BMJ Open

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Journal:	*BMJ Open*
Manuscript ID	bmjopen-2019-032248
Article Type:	Original research
Date Submitted by the Author:	11-Jun-2019
Complete List of Authors:	de Bruin, Willemijn ; University of Otago, Medicine Ward, Aimee; University of Otago, Medicine Taylor, Rachael; University of Otago, Medicine Jospe, Michelle; University of Otago, Medicine
Keywords:	NUTRITION & DIETETICS, PUBLIC HEALTH, QUALITATIVE RESEARCH, OBESITY, TRANSLATIONAL RESEARCH, ADHERENCE

"Am I really hungry?" A qualitative exploration of patients' experience, adherence, and behaviour change during a Hunger Training intervention

Authors:
Willemijn E. de Bruin[a], Aimee L. Ward[a], Rachael W. Taylor[a] and Michelle R. Jospe[a]

Author affiliation:
[a]Dept of Medicine, University of Otago, PO Box 56, Dunedin, New Zealand, 9054
w.debruin@otago.ac.nz
aimee.ward@otago.ac.nz
rachael.taylor@otago.ac.nz
michelle.jospe@otago.ac.nz

Corresponding author:
Dr Michelle R Jospe
Dept of Medicine, University of Otago, PO Box 56, Dunedin, New Zealand, 9054
Michelle.jospe@otago.ac.nz, +64 21 037 5002

3334 words

ABSTRACT

Objectives Hunger training is an intervention designed to teach people to eat according to their hunger by connecting physical symptoms of appetite with glucose levels. Hunger training is most effective for weight loss, and improving eating behaviours when adherence is high. However, adherence is a challenge that should be prior to wider dissemination. The aim of this study was to explore participants' experience, adherence, and behaviour change related to hunger training.

Design A qualitative study, nested within a randomised controlled pilot study of two different methods of monitoring glucose during hunger training. Semi-structured interviews were audio-recorded, transcribed verbatim, and analysed thematically using an inductive approach.

Setting Single centre study with participants recruited from the local area.

Participants 40 participants began the pilot study and 38 participants (52.6% female) remained at 1 month and completed interviews.

Results Most participants felt they were able to match their hunger to their glucose levels by the end of the intervention. The main adherence barriers were the social pressure to eat, lack of time, and lack of flexibility in participants' meal schedules. Common adherence enablers were having a set routine, social support, and accountability. Participants described increased awareness of hungry versus non-hungry eating and better cognition of feelings of hunger and satiety as a result of the intervention, which in turn led to changes of food choice, portion size, and adjusted meal timing and frequency.

Conclusions Findings show that hunger training is acceptable from a patient perspective, and results can be used to inform the translation of hunger training programs to health care settings.

Trial registration ACTRN12618001257257

Strengths and limitations of study

- In-depth interviews allowed for detailed insight into participants' experiences of hunger training, including adherence barriers and enablers as well as behaviour change.
- Rigorous analysis provided confidence in our findings, which are applicable to other lifestyle interventions.
- While our sample was diverse in terms of sex, age, education, and income, the New Zealand setting, as well as the predominantly European ethnicity of participants may limit extrapolation to other countries and cultures.
- As with all interviews, there was potential for response biases, however we tried to limit this by introducing an independent researcher for the interviews.

INTRODUCTION

Weight management is crucial to prevent chronic diseases, however most weight loss diets prove unsustainable in the long-term.[1 2] A more viable approach may be to teach people to eat according to their appetite signals, which has been shown to benefit weight maintenance. However, they have been inconsistently effectively for weight loss.[3-7] This may be because overweight and obesity is linked with difficulty sensing and responding to physiological hunger and satiety cues, decreasing awareness of appetite.[8-10]

To overcome this barrier, an intervention known as hunger training (HT) uses glucose monitoring as an indicator of hunger to help people gain greater awareness of their appetite signals, and eat accordingly.[11 12] Hunger training produces clinically important weight loss, and reduced emotional and external eating.[13-15]

The combination of the minimal human resources required for the delivery of HT, and the potential of sustainable weight management makes it a promising intervention for primary health care. However, as with most health interventions, adherence is a challenge that must be investigated prior to wider dissemination.[16 17] Previous work has shown that benefits of HT are greater for participants with higher adherence, and that only about one-third of participants sufficiently adhere to experience a clinically beneficial effect.[15] Before HT can be implemented widely, the underlying mechanisms that contribute to the effectiveness of HT and the barriers and enablers to adherence must be determined. We aimed to qualitatively explore study participants' experience, adherence, and behaviour change after experiencing HT to inform translation of HT from research to practice.

METHODS

Study design and participants

This study was approved by the New Zealand Southern Health and Disability Ethics Committee (18/STH/105) and was registered with the Australian New Zealand Clinical Trials Registry (ACTRN12618001257257). All participants provided written informed consent.

Forty adults were recruited from Aug–Oct 2018 from the local community through social media channels and local advertisement, and were included if they were 18 years of age or older, had a body mass index (BMI) of 30 kg/m^2 or higher, and were willing to measure their glucose by fingerprick blood sample and wear a continuous glucose monitor. Exclusion criteria were use of medication that affects weight; pregnancy or breastfeeding; allergy to surgical adhesive; skin changes or disease on the upper arm; or imaging appointments scheduled during the study.

Patient and public involvement

No patient or public were involved in the development of the research question, interpretation of the results, or writing of this document. The results will be disseminated to participants via email.

Randomisation and procedures

Participants were randomized to one of two groups using computerized block randomisation with random length blocks after stratification for sex. The "fingerpricking" group measured their capillary glucose from a fingerprick sample by portable glucometer (Abbott Freestyle Optium Glucose Meter, Australia, Figure 1a). The "scanning" group used the Freestyle Libre Flash Glucose Monitoring system (Abbott Diabetes Care, Australia, Figure 1b), which continuously measures interstitial glucose every 15 minutes. A thin water-resistant sensor was inserted just under the skin on the back of the arm, and remained there for 14 days, then replaced. When the participant wanted to test their glucose, they passed a reader over their arm to display current glucose levels. Both HT groups received the same guidance and support.

Hunger training intervention

Participants were instructed to only eat or drink a caloric beverage if their glucose concentration was below their individualised cut-off, which was based on the average of fasting glucose from their first two mornings. If participants' glucose was above their cut-off value, they were instructed to wait at least 20 minutes before retesting.

Alongside the glucose monitoring, participants were asked to rate their hunger level (Figure 2), and to note their glucose level and whether they ate, every time they wanted to consume food or caloric drink. Participants attended three HT appointments. At baseline, participants were introduced to HT and taught how to measure their glucose, based on their randomisation. At the day 14 visit, participants could ask questions and discuss challenges and successes, and were provided with a reading on intuitive eating using glucose monitoring.[18] On the last visit, participants returned their equipment and participated in a semi-structured interview.

Data collection

Researchers conducted in-depth interviews with each participant at the last visit. A semi-structured interview guide (see supplementary file) was developed to explore 1) participants' experiences of HT; 2) perceived behaviour change due to HT; 3) adherence to the intervention; 4) future expectations; and 5) intervention feedback. All interviews were digitally recorded, and professionally transcribed verbatim. Transcripts were processed anonymously. After reviewing the transcribed interviews, it was clear that saturation had been reached and it was deemed unlikely that new topics would arise.[19 20]

Data analysis

The transcribed interviews were systematically scrutinized to guide coding development, key to employing grounded theory in qualitative work.[21 22] Codes were first piloted and refined using a subset of interviews; each interview was coded for themes by two researchers using NVivo.[23] The thematic analyses took an inductive approach and included familiarisation with the interviews and transcripts, development of codes,

collating codes into themes, and the researchers convened to reconsolidate any disagreements.[22 24] Researchers conducting analyses were blind to any participant classifications.

The results section includes the use of qualifiers that have been adapted from previous studies.[25-27] When an issue was discussed by 1 to 9 participants, we referred to a 'few'; for between 10 and 20 participants, we referred to 'some'; for between 21 and 30 participants we referred to 'most'; for between 31 and 37 we referred to 'almost all'; and for 38 we referred to 'all'.

RESULTS

The research team conducted a total of 38 semi-structured interviews with HT participants; 2 participants dropped out of the study before their interview. Participants ranged in age from 20 to 78 years, had an HbA1c between 28 and 100 mmol/mol, and an individualised glucose cut-off between 4.0 and 14.0 mmol/L (Table 1). Overall themes can be found in Figure 3.

Table 1. Baseline characteristics of participants

Variable	All (n=38)
Randomised to scanning, n (%)	19 (50.0)
Female, n (%)	20 (52.6)
Age (years)	45.0 (13.0)
HbA1C (mmol/mol) (median, IQR)	37.0 (34-42)
Glucose cut-off (mmol/L)	6.1 (1.9)
Diabetes status, n (%)	
Non-diabetic	27 (71.1)
Pre-diabetic	8 (21.1)
Type 2 diabetes	3 (7.9)
Body mass index (kg/m^2)	38.3 (7.4)
Education, n (%)	
School only	12 (31.6)
Post-secondary	4 (10.5)
University	22 (57.9)
Ethnicity, n (%)[a]	
New Zealand European	36 (94.7)
Māori	4 (10.5)
Samoan	2 (5.3)
Other	3 (7.9)
Partnered, n (%)	25 (65.8)
Household income (New Zealand Dollar), n (%)	
<50k	14 (36.8)
50-100k	11 (28.9)
100-150k	12 (31.6)
>150k	1 (2.6)
Depression Anxiety Stress Scale (DASS-21)	
Stress	12.2 (8.7)
Depression	9.1 (9.3)
Anxiety	7.7 (5.7)

Values are mean (standard deviation) unless otherwise indicated. [a]Multiple options are possible therefore responses surpass 100%.

