcomes ($p < .01$). Table 1 shows estimated changes in the outcome measures at one-month post-intervention and at two-months follow-up, relative to the baseline assessment.

Neither of the sensitivity analyses showed a significant intervention effect (Appendix). The complete-case analysis performed on 369 participants (185 control, 183 intervention) yielded similar results to the main analysis, confirming the robustness of the model. Limiting the analysis to 171 participants whose baseline sugar consumption exceeded 10%DEI (82 control, 89 intervention) showed greater reductions in sugar consumption and craving in both groups compared to the main analysis. Specifically, in the intervention group, sugar intake decreased by 25% post-intervention (Cohen's $d = -0.91$) and 29% at two-month follow-up (Cohen's $d = -0.93$), while in the control group reductions were 27% post-intervention (Cohen's $d = -0.96$) and 34% at two-month follow-up (Cohen's $d = -1.07$).

Discussion

Although PNF interventions may yield only small effects, their low cost and scalability make them a potentially valuable public health strategy (Dotson et al., 2015). The PNF intervention of this study was a minimal-cost low-intensity approach, involving a one-time normative feedback report automatically generated on participant input. This exploratory study was designed to provide initial insights into the feasibility and potential impact of a PNF intervention targeting sugar intake. Both the intervention and control groups demonstrated reductions in sugar intake at one-month post-intervention and two-months follow-up. The high level of interest and rapid recruitment indicate strong public curiosity about sugar intake, pointing to a broader need for accessible, evidence-based tools to assess and reflect on personal consumption. Notably, follow-up rates remained relatively high despite the absence of individual compensation, which may reflect both the minimal burden of participation and the relevance of the topic to participants.

Intervention effects attributable to the normative feedback component were difficult to isolate, as no significant additional effect of the intervention was observed over the control condition. This suggests that the normative component may require further refinement. Similar studies have used graphs and visual displays to present normative feedback and comparisons with the participant's own scores (Saxton et al., 2021). As this was a low-cost exploratory study delivered via Qualtrics, graphical representations were not implemented, which may have reduced the impact of the feedback. Alongside the PNF, the intervention group also received information on their secondary outcome measures scores as well as additional self-help materials. The normative component constituted approximately 25% of the report, which may have minimised its influence. Earlier meta-analysis on PNF indicated that combining normative feedback with additional information may reduce effectiveness by interrupting the cognitive dissonance that typically drives behaviour change (Saxton et al., 2021). Future research should examine this more systematically, for example through a factorial design comparing pure PNF with and without additional information or support strategies.

The effects of personalised feedback across study outcomes may be enhanced by increasing the specificity and individual relevance of the information provided. Descriptive trends indicated that snack foods and, to a lesser extent, beverages remained the predominant sources of sugar intake throughout the study. Future interventions could utilise our adapted FFQ to provide personalised feedback on specific sugar categories rather than total sugar intake alone. This would enable participants to more clearly identify where reductions may be warranted. The intervention condition, which provided participants with their individual scores on secondary outcome measures along with generic interpretative information about the measures, improved craving strength, craving frequency, and self-efficacy. However, no additional significant effect of the intervention was observed compared to the control condition, which provided individual scores alone, indicating that the additional generic information did not confer a measurable benefit. The absence of change in mental wellbeing may reflect high baseline wellbeing within the sample, limiting potential for improvement. Moreover, feedback on wellbeing was not explicitly linked to sugar consumption, potentially reducing its relevance. Further research should investigate which components of personalised feedback are perceived as meaningful and whether increasing individualisation enhances intervention effectiveness.

The present study targeted a broad adult population to assess free sugar consumption and perceptions about personal and peer sugar intake. Participants' estimation of their

Table 1. Comparison of changes in sugar consumption between and within participants in PNF intervention and control group.

	One-month post-intervention Mean change [95% CI]	Two-months follow-up Mean change [95% CI]	Time effect p-value	Intervention effect p-value	Interaction effect (time-group) p-value
Sugar consumption					
Control	−3.61 [−5.61, −1.60]	−6.48 [−8.92, −4.05]	.000	.511	.479
Intervention	−4.23 [−6.28, −2.19]	−4.67 [−7.10, −2.25]			
Mental well-being					
Control	0.42 [−0.99, 1.82]	0.63 [−1.07, 2.33]	.120	.248	.108
Intervention	−1.98 [−3.41, −0.56]	0.76 [−0.93, 2.45]			
Self-efficacy					
Control	3.35 [2.10, 4.60]	4.14 [2.62, 5.66]	.000	.636	.238
Intervention	4.70 [3.43, 5.97]	4.21 [2.70, 5.71]			
Craving frequency					
Control	−2.70 [−4.26, −1.15]	−3.49 [−5.39, −1.58]	.000	.905	.110
Intervention	−4.33 [−5.91, −2.75]	−1.75 [−3.63, 0.13]			
Craving strength					
Control	−4.39 [−5.96, −2.81]	−4.24 [−6.16, −2.31]	.000	.536	.342
Intervention	−4.84 [−6.44, −3.24]	−2.31 [−4.21, −0.40]			