Participants' experiences with hunger training

Glucose measuring experience and adherence

Participants explained that is was useful to have an objective measure of their hunger; *"It was helpful to see an actual concrete measurement of 'Was I actually hungry? Or was I just imagining that kind of thing?' […] it was actually something quite tangible." - #25, scanner.* A few participants commented that HT increased their self-efficacy; *"I was unprepared to feel empowered by taking that modicum of control. So that was really cool. - #63, scanner.*

Almost all participants described situations where they were unable to adhere to the HT protocol, and ate without measuring their glucose levels or ate when their glucose was above their cut-off. Some reasons for not measuring were because they forgot equipment or forgot to measure; were too busy; or were in social situations that made measuring difficult. Reasons for eating above cut-off included social pressure to eat, feeling extremely hungry, a lack of flexibility to eat at different times, illness and eating out of habit.

Most participants discussed the social pressure to eat; *"In a dinner situation where you've got to eat when everyone else is eating. You can't not eat, can't just say 'sorry, I'm checking my glucose'." - #72, scanner.* Participants also described the cultural importance of food in their families or social groups as reasons for not adhering.

There was a clear distinction in experiences and adherence barriers between participants randomized to fingerpricking compared to those who were randomized to scanning. Most of those who were ambivalent, and all three participants who were outspokenly negative about their glucose measuring experience, were randomised to fingerpricking. Almost all fingerprickers addressed the pain and inconvenience of testing, such as spilling blood, difficulty in obtaining sufficient blood, having to wash hands before pricking and disposing the lancets safely. A few explained that they were initially hindered by the pain but that they got used to it over time, whereas others thought that pain got worse. A few also explained the pain and inconvenience helped them be mindful; "T*hat pain and inconvenience did I help me, it set the routine because it's like ok to eat I have to do this very inconvenient thing and cause myself a little bit of pain, do I really want to go ahead with that, is that chocolate biscuit really worth that and often the answer was no." - #9, fingerpricker.* Those in the fingerpricking group were more likely to describe social situations in which they did not adhere since measuring their glucose made them feel self-conscious and a few expressed worries about being stigmatized.

Those who used the scanner were generally more positive about their glucose measuring experience. Almost all said scanning was quick, easy, discreet, and convenient, which allowed for frequent checking.

Participants who were classified as pre-diabetic or diabetic did not report remarkably different experiences than those who were non-diabetic.

Booklet experience and adherence

A few participants explained the booklet helped them discover a pattern between their hunger and glucose and be more aware of food intake. A few explained how the hunger scale helped them understand hunger and fullness.

A few participants explained they occasionally forgot to complete the booklet, that it was impractical, and that it was "just another thing to carry around". Hence, some participants explained that they only completed the booklet retrospectively. Several participants suggested developing a smartphone app to replace the booklet.

A few felt that the hunger scale should be personalized, or reflect feelings instead of numbers. Participants also talked about additional information that could be included in the booklet, including exercise and dietary recommendations, mindfulness and adherence techniques, and coping strategies for cravings.

Adherence enablers

Some participants stated that daily structure and normal routine helped them comply. Social support and accountability was another adherence enabler for some participants, specifically that provided by family and friends who helped them stick to the routine of checking their glucose and eating appropriately. A few mentioned their doctors expressed interest in the study and were supportive, providing another level of accountability.

Others indicated that adherence became easier; *"I think it got easier as time's gone on because as I was more mindful about eating breakfast and I guess doing preparations for lunch, knowing what's coming and how to fit it in with the [glucose] levels." - #37, scanner.*

Association between glucose and hunger

Most participants were able to determine a clear association between their glucose levels and hunger; *"I noticed that […] when I was feeling really hungry, stomach growling, that my glucose was under four, which was like my threshold. I kind of almost got intuitive about it." – #38, scanner.* Those who were able to detect an association described a learning curve, with the association became clearer over time.

A few were unable to recognise an association and felt confused. This was more common among fingerprickers. Common reasons for confusion were when glucose levels were high before breakfast, after physical activity, and when they felt very hungry. Some recognised that glucose readings were elevated when they were busy, stressed, or unwell.

Awareness of hunger

The majority of participants reported that they became better at recognising hunger. This made HT different from other weight management strategies they had previously attempted; *"I've tried listening to people, I've tried following routines, I've tried all that sort of thing and I occasionally lose [a few] kilos and then I go straight back to square one because I don't know how to... read my body. I didn't know what it felt like to be hungry. I didn't know that the*

way I felt was actually what it feels like to be full. So, I was keeping myself constantly full." - #42, scanner. The scale opened their eyes to the fact there was a continuum of hunger sensations

Some struggled to identify with the provided descriptors of each of the hunger levels on the hunger scale. A few overcame this by personalising their scale and/or using half points. However, others referred to initially being unfamiliar with some cues but then experiencing them for the first time during the study; *"I've been married 11 years and my wife heard my stomach rumble and she was like "I've never heard that before!" – #64, fingerpricker*. Only a few participants felt that HT did not improve their ability to recognise real hunger.

Awareness of non-hungry eating

Almost all participants learned to tell the difference between hungry and non-hungry eating; *"It was interesting to start to find out whether there was an actual need for food from the blood glucose reading versus whether it was a mind thing. I was actually quite quick to adjust to it and it gave a good chance to understand the feelings of hunger that you get, whether it might be physical or psychological, or just the environment you're in." – #37, scanner.* Some were surprised to discover that they regularly ate when they were not hungry; *"I didn't think that I would be susceptible, like at the start of the study they talked about eating when you're bored, or eating when you're emotional and I totally expected to be above all of that petty human [stuff] because I'm intelligent. It was really eye opening, especially in the first two weeks of the study, just how programmed or routine a lot of my eating is." - #63, scanner*.

Once aware of their non-hungry eating, participants generally avoided it; *"If I have anything now, even if blood glucose is fine, that's going to affect my ability to have something, a meal later on when I'm really hungry and I then my blood glucose would be more than likely too high to allow me to eat when I wanted to later on" - #9, fingerpricker.*

The most popular reason for non-hungry eating was boredom; *"I'd say I was a bored eater. Like I'd be at home, what do I want to do? Uh, I don't really know, I'm just walking around the kitchen, just open up the pantry for no reason, and […], I'm here, so I'll grab something." - #79, fingerpricker.* A few turned to food when stressed or upset. Some believed that if they didn't eat regularly, their body would go into "starvation mode"; *"Well, often people tell you if you ate too little that you will put your body into starvation mode and then it will hold onto the fat." - #42, scanner.*

In terms of physical symptoms, some realised that they had confused hunger and thirst. Others realised they ate when tired, in order to give them energy. For a few, non-hungry cravings reduced once they stopped responding to them.

A few mentioned they ate when they were not hungry because of their environment; *"I walked down past the café this morning, I went, 'Ah, food'. It was really good to go to my brain, 'No, you're not hungry, this is just your body pretending'." – #62, scanner.* A lot mentioned they used to eat out of habit or routine, related to time of day; *"Eat when I'm hungry, rather than*

eat because it's 12 o'clock." - #22, fingerpricker, or activity; *"Have chips and dip and watch the rugby" – #69, scanner.*

Participants developed strategies when faced with triggers. The most common coping mechanism to avoid non-hungry eating was to drink water or another sugar-free beverage. Some diverted themselves with chores, a walk, or other activities. Participants dealt with social eating by planning ahead ; *"There's another gathering this Saturday, so if I'm going to go and don't feel like I'm really hungry to eat, I can take the food and do a takeaway and say, 'oh I'll take this and I'll have it later'." – #76, scanner*. One participant used strategies she used when quitting smoking; *"I'd implement the breathing like you would have [when] you were having a cigarette. I would talk to someone or talk to myself if no one was around, 'you know what this is you know that this is a craving, you just have to ride through it.'" – #42, scanner.*

Awareness of fullness

A couple of participants randomised to the scanner connected their physical sensations with their glucose; *"I could scan myself within half an hour of a heavy meal and be able to go see 'you're full, look what that's done' and show myself that actually this is what your body needs versus what it wants." - #42, scanner*. Participants also used the hunger scale to identify their satiety, however, they expressed they were less confident about recognising fullness.

Some participants became aware of feeling uncomfortable from overeating, especially after their evening meal. A couple of participants noticed their sleep improved after reducing overeating.

Behaviour change

The main behaviour changes were changing their portions, food choices, and timing and frequency of meals (Table 2).

Table 2. Behaviour changes due to hunger training

Theme description	Representative quotes
Portion size reduction	
Most participants reduced the amount of food they ate at a given meal	*"This could show me in a physical way that you're not actually starving yourself eating this small amount. I learned really quickly that actually if I get a six-inch subway sandwich, I'm just as full and satisfied for just as long a time period as I am if I have [the amount] that I'd normally get."- #42 scanner*
Some specifically reduced their portions of unhealthy foods, or foods that spiked their glucose	*"Instead of buying a decent size cake of chocolate I bought the little bars and that was because I had in my mind the spike that would then come and associated the spike with what then is happening in your body." - #25, scanner*
Others reduced their intake in order to be able to eat when desired	*"I've noticed that if I'm having less at lunch […] then I'm able to eat my dinner at dinner time versus having a huge lunch and then my blood sugar is still so high that I couldn't have dinner." – #38, scanner.*
A few participants noticed their evening meal influenced morning glucose levels, often modifying their evening meal to eat breakfast at a convenient time	*"We had a friend round and I had a dessert. I had to wait 20 minutes or longer in the morning. But I don't have 20 minutes in the morning. So, I was like, 'okay, let's not do that'." - #79, fingerpricker.*
Food choice	

Participants from both groups found particular foods delayed their next subsequent meals due to being over their glucose cut-offs, and those wearing the scanner reported seeing a spike in glucose levels after consuming certain foods (or "spikey" foods). People also noticed which foods kept them satisfied for longer, which they viewed as positive.	*"It made me acutely aware of what foods lasted me longer before the start growl [stomach growl] level was achieved." - #50, scanner.*
Reduced intake of "sugary foods" and "sweet stuff", bread, chips, biscuits, chocolate, cakes, takeaways and fast food, sugar-sweetened beverages (SSBs), and alcohol.	*"It was more around the drinking because I take a lot of convincing that things [are] right loaded with sugar and if I can't see it, I'm probably not going to believe a word you say. So, it was good to see it […] After [I drank] I pricked my finger and saw it did shoot up, I would think a bit and have a look at what I was drinking and what was in it." – #40, fingerpricker.*
Increased intake of vegetables, salads, homemade meals, nuts, eggs, water, and coffee.	
Increased planning of meals	
Timing and frequency of meals	
Most reduced their number of eating occasions by eliminating snacking. The majority of this group changed their habit of grazing to eating a fixed number of meals a day, because they realised that they were not hungry, did not want to delay their next meal, and/or to avoid fingerpricking. Most chose to have a sugar-free beverage instead of food; a few combined their snack food with their main meal.	*I would amalgamate [a snack] into a meal. So, this last weekend we were away so you know, we'd have a handful of chips, one or two crackers, some bits and pieces […], and then you go, okay well I've had it. Now the old me, prior to this [study], would be having it a bit later on when the blood sugar would still be high and two, I'd probably be having the entire pack – #64, fingerpricker.*
For most, monitoring their glucose confirming their normal morning food pattern. However, some had glucose levels that were too high to eat breakfast at their usual time. For these participants, elevated morning glucose was frustrating. Some ate later, and others ignored their glucose and ate anyway. A few were glad their glucose levels confirmed they did not need to eat breakfast, as they never enjoyed breakfast and felt guilty about skipping it	*"Because based on my monitoring, I'm pretty good, and I don't need to have breakfast, which was a relief, because I'm not a fan of breakfast to begin with." - #62, scanner*

Note: Themes listed in order of frequency

Future expectations

Almost all participants expressed they were motivated and hopeful about continuing with their recent behaviour changes. A few explained they would have liked to measure their glucose for longer to gain confidence about their hunger levels and some (mostly those who scanned) expressed concern about being without their equipment. This feeling of concern generally revolved around the fact that they would be without immediate feedback. On the contrary, other participants were happy and confident to leave their equipment behind. A few participants reflected that following HT without equipment would be the next step.

DISCUSSION

Most participants had a positive experience of HT, and were able to match their hunger to their glucose levels by the end of the study, which is consistent with other findings[28] and our previous results.[14] While the majority found an association between hunger and glucose, some experienced confusion, which is likely related to the homeostatic control of glucose.[12]

The main adherence barriers of social pressure to eat, lack of time, and lack of flexibility in meal schedule, and the main enablers of routine, social support, and accountability, are consistent with those of a systematic review of determinants of adherence to lifestyle interventions in adults with obesity.[16] Participants realised that they were previously unaware of feelings of appetite, supporting the theory that some with overweight/obesity have blunted sensations of hunger and satiety.[8-10] Participants primarily changed their behaviour by becoming aware of hungry versus non-hungry eating, recognising feelings of hunger and satiety, reducing their number of meals, and exploring the effect of different types of foods on their glucose. This is in line with a review of mindful and intuitive eating interventions wherein participants became more aware of and reduced non-hungry eating.[29] Although historically HT enhances recognition of hunger rather than satiety,[28] our results indicate our participants learned to recognize feelings of fullness.

Participants randomised to use the scanners generally described fewer negative experiences and less adherence barriers, and were more inclined to try different foods to see the effects on their glucose, due to the ease of scanning. However, those randomised to fingerpricking may have become more mindful of their hunger, since they carefully considered their hunger before submitting to the effort and discomfort of fingerpricking. Fingerprickers were more confident returning their glucose measuring equipment, perhaps due to their established awareness of hunger.

As suggested by our participants, a mobile app instead of a paper booklet, and including nutrition and exercise recommendations, and strategies to cope with emotional and social eating may increase adherence, and this agrees with current recommendations.[30] Social support , and involving family and friends may improve adherence and benefits, as demonstrated elsewhere.[31-33]

Our analysis was robust; the researchers were blinded for participant characteristics, all transcripts were double-coded, and the results were analysed and interpreted by three researchers. As with all interviews there is potential for response bias, with a chance of study participants providing socially desirable answers to appease researchers.[34] We tried to limit this by introducing an independent researcher for the interviews.

Our interviews allowed understanding of implemented behaviour changes and provided suggestions of how to better support participants in establishing healthy eating routines. Results of this study can be used to inform future HT programs and other healthy eating interventions in both primary care and public health settings.

DECLARATIONS

Author Contributions: Conceptualization, W.E.dB., A.L.W., R.W.T. and M.R.J; Methodology, W.E.dB., A.L.W. and M.R.J; Formal Analysis, W.E.dB., A.L.W. and M.R.J; Resources, M.R.J; Data Curation, W.E.dB., A.L.W. and M.R.J; Writing-Original Draft Preparation, W.E.dB and M.R.J; Writing-Review & Editing, W.E.dB., A.L.W., R.W.T. and

M.R.J; Visualization, M.R.J; Project Administration, W.E.dB. and M.R.J; Funding Acquisition, R.W.T. and M.R.J.

Funding: This research was supported by a University of Otago Research Grant.

Acknowledgments: We would like to thank all participants involved in the hunger training pilot study (ACTRN12618001257257). Thank you to Associate Professor Ben Wheeler and Dr Sara Boucher for sharing their expertise with the Freestyle Libre Flash Glucose Monitoring system.

Conflicts of Interest: The authors declare no conflict of interest.

List of Abbreviations: BMI: Body Mass Index, DASS-21: Depression Anxiety Stress Scale, HbA1c: Hemoglobine A1c, HT: Hunger Training, IQR: Inter-Quartile Range, SSBs: Sugar-Sweetened Beverages.

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FIGURE CAPTIONS

Figure 1. Glucose measuring equipment, (a) the Freestyle Optium Glucose Meter (Abbott Freestyle Optium Glucose Meter, Australia), test strip and lancet used by the "fingerpricking" group; (b) the Freestyle Libre Flash Glucose Monitoring system (Abbott Diabetes Care, Australia), worn by the "scanner" group.

Figure 2. A page spread from the hunger training booklet

Figure 3. Themes emerging from hunger training pilot study

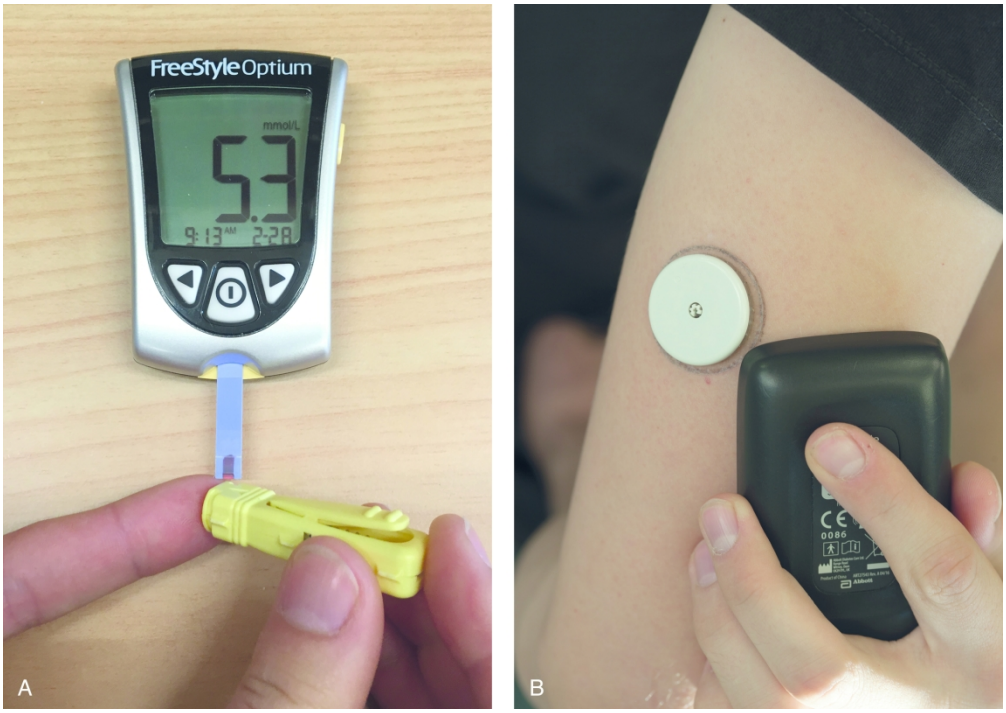

Figure 1. Glucose measuring equipment, (a) the Freestyle Optium Glucose Meter (Abbott Freestyle Optium Glucose Meter, Australia), test strip and lancet used by the "fingerpricking" group; (b) the Freestyle Libre Flash Glucose Monitoring system (Abbott Diabetes Care, Australia), worn by the "scanner" group. Photo by Thirunavukkarasye-Raveendran [CC BY 4.0 (https://creativecommons.org/licenses/by/4.0)]

189x133mm (300 x 300 DPI)