PNF: personalised normative feedback.
Mean change values represent estimated mean changes from baseline, adjusted for age, gender, ethnicity, BMI, and baseline outcome value. Sugar consumption values represent change in grams, all other outcomes values represent change in points on scale.

own consumption was broadly similar to their actual consumption, suggesting good self-awareness. Additionally, participants consumed less sugar than they believed was typical for their peers. There was scope for additional health benefits through further reduction of sugar consumption to 5% DEI. This highlights the question of what individuals consider the optimal daily sugar intake and how this aligns with WHO guidelines. Future studies could survey perceptions of recommended limits and optimal intake, which may vary by context and location. As the study advertising did not clearly specify that this was an intervention to reduce sugar intake, participants may have self-selected based on prior interest or awareness of sugar-related health outcomes. Consistent with such self-selection, baseline data indicated that fewer than one-third of participants exceeded the WHO's recommended limit for daily free sugar intake. Research shows greater reductions among individuals with higher pre-interventions sugar intake (Boxall et al., 2025). Our findings align with this pattern, showing substantially larger reductions when the analysis was restricted to those exceeding WHO guidelines, indicating promise in the use of a brief intervention and perhaps integration of such an intervention with other services or support.

In addition to limitations already mentioned, other considerations are related to study registration, measurement and treatment fidelity. The protocol was not prospectively registered as the study was exploratory and primarily aimed at assessing feasibility and potential effects. There are limited studies delivering a brief intervention for sugar reduction and we were uncertain whether people would be receptive to our study and whether such a brief intervention would have an impact. Building on this work, prospective registration is important to strengthen transparency and reduce the risk of outcome reporting bias. Furthermore, there may have been measurement error in the main outcome. The FFQ, in original or adapted form, is the most commonly employed measure in intervention research targeting sugar intake (Azhar Hilmy et al., 2024). Still, as a retrospective, self-reported measure, the FFQ is subject to both recall and social desirability bias. Future research should validate the FFQ for sugar against more sensitive assessment tools, such as biomarkers or ecological momentary assessment methods, to improve measurement precision (Shiffman et al., 2008). Additionally, a small number of participants reported not receiving the intervention, likely due to closing the survey before reviewing the feedback report. Future studies could provide additional signposting to ensure engagement. Most participants accurately recalled their personal sugar intake and the WHO-recommended limits, indicating meaningful engagement with the PNF component. Participants in the intervention condition spent an average of 16 min on the assessment and feedback, compared with 13 min in the control. As the survey alone required approximately 10 min, this suggests substantially more time was devoted to the intervention report.

Meta-analytic findings show that internet interventions have small effects on health-related behaviours (Webb et al., 2010). In our study, the effect of an internet-delivered

PNF intervention on sugar consumption compared to minimal feedback only did not reach statistical significance. However, sugar consumption in those in the intervention group decreased by over 10%, reflecting a small and clinically relevant effect. When interpreting our findings, it is important to consider the study context. Based on the findings that the control group had an effect which contributed to the null trial finding, we recommend future studies assess both arms against a pure control group. Together, these findings underscore the feasibility and potential of brief, scalable interventions targeting sugar reduction, while also highlighting key considerations for optimising their design, implementation, and evaluation.

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ORCID iDs

Rimke Bijker https://orcid.org/0000-0002-9150-2078
Hiranya Khullar https://orcid.org/0009-0005-1656-5174
Simone N Rodda https://orcid.org/0000-0002-7973-1003

Ethical considerations

This study was approved by the University of Auckland Human Participants Ethics Committee.

Consent to participate

All participants provided informed written consent prior to participation.

Consent for publication

Not applicable.

Author contributions

SR conceptualised the study and developed the design and methodology; HK conducted the research and investigation process, specifically performing the development of resources, conducting the recruitment and designing the algorithms for the study; BTO and SR supervised the project; RB was responsible for statistical analysis, data interpretation and writing the manuscript. All authors reviewed subsequent drafts of the manuscript and approved the final version.

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Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Supplemental material

Supplemental material for this article is available online.

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