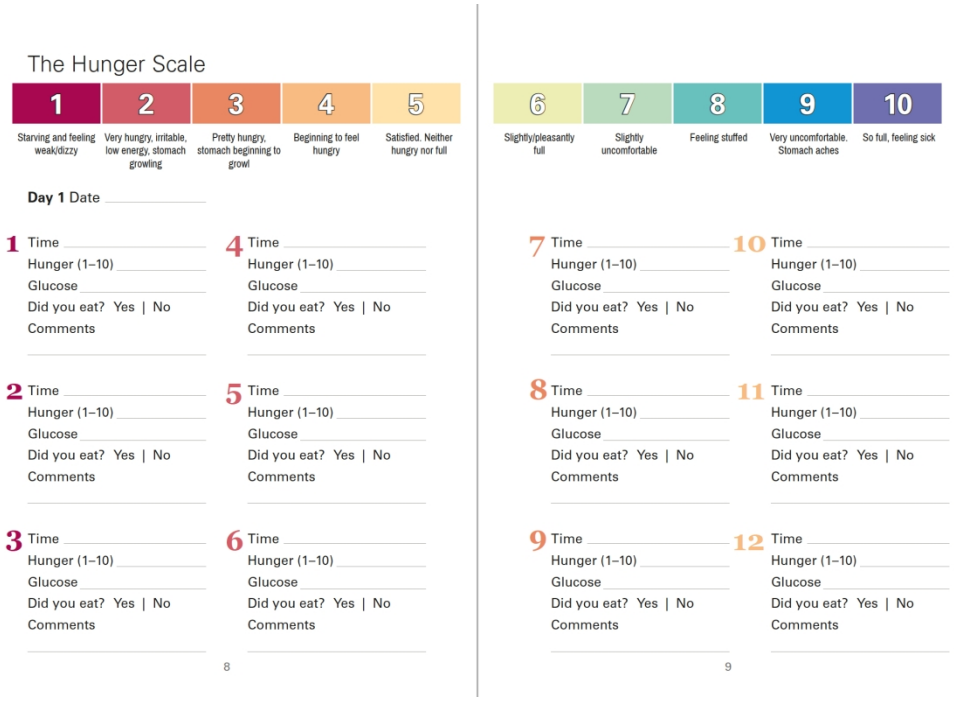

Figure 2. A page spread from the hunger training booklet

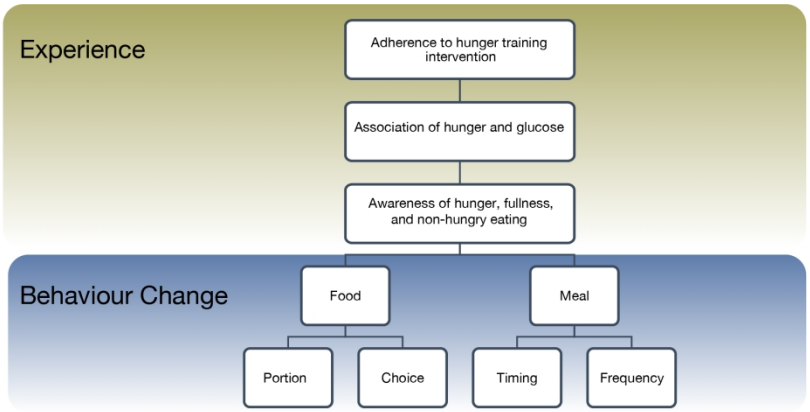

Figure 3. Themes emerging from hunger training pilot study

209x107mm (300 x 300 DPI)

SUPPLEMENTARY FILE

Semi-structured interview guide

1. What was it like to measure your **glucose** over the past month?
    a. Could you tell me something about what you **liked** about measuring your glucose?
    b. Could you tell me something about what you **disliked** about measuring your glucose?
2. What was it like to **fill in the booklet** over the past month?
    a. Can you tell something about what you **liked** about filling in the booklet?
    b. Can you tell something about what you **disliked** about filling in the booklet?
3. Did you see a pattern between your hunger and glucose?
    a. If no, how much of a problem was this?
    b. If yes, could you tell a bit more about what you learned?
4. Can you please let me know whether you have **experienced any changes in your behavior** in the past month?
    a. Do you think this changed because of hunger training?
    b. You told me something about …. , were there any other changes because of hunger training?
        i. Possible topics for discussion: routine, number of eating occasions (e.g. number of meals), avoidance of eating due to pain, food choice, awareness of hunger/recognizing when body needs food, previous non-hungry eating (e.g. eating because of routine, emotions, environment), awareness of fullness/satiety (e.g. doesn't have to eat as much as previously thought), awareness of social pressure to eat, physical activity or coping mechanisms (e.g. ways to distract yourself when "hungry" but not allowed to eat).
5. We asked you to measure your glucose every time you felt like eating, and to only eat if your glucose was under your cut-off. How did this work out for you?
    a. We can imagine this was not always easy, can you tell me why it was sometimes **difficult**?
        i. Can you please tell me about situations that you **didn't measure** your glucose before eating (if any)?
        ii. Can you please tell me about situations that your **glucose was too high to eat**, but you ate anyways (if any)?
    b. Some days it may have **been easier** to follow our instructions than others, can you tell me why?

6. Now that you're finished the first month of hunger training, you are no longer going to measure glucose to help you figure out when to eat. You'll continue to fill in the booklet, but only for one week every month. What do you **expect** to happen over the next 5 months?
    a. Do you feel like you have trained yourself to recognize when you are hungry?
    b. Do yourself to know when to eat without being able to measure your glucose?
7. Do you have any suggestions for us on how we can **improve** hunger training?
    a. Length of time of measuring glucose,
    b. Communication (e.g. appointments, reminders)
    c. Equipment
    d. Booklet/instructions

Standards for Reporting Qualitative Research (SRQR)*

http://www.equator-network.org/reporting-guidelines/srqr/

	Page/line no(s).
Title and abstract	
Title - Concise description of the nature and topic of the study Identifying the study as qualitative or indicating the approach (e.g., ethnography, grounded theory) or data collection methods (e.g., interview, focus group) is recommended	1
Abstract - Summary of key elements of the study using the abstract format of the intended publication; typically includes background, purpose, methods, results, and conclusions	2
Introduction	
Problem formulation - Description and significance of the problem/phenomenon studied; review of relevant theory and empirical work; problem statement	3
Purpose or research question - Purpose of the study and specific objectives or questions	3
Methods	
Qualitative approach and research paradigm - Qualitative approach (e.g., ethnography, grounded theory, case study, phenomenology, narrative research) and guiding theory if appropriate; identifying the research paradigm (e.g., postpositivist, constructivist/ interpretivist) is also recommended; rationale**	4-5
Researcher characteristics and reflexivity - Researchers' characteristics that may influence the research, including personal attributes, qualifications/experience, relationship with participants, assumptions, and/or presuppositions; potential or actual interaction between researchers' characteristics and the research questions, approach, methods, results, and/or transferability	4
Context - Setting/site and salient contextual factors; rationale**	4
Sampling strategy - How and why research participants, documents, or events were selected; criteria for deciding when no further sampling was necessary (e.g., sampling saturation); rationale**	4
Ethical issues pertaining to human subjects - Documentation of approval by an appropriate ethics review board and participant consent, or explanation for lack thereof; other confidentiality and data security issues	3
Data collection methods - Types of data collected; details of data collection procedures including (as appropriate) start and stop dates of data collection and analysis, iterative process, triangulation of sources/methods, and modification of procedures in response to evolving study findings; rationale**	4

Data collection instruments and technologies - Description of instruments (e.g., interview guides, questionnaires) and devices (e.g., audio recorders) used for data collection; if/how the instrument(s) changed over the course of the study	4
Units of study - Number and relevant characteristics of participants, documents, or events included in the study; level of participation (could be reported in results)	5
Data processing - Methods for processing data prior to and during analysis, including transcription, data entry, data management and security, verification of data integrity, data coding, and anonymization/de-identification of excerpts	4
Data analysis - Process by which inferences, themes, etc., were identified and developed, including the researchers involved in data analysis; usually references a specific paradigm or approach; rationale**	4-5
Techniques to enhance trustworthiness - Techniques to enhance trustworthiness and credibility of data analysis (e.g., member checking, audit trail, triangulation); rationale**	4

Results/findings

Synthesis and interpretation - Main findings (e.g., interpretations, inferences, and themes); might include development of a theory or model, or integration with prior research or theory	5-10
Links to empirical data - Evidence (e.g., quotes, field notes, text excerpts, photographs) to substantiate analytic findings	5-10

Discussion

Integration with prior work, implications, transferability, and contribution(s) to the field - Short summary of main findings; explanation of how findings and conclusions connect to, support, elaborate on, or challenge conclusions of earlier scholarship; discussion of scope of application/generalizability; identification of unique contribution(s) to scholarship in a discipline or field	10-11
Limitations - Trustworthiness and limitations of findings	11

Other

Conflicts of interest - Potential sources of influence or perceived influence on study conduct and conclusions; how these were managed	12
Funding - Sources of funding and other support; role of funders in data collection, interpretation, and reporting	12

*The authors created the SRQR by searching the literature to identify guidelines, reporting standards, and critical appraisal criteria for qualitative research; reviewing the reference lists of retrieved sources; and contacting experts to gain feedback. The SRQR aims to improve the transparency of all aspects of qualitative research by providing clear standards for reporting qualitative research.

**The rationale should briefly discuss the justification for choosing that theory, approach, method, or technique rather than other options available, the assumptions and limitations implicit in those choices, and how those choices influence study conclusions and transferability. As appropriate, the rationale for several items might be discussed together.

Reference:

O'Brien BC, Harris IB, Beckman TJ, Reed DA, Cook DA. **Standards for reporting qualitative research: a synthesis of recommendations.** *Academic Medicine*, Vol. 89, No. 9 / Sept 2014
DOI: 10.1097/ACM.0000000000000388

BMJ Open

"Am I really hungry?" A qualitative exploration of patients' experience, adherence, and behaviour change during a pilot Hunger Training intervention

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2019-032248.R1
Article Type:	Original research
Date Submitted by the Author:	03-Nov-2019
Complete List of Authors:	de Bruin, Willemijn ; University of Otago, Medicine Ward, Aimee; University of Otago, Medicine Taylor, Rachael; University of Otago, Medicine Jospe, Michelle; University of Otago, Medicine
Primary Subject Heading:	Nutrition and metabolism
Secondary Subject Heading:	Public health, Qualitative research
Keywords:	NUTRITION & DIETETICS, PUBLIC HEALTH, QUALITATIVE RESEARCH, OBESITY, TRANSLATIONAL RESEARCH, ADHERENCE

"Am I really hungry?" A qualitative exploration of patients' experience, adherence, and behaviour change during a pilot Hunger Training intervention

Authors:
Willemijn E. de Bruin[a], Aimee L. Ward[a], Rachael W. Taylor[a] and Michelle R. Jospe[a]

Author affiliation:
[a]Dept of Medicine, University of Otago, PO Box 56, Dunedin, New Zealand, 9054
w.debruin@otago.ac.nz
aimee.ward@otago.ac.nz
rachael.taylor@otago.ac.nz
michelle.jospe@otago.ac.nz

Corresponding author:
Dr Michelle R Jospe
Dept of Medicine, University of Otago, PO Box 56, Dunedin, New Zealand, 9054
Michelle.jospe@otago.ac.nz, +64 21 037 5002

3,940 words

Data sharing: Deidentified participant data underlying published results will be available upon reasonable email request to the corresponding author.

ABSTRACT

Objectives Hunger training is an intervention designed to teach people to eat according to their hunger by connecting physical symptoms of appetite with glucose levels. Hunger training is most effective for weight loss, and improving eating behaviours when adherence is high. However, adherence is a challenge that should be explored prior to wider dissemination. The aim of this study was to explore participants' experience, and self-reported adherence and behaviour change related to hunger training.

Design A qualitative study, nested within a randomised controlled pilot study of two different methods of monitoring glucose during hunger training. Semi-structured interviews were audio-recorded, transcribed verbatim, and analysed thematically using a phenomenological approach.

Setting Single centre study with participants recruited from the local area.

Participants 40 participants began the pilot study and 38 participants (52.6% female) remained at 1 month and completed interviews.

Results Most participants felt they were able to match their hunger to their glucose levels by the end of the intervention. The main adherence barriers were the social pressure to eat, lack of time, and lack of flexibility in participants' meal schedules. Common adherence enablers were having a set routine, social support, and accountability. Participants described increased awareness of hungry versus non-hungry eating and better cognition of feelings of hunger and satiety as a result of the intervention, which in turn led to changes of food choice, portion size, and adjusted meal timing and frequency.

Conclusions Findings show that hunger training is acceptable from a patient perspective, and results can be used to inform the translation of hunger training programs to health care settings.

Trial registration ACTRN12618001257257

Strengths and limitations of study

- In-depth interviews allowed for detailed insight into participants' experiences of hunger training, including adherence barriers and enablers as well as behaviour change.
- Adherence to rigorous qualitative methods and analysis provided confidence in our findings, which are applicable to other lifestyle interventions.
- While our sample was diverse in terms of sex, age, education, and income, the New Zealand "university town" setting, as well as the predominantly European ethnicity of participants may limit extrapolation to other countries and cultures.
- As with all interviews, there was potential for response biases, however we tried to limit this by introducing two independent researchers to conduct the interviews.

INTRODUCTION

Weight management is crucial to prevent chronic diseases, however most weight loss diets prove unsustainable in the long-term.[1 2] A more viable approach may be to teach people to eat according to their appetite signals, which has been shown to benefit weight maintenance. However, they have been inconsistently effective for weight loss.[3-7] This may be because overweight and obesity is linked with difficulty sensing and responding to physiological hunger and satiety cues, decreasing awareness of appetite.[8-10]

To overcome this barrier, an intervention known as hunger training (HT) uses glucose monitoring as an indicator of hunger to help people gain greater awareness of their appetite signals, and eat accordingly.[11 12] A limited body of research has found that HT produces clinically important weight loss, and reduces emotional and external eating,[13-15] however more research into the efficacy of hunger training and the ability of participants to adhere to this novel method is needed.

The combination of the minimal human resources required for the delivery of HT, and the potential of sustainable weight management makes it a promising intervention for primary health care. However, as with most health interventions, adherence is a challenge that must be investigated prior to wider dissemination.[16 17] Previous work has shown that benefits of HT are greater for participants with higher adherence, and that only about one-third of participants sufficiently adhere to experience a clinically beneficial effect.[15] Before HT can be implemented widely, the underlying mechanisms that contribute to the effectiveness of HT and the barriers and enablers to adherence must be determined. We recently undertook a randomised controlled pilot study of two different methods of monitoring glucose during HT, which included the theoretical approach of phenomenology to qualitatively examine personal participant experiences to arrive at a better understanding of how HT affected their behaviour as a whole.[18] The aim of this manuscript was to qualitatively explore, from the participants' perspective, their overall experiences with HT, their personal practice in adhering to HT, and any resulting behaviour change they observed after experiencing HT, in order to inform translation of HT from research to practice, including whether any differences arose as a consequence of the different glucose monitoring methods.

METHODS

Study design and participants

This study was approved by the New Zealand Southern Health and Disability Ethics Committee (18/STH/105) and was registered with the Australian New Zealand Clinical Trials Registry (ACTRN12618001257257). All participants provided written informed consent.

Forty adults were recruited from Aug–Oct 2018 from the local community through social media channels and local advertisement, and were included if they were 18 years of age or

older, had a body mass index (BMI) of 30 kg/m^2 or higher, and were willing to measure their glucose by fingerprick blood sample and wear a continuous glucose monitor. Exclusion criteria were use of medication that affects weight; pregnancy or breastfeeding; allergy to surgical adhesive; skin changes or disease on the upper arm; or imaging appointments scheduled during the study.

Patient and public involvement

No patient or public were involved in the development of the research question, interpretation of the results, or writing of this document. The results will be disseminated to participants via email.

Randomisation and procedures

Participants were randomized to one of two groups using computerized block randomisation with random length blocks after stratification for sex. The "fingerpricking" group measured their capillary glucose from a fingerprick sample by portable glucometer (Abbott Freestyle Optium Glucose Meter, Australia, Figure 1a). The "scanning" group used the Freestyle Libre Flash Glucose Monitoring system (Abbott Diabetes Care, Australia, Figure 1b), which continuously measures interstitial glucose every 15 minutes. A thin water-resistant sensor was inserted just under the skin on the back of the arm, and remained there for 14 days, then replaced. When the participant wanted to test their glucose, they passed a reader over their arm to display current glucose levels. Both HT groups received the same guidance and support.

Hunger training intervention

Participants were instructed to only eat or drink a caloric beverage if their glucose concentration was below their individualised cut-off, which was based on the average of fasting glucose from their first two mornings. If participants' glucose was above their cut-off value, they were instructed to wait at least 20 minutes before retesting.

Alongside glucose monitoring, participants were asked to rate their hunger level (Figure 2), and to note their glucose level and whether they ate, every time they wanted to consume food or caloric drink. Participants attended three HT appointments. At baseline, participants were introduced to HT and taught how to measure their glucose, based on their randomisation. At the day 14 visit, participants could ask questions and discuss challenges and successes, and were provided with a reading on intuitive eating using glucose monitoring.[19] On the last visit (at one month), participants returned their equipment and participated in a semi-structured interview with an independent interviewer (WEdB or ALW) not previously known to the participants.

Data collection

Researchers conducted in-depth interviews with each participant at the last visit. A semi-structured interview guide (see supplementary file) was developed to explore 1)

participants' experiences of HT; 2) perceived behaviour change due to HT; 3) self-reported adherence to the intervention; 4) future expectations; and 5) intervention feedback. All interviews were digitally recorded, and professionally transcribed verbatim. Transcripts were processed anonymously. After reviewing the transcribed interviews, it was clear that saturation had been reached and it was deemed unlikely that new topics would arise.[20 21]

Data analysis

The transcribed interviews were systematically scrutinized to guide coding development, key to employing grounded theory in analysing qualitative work.[22 23] Codes were first piloted and refined using a subset of interviews; each interview was coded for themes by two researchers using NVivo.[24] The thematic analyses took an inductive approach and included familiarisation with the interviews and transcripts, development of codes, coding of transcript, and a convening meeting to dicuss coded content, to collate codes into themes and to reconsolidate any disagreements.[23 25] Researchers conducting analyses (WEdB, ALW and MRJ) were blind to any participant classifications at the time of analyses.

The results section includes the use of qualifiers that have been adapted from previous studies.[26-28] When an issue was discussed by 1 to 9 participants, we referred to a 'few'; for between 10 and 20 participants, we referred to 'some'; for between 21 and 30 participants we referred to 'most'; for between 31 and 37 we referred to 'almost all'; and for 38 we referred to 'all'.

RESULTS

The research team conducted a total of 38 semi-structured interviews with HT participants; two participants dropped out of the study before their interview. Participants ranged in age from 20 to 78 years, had an HbA1c between 28 and 100 mmol/mol, and an individualised glucose cut-off between 4.0 and 14.0 mmol/L (Table 1). Participants lost an average of 4 kg (SD 6.7 kg) at six months, with similar results between scanners and fingerprickers.

Table 1. Baseline characteristics of participants

Variable	All (n=38)
Randomised to scanning, n (%)	19 (50.0)
Female, n (%)	20 (52.6)
Age (years)	45.0 (13.0)
HbA1C (mmol/mol) (median, IQR)	37.0 (34-42)
Glucose cut-off (mmol/L)	6.1 (1.9)
Diabetes status, n (%)	
Non-diabetic	27 (71.1)
Pre-diabetic	8 (21.1)
Type 2 diabetes	3 (7.9)
Body mass index (kg/m^2)	38.3 (7.4)
Education, n (%)	
School only	12 (31.6)
Post-secondary	4 (10.5)
University	22 (57.9)
Ethnicity, n (%)[a]	
New Zealand European	36 (94.7)
Māori	4 (10.5)
Samoan	2 (5.3)
Other	3 (7.9)
Partnered, n (%)	25 (65.8)
Household income (New Zealand Dollar), n (%)	
<50k	14 (36.8)
50-100k	11 (28.9)
100-150k	12 (31.6)
>150k	1 (2.6)
Depression Anxiety Stress Scale (DASS-21)	
Stress	12.2 (8.7)
Depression	9.1 (9.3)
Anxiety	7.7 (5.7)

Values are mean (standard deviation) unless otherwise indicated. [a]Multiple options are possible therefore responses surpass 100%.

Participants' experiences with hunger training

Glucose measuring experience and self-reported adherence

Participants explained that is was useful to have an objective measure of their hunger; *"It was helpful to see an actual concrete measurement of 'Was I actually hungry? Or was I just imagining that kind of thing?' […] it was actually something quite tangible." - #25, scanner.* A few participants commented that HT increased their self-efficacy; *"I was unprepared to feel empowered by taking that modicum of control. So that was really cool. - #63, scanner.*

Almost all participants described situations where they were unable to adhere to the HT protocol, and ate without measuring their glucose levels or ate when their glucose was above their cut-off. Some reasons for not measuring were because they forgot equipment or forgot to measure; were too busy; or were in social situations that made measuring difficult. Reasons for eating above cut-off included social pressure to eat, feeling extremely hungry, a lack of flexibility to eat at different times, illness and eating out of habit.

Most participants discussed the social pressure to eat; *"In a dinner situation where you've got to eat when everyone else is eating. You can't not eat, can't just say 'sorry, I'm checking my glucose'."* - *#72, scanner.* Participants also described the cultural importance of food in their families or social groups as reasons for not adhering.

There was a clear distinction in experiences and adherence barriers between participants randomized to fingerpricking compared to those who were randomized to scanning. Most of those who were ambivalent, and all three participants who were outspokenly negative about their glucose measuring experience, were randomised to fingerpricking. Almost all fingerprickers addressed the pain and inconvenience of testing, such as spilling blood, difficulty in obtaining sufficient blood, having to wash hands before pricking and disposing the lancets safely. A few explained that they were initially hindered by the pain but that they got used to it over time, whereas others thought that pain got worse. A few also explained the pain and inconvenience helped them be mindful; "*That pain and inconvenience did help me, it set the routine because it's like ok to eat I have to do this very inconvenient thing and cause myself a little bit of pain, do I really want to go ahead with that, is that chocolate biscuit really worth that and often the answer was no." - #9, fingerpricker.* Those in the fingerpricking group were more likely to describe social situations in which they did not adhere since measuring their glucose made them feel self-conscious and a few expressed worries about being stigmatized.

Those who used the scanner were generally more positive about their glucose measuring experience. Almost all said scanning was quick, easy, discreet, and convenient, which allowed for frequent checking.

For the remaining themes, no clear differences were apparent between participants randomised to the different methods of gluicose measuring.

Booklet experience and self-reported adherence

A few participants explained the booklet helped them discover a pattern between their hunger and glucose and be more aware of food intake. A few explained how the hunger scale helped them understand hunger and fullness.

A few participants explained they occasionally forgot to complete the booklet, that it was impractical, and that it was "just another thing to carry around". Hence, some participants explained that they only completed the booklet retrospectively. Several participants suggested developing a smartphone app to replace the booklet.

A few felt that the hunger scale should be personalized, or reflect feelings instead of numbers. Participants also talked about additional information that could be included in the booklet, including exercise and dietary recommendations, mindfulness and adherence techniques, and coping strategies for cravings.

Adherence enablers

Some participants stated that daily structure and normal routine helped them comply. Social support and accountability was another adherence enabler for some participants, specifically that provided by family and friends who helped them stick to the routine of checking their glucose and eating appropriately. A few mentioned their doctors expressed interest in the study and were supportive, providing another level of accountability.

Others indicated that adherence became easier; *"I think it got easier as time's gone on because as I was more mindful about eating breakfast and I guess doing preparations for lunch, knowing what's coming and how to fit it in with the [glucose] levels." - #37, scanner.*

Association between glucose and hunger

Most participants were able to determine a clear association between their glucose levels and hunger; *"I noticed that […] when I was feeling really hungry, stomach growling, that my glucose was under four, which was like my threshold. I kind of almost got intuitive about it." – #38, scanner.* Those who were able to detect an association described a learning curve, with the association became clearer over time; *"Yeah, and I had the data in front of me that just said, well logically you're not hungry. You don't feel hungry with that grade of 1 to 10, your glucose says you're not hungry because you've still got obviously some sugars in your system providing energy, and I just thought 'well alright then, I'll have a drink'. And then I just got in the habit of doing it and I found that really helpful." - #39, fingerpricker.*

A few were unable to recognise an association and felt confused. While there was no clear delineation between groups regarding the association between glucose levels and hunger, confusion was slightly more common among fingerprickers. Common reasons for confusion were when glucose levels were high before breakfast, after physical activity, and when they felt very hungry. Some recognised that glucose readings were elevated when they were busy, stressed, or unwell.

Awareness of hunger

The majority of participants reported that they became better at recognising hunger. This made HT different from other weight management strategies they had previously attempted; *"I've tried listening to people, I've tried following routines, I've tried all that sort of thing and I occasionally lose [a few] kilos and then I go straight back to square one because I don't know how to... read my body. I didn't know what it felt like to be hungry. I didn't know that the way I felt was actually what it feels like to be full. So, I was keeping myself constantly full." - #42, scanner.* The HT scale opened their eyes to the fact there was a continuum of hunger sensations

Some struggled to identify with the provided descriptors of each of the hunger levels on the hunger scale. A few overcame this by personalising their scale and/or using half points. However, others referred to initially being unfamiliar with some cues but then experiencing them for the first time during the study; *"I've been married 11 years and my wife*

heard my stomach rumble and she was like 'I've never heard that before!'" – #64, fingerpricker. Only a few participants felt that HT did not improve their ability to recognise real hunger.

Awareness of non-hungry eating

Almost all participants reported they learned to tell the difference between hungry and non-hungry eating; *"It was interesting to start to find out whether there was an actual need for food from the blood glucose reading versus whether it was a mind thing. I was actually quite quick to adjust to it and it gave a good chance to understand the feelings of hunger that you get, whether it might be physical or psychological, or just the environment you're in." – #37, scanner.* Some were surprised to discover that they regularly ate when they were not hungry; *"I didn't think that I would be susceptible, like at the start of the study they talked about eating when you're bored, or eating when you're emotional and I totally expected to be above all of that petty human [stuff] because I'm intelligent. It was really eye opening, especially in the first two weeks of the study, just how programmed or routine a lot of my eating is." - #63, scanner.*

Once aware of their non-hungry eating, participants generally avoided it; *"If I have anything now, even if blood glucose is fine, that's going to affect my ability to have something, a meal later on when I'm really hungry and I then my blood glucose would be more than likely too high to allow me to eat when I wanted to later on" - #9, fingerpricker.*

The most popular reason for non-hungry eating was boredom; *"I'd say I was a bored eater. Like I'd be at home, what do I want to do? Uh, I don't really know, I'm just walking around the kitchen, just open up the pantry for no reason, and […], I'm here, so I'll grab something." - #79, fingerpricker.* A few turned to food when stressed or upset. Some believed that if they didn't eat regularly, their body would go into "starvation mode"; *"Well, often people tell you if you ate too little that you will put your body into starvation mode and then it will hold onto the fat." - #42, scanner.*

In terms of physical symptoms, some realised that they had confused hunger and thirst. Others realised they ate when tired, in order to give them energy. For a few, non-hungry cravings reduced once they stopped responding to them.

A few mentioned they ate when they were not hungry because of their environment; *"I walked down past the café this morning, I went, 'Ah, food'. It was really good to go to my brain, 'No, you're not hungry, this is just your body pretending'." – #62, scanner.* A lot mentioned they used to eat out of habit or routine, related to time of day; *"Eat when I'm hungry, rather than eat because it's 12 o'clock." - #22, fingerpricker*, or activity; *"Have chips and dip and watch the rugby" – #69, scanner.*

Participants developed strategies when faced with triggers. The most common coping mechanism to avoid non-hungry eating was to drink water or another sugar-free beverage. Some diverted themselves with chores, a walk, or other activities. Participants dealt with social eating by planning ahead; *"There's another gathering this Saturday, so if I'm going to go and don't feel like I'm really hungry to eat, I can take the food and do a takeaway and*

say, 'oh I'll take this and I'll have it later'." – #76, scanner. One participant used strategies she used when quitting smoking; *"I'd implement the breathing like you would have [when] you were having a cigarette. I would talk to someone or talk to myself if no one was around, 'you know what this is you know that this is a craving, you just have to ride through it.'" – #42, scanner.*

Awareness of fullness

A couple of participants randomised to the scanner connected their physical sensations with their glucose; *"I could scan myself within half an hour of a heavy meal and be able to go see 'you're full, look what that's done' and show myself that actually this is what your body needs versus what it wants." - #42, scanner*. Participants also used the hunger scale to identify their satiety, however, they expressed they were less confident about recognising fullness.

Some participants became aware of feeling uncomfortable from overeating, especially after their evening meal. A couple of participants noticed their sleep improved after reducing overeating.

Behaviour change

The main self-reported behaviour changes were changing their portions, food choices, and timing and frequency of meals (Table 2).

Table 2. Behaviour changes due to hunger training

Theme description	Representative quotes
Portion size reduction	
Most participants reduced the amount of food they ate at a given meal	*"This could show me in a physical way that you're not actually starving yourself eating this small amount. I learned really quickly that actually if I get a six-inch subway sandwich, I'm just as full and satisfied for just as long a time period as I am if I have [the amount] that I'd normally get."- #42 scanner*
Some specifically reduced their portions of unhealthy foods, or foods that spiked their glucose	*"Instead of buying a decent size cake of chocolate I bought the little bars and that was because I had in my mind the spike that would then come and associated the spike with what then is happening in your body." - #25, scanner* *"I'd actually stop and think before I ate. So in the past I would have my cup of tea and just automatically reach for the biscuit tin. And maybe have two or three, instead of stopping at one. It's like 'I only need that one, I'm fine now'. So definitely changed, my behaviors there. Even just being aware of when I was eating, of having that sensation of fullness, instead of just carrying on eating." - #57, fingerpricker*
Others reduced their intake in order to be able to eat when desired	*"I've noticed that if I'm having less at lunch […] then I'm able to eat my dinner at dinner time versus having a huge lunch and then my blood sugar is still so high that I couldn't have dinner." – #38, scanner.*
A few participants noticed their evening meal influenced morning glucose levels, often modifying their evening meal to eat breakfast at a convenient time	*"We had a friend round and I had a dessert. I had to wait 20 minutes or longer in the morning. But I don't have 20 minutes in the morning. So, I was like, 'okay, let's not do that'." - #79, fingerpricker.*
Food choice	
Participants from both groups found particular foods delayed their next subsequent meals due to being over their glucose cut-offs, and those wearing the scanner reported seeing a spike in glucose levels after consuming certain foods (or "spikey" foods). People also noticed which foods kept them satisfied for longer, which they viewed as positive.	*"It made me acutely aware of what foods lasted me longer before the start growl [stomach growl] level was achieved." - #50, scanner.*
Reduced intake of "sugary foods" and "sweet stuff", bread, chips, biscuits, chocolate, cakes, takeaways and fast food, sugar-sweetened beverages (SSBs), and alcohol.	*"It was more around the drinking because I take a lot of convincing that things [are] right loaded with sugar and if I can't see it, I'm probably not going to believe a word you say. So, it was good to see it […] After [I drank] I pricked my finger and saw it did shoot up, I would think a bit and have a look at what I was drinking and what was in it." – #40, fingerpricker.*
Increased intake of vegetables, salads, homemade meals, nuts, eggs, water, and coffee.	*"Especially on a day off if I go up into the hills. I tend to bring things like muesli bars and just keep snacking all day, whereas now I'm not doing that. I'm waiting 'til I'm hungry and have a proper sit down. I'm drinking a lot more water, as well." - #20, fingerpricker*
Increased planning of meals	*"Actually I probably have thought about planning my day out meal wise a little bit more 'cause I'd just grab whatever and just eat till I was full or you know, it used to be I'd come home from work and grab a snack and have dinner some time after that and yeah, I don't snack anymore." - #9, fingerpricker*
Timing and frequency of meals	
Most reduced their number of eating occasions by eliminating snacking. The majority of this group changed their habit of grazing to eating a fixed number of meals a day, because they realised that they were not hungry, did not want to delay their next meal, and/or to avoid fingerpricking. Most chose to have a sugar-free beverage	*I would amalgamate [a snack] into a meal. So, this last weekend we were away so you know, we'd have a handful of chips, one or two crackers, some bits and pieces […], and then you go, okay well I've had it. Now the old me, prior to this [study], would be having it a bit later on when the blood sugar would still be high and two, I'd probably be having the entire pack – #64, fingerpricker.*

instead of food; a few combined their snack food with their main meal.	
For most, monitoring their glucose confirmed their normal morning food pattern. However, some had glucose levels that were too high to eat breakfast at their usual time. For these participants, elevated morning glucose was frustrating. Some ate later, and others ignored their glucose and ate anyway.	*"Because based on my monitoring, I'm pretty good, and I don't need to have breakfast, which was a relief, because I'm not a fan of breakfast to begin with." - #62, scanner*

Note: Themes listed in order of frequency

Future expectations

Almost all participants expressed they were motivated and hopeful about continuing with their recent behaviour changes; *"It seems an easy way to do it, 'cause it's not a diet. It's just eating sensibly and just waiting 'til your body's ready to eat. Rather than just eating for the sake of eating." - #20, fingerpricker.* A few explained they would have liked to measure their glucose for longer to gain confidence about their hunger levels and some (mostly those who scanned) expressed concern about being without their equipment. This feeling of concern generally revolved around the fact that they would be without immediate feedback. On the contrary, other participants were happy and confident to leave their equipment behind. A few participants reflected that following HT without equipment would be the next step.

DISCUSSION

Our use of pheonomenology to explore the experience of participants using HT provided rich descriptions that aided our understanding of the daily lived experiences of those monitoring their glucose on a regular basis. Most participants had a positive experience of HT, and were able to match their hunger to their glucose levels by the end of the study, which is consistent with other findings[29] and our previous results.[14] While the majority found an association between hunger and glucose, some experienced confusion, which is likely related to the homeostatic control of glucose.[12]

The main adherence barriers of social pressure to eat, lack of time, and lack of flexibility in meal schedule, and the main enablers of routine, social support, and accountability, are consistent with those of a systematic review of determinants of adherence to lifestyle interventions in adults with obesity.[16] Participants realised that they were previously unaware of feelings of appetite, supporting the theory that some with overweight/obesity have blunted sensations of hunger and satiety.[8-10] Participants primarily changed their behaviour by becoming aware of hungry versus non-hungry eating, recognising feelings of hunger and satiety, reducing their number of meals, and exploring the effect of different types of foods on their glucose. This is in line with a review of mindful and intuitive eating interventions wherein participants became more aware of and reduced non-hungry eating.[30] Although historically HT enhances recognition of hunger rather than satiety,[29] our results indicate our participants felt they learned to recognize feelings of fullness. Whether this translated to long-term behaviour change is unknown.

Participants randomised to use the scanners generally described fewer negative experiences and less adherence barriers, and were more inclined to try different foods to see the effects on their glucose, due to the ease of scanning. However, those randomised to fingerpricking may have become more mindful of their hunger, since they carefully considered their hunger before submitting to the effort and discomfort of fingerpricking. Fingerprickers were more confident returning their glucose measuring equipment, perhaps due to their established awareness of hunger. As suggested by our participants, a mobile app instead of a paper booklet, and including nutrition and exercise recommendations, and strategies to cope with emotional and social eating may increase adherence, and this agrees with current recommendations.[31] Social support and involving family and friends may improve adherence and benefits, as demonstrated elsewhere.[32-34]

Our analysis was robust; the researchers were blinded for participant characteristics, all transcripts were double-coded, and the results were analysed and interpreted by three researchers. As with all interviews there is potential for response bias, with a chance of study participants providing socially desirable answers to appease researchers.[35] We tried to reduce this by introducing an independent researcher for the interviews. Our study also has some limitations, principally related to the limited diversity obtained in our sample. Our participants were highly educated as recruitment occurred in a university town, and a smaller proportion of participants were diabetic than was anticipated.[36] Anecdotal feedback indicated that diabetic patients were unwilling to be involved in research that might require additional blood glucose testing than was already required by their condition. It is possible that participants reported on HT experiences that were intertwined with their own past struggles with other weight loss programs. Thus it is impossible to know if participants' self-reported experiences here are a result solely of the HT protocol, or exposure to weight management strategies in general. This would be a relevant topic for further research.

Our interviews allowed insight into how participants undergoing HT felt it influenced their eating behaviour, and suggestions for how to better support participants in establishing healthy eating routines, both of which can be used to inform future HT programs and other healthy eating interventions in both primary care and public health settings.

DECLARATIONS

Author Contributions: Conceptualization, W.E.dB., A.L.W., R.W.T. and M.R.J; Methodology, W.E.dB., A.L.W. and M.R.J; Formal Analysis, W.E.dB., A.L.W. and M.R.J; Resources, M.R.J; Data Curation, W.E.dB., A.L.W. and M.R.J; Writing-Original Draft Preparation, W.E.dB and M.R.J; Writing-Review & Editing, W.E.dB., A.L.W., R.W.T. and M.R.J; Visualization, M.R.J; Project Administration, W.E.dB. and M.R.J; Funding Acquisition, R.W.T. and M.R.J.

Funding: This research was supported by a University of Otago Research Grant.

Acknowledgments: We would like to thank all participants involved in the hunger training pilot study (ACTRN12618001257257). Thank you to Associate Professor Ben Wheeler and Dr Sara Boucher for sharing their expertise with the Freestyle Libre Flash Glucose Monitoring system.

Conflicts of Interest: The authors declare no conflict of interest.

List of Abbreviations: BMI: Body Mass Index, DASS-21: Depression Anxiety Stress Scale, HbA1c: Hemoglobine A1c, HT: Hunger Training, IQR: Inter-Quartile Range, SSBs: Sugar-Sweetened Beverages.

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FIGURE CAPTIONS

Figure 1. Glucose measuring equipment, (a) the Freestyle Optium Glucose Meter (Abbott Freestyle Optium Glucose Meter, Australia), test strip and lancet used by the "fingerpricking" group; (b) the Freestyle Libre Flash Glucose Monitoring system (Abbott Diabetes Care, Australia), worn by the "scanner" group.

Figure 2. A page spread from the hunger training booklet

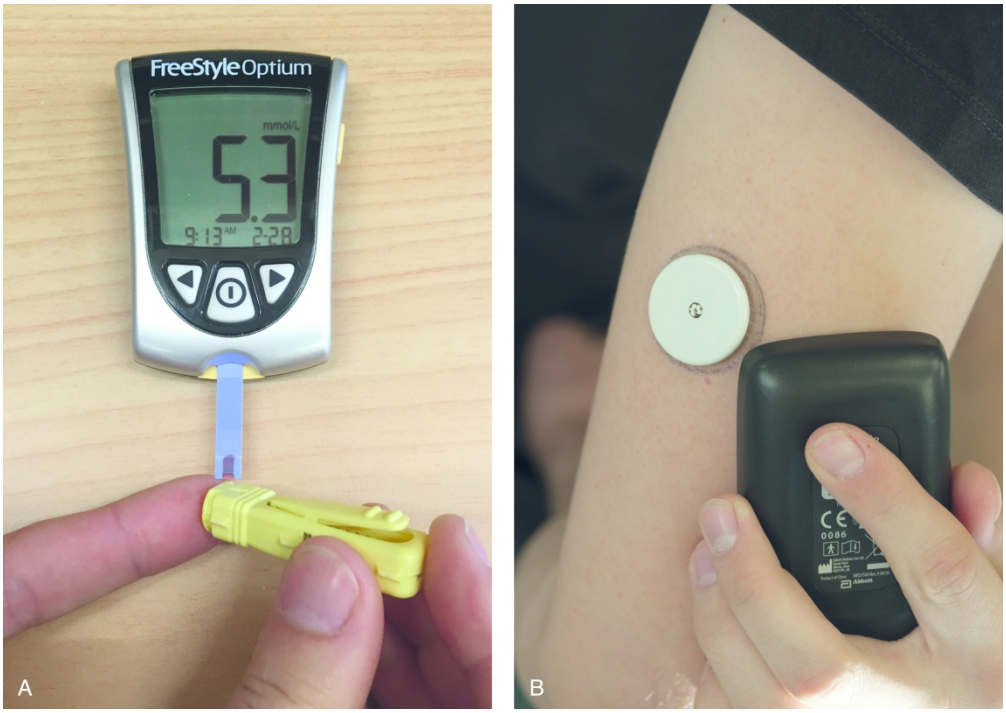

Figure 1. Glucose measuring equipment, (a) the Freestyle Optium Glucose Meter (Abbott Freestyle Optium Glucose Meter, Australia), test strip and lancet used by the "fingerpricking" group; (b) the Freestyle Libre Flash Glucose Monitoring system (Abbott Diabetes Care, Australia), worn by the "scanner" group. Photo by Thirunavukkarasye-Raveendran [CC BY 4.0 (https://creativecommons.org/licenses/by/4.0)]

189x133mm (300 x 300 DPI)

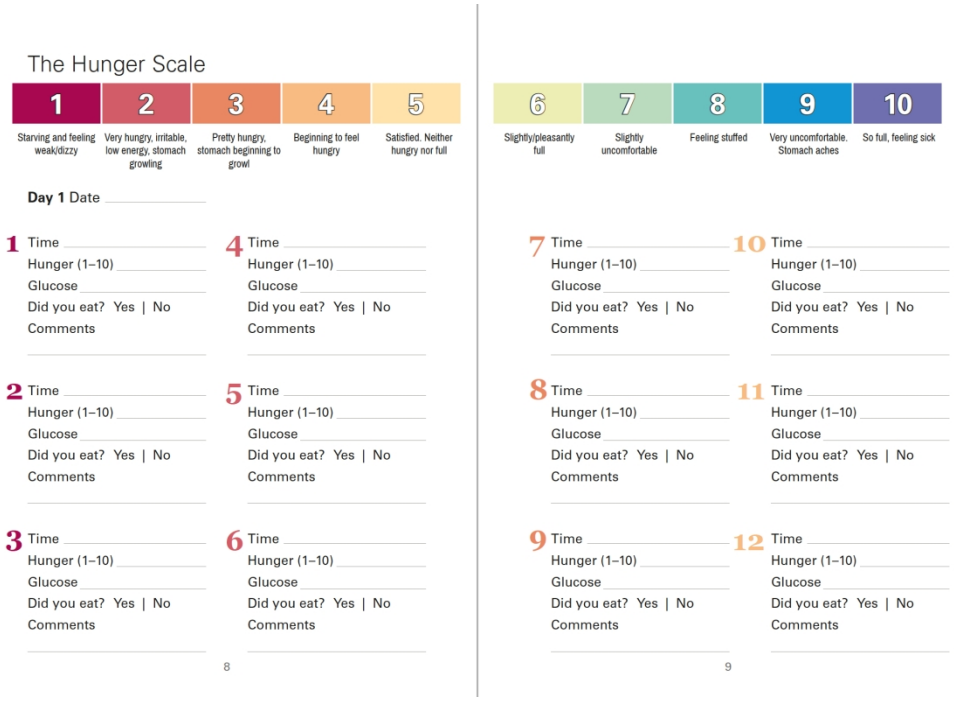

Figure 2. A page spread from the hunger training booklet

SUPPLEMENTARY FILE

Semi-structured interview guide

1. What was it like to measure your **glucose** over the past month?
    a. Could you tell me something about what you **liked** about measuring your glucose?
    b. Could you tell me something about what you **disliked** about measuring your glucose?
2. What was it like to **fill in the booklet** over the past month?
    a. Can you tell something about what you **liked** about filling in the booklet?
    b. Can you tell something about what you **disliked** about filling in the booklet?
3. Did you see a pattern between your hunger and glucose?
    a. If no, how much of a problem was this?
    b. If yes, could you tell a bit more about what you learned?
4. Can you please let me know whether you have **experienced any changes in your behavior** in the past month?
    a. Do you think this changed because of hunger training?
    b. You told me something about …. , were there any other changes because of hunger training?
        i. Possible topics for discussion: routine, number of eating occasions (e.g. number of meals), avoidance of eating due to pain, food choice, awareness of hunger/recognizing when body needs food, previous non-hungry eating (e.g. eating because of routine, emotions, environment), awareness of fullness/satiety (e.g. doesn't have to eat as much as previously thought), awareness of social pressure to eat, physical activity or coping mechanisms (e.g. ways to distract yourself when "hungry" but not allowed to eat).
5. We asked you to measure your glucose every time you felt like eating, and to only eat if your glucose was under your cut-off. How did this work out for you?
    a. We can imagine this was not always easy, can you tell me why it was sometimes **difficult**?
        i. Can you please tell me about situations that you **didn't measure** your glucose before eating (if any)?
        ii. Can you please tell me about situations that your **glucose was too high to eat**, but you ate anyways (if any)?
    b. Some days it may have **been easier** to follow our instructions than others, can you tell me why?

6. Now that you're finished the first month of hunger training, you are no longer going to measure glucose to help you figure out when to eat. You'll continue to fill in the booklet, but only for one week every month. What do you **expect** to happen over the next 5 months?
    a. Do you feel like you have trained yourself to recognize when you are hungry?
    b. Do yourself to know when to eat without being able to measure your glucose?
7. Do you have any suggestions for us on how we can **improve** hunger training?
    a. Length of time of measuring glucose,
    b. Communication (e.g. appointments, reminders)
    c. Equipment
    d. Booklet/instructions

Standards for Reporting Qualitative Research (SRQR)*

http://www.equator-network.org/reporting-guidelines/srqr/

	Page/line no(s).
Title and abstract	
Title - Concise description of the nature and topic of the study Identifying the study as qualitative or indicating the approach (e.g., ethnography, grounded theory) or data collection methods (e.g., interview, focus group) is recommended	1
Abstract - Summary of key elements of the study using the abstract format of the intended publication; typically includes background, purpose, methods, results, and conclusions	2
Introduction	
Problem formulation - Description and significance of the problem/phenomenon studied; review of relevant theory and empirical work; problem statement	3
Purpose or research question - Purpose of the study and specific objectives or questions	3
Methods	
Qualitative approach and research paradigm - Qualitative approach (e.g., ethnography, grounded theory, case study, phenomenology, narrative research) and guiding theory if appropriate; identifying the research paradigm (e.g., postpositivist, constructivist/ interpretivist) is also recommended; rationale**	4-5
Researcher characteristics and reflexivity - Researchers' characteristics that may influence the research, including personal attributes, qualifications/experience, relationship with participants, assumptions, and/or presuppositions; potential or actual interaction between researchers' characteristics and the research questions, approach, methods, results, and/or transferability	4
Context - Setting/site and salient contextual factors; rationale**	4
Sampling strategy - How and why research participants, documents, or events were selected; criteria for deciding when no further sampling was necessary (e.g., sampling saturation); rationale**	4
Ethical issues pertaining to human subjects - Documentation of approval by an appropriate ethics review board and participant consent, or explanation for lack thereof; other confidentiality and data security issues	3
Data collection methods - Types of data collected; details of data collection procedures including (as appropriate) start and stop dates of data collection and analysis, iterative process, triangulation of sources/methods, and modification of procedures in response to evolving study findings; rationale**	4

Data collection instruments and technologies - Description of instruments (e.g., interview guides, questionnaires) and devices (e.g., audio recorders) used for data collection; if/how the instrument(s) changed over the course of the study	4
Units of study - Number and relevant characteristics of participants, documents, or events included in the study; level of participation (could be reported in results)	5
Data processing - Methods for processing data prior to and during analysis, including transcription, data entry, data management and security, verification of data integrity, data coding, and anonymization/de-identification of excerpts	4
Data analysis - Process by which inferences, themes, etc., were identified and developed, including the researchers involved in data analysis; usually references a specific paradigm or approach; rationale**	4-5
Techniques to enhance trustworthiness - Techniques to enhance trustworthiness and credibility of data analysis (e.g., member checking, audit trail, triangulation); rationale**	4

Results/findings

Synthesis and interpretation - Main findings (e.g., interpretations, inferences, and themes); might include development of a theory or model, or integration with prior research or theory	5-10
Links to empirical data - Evidence (e.g., quotes, field notes, text excerpts, photographs) to substantiate analytic findings	5-10

Discussion

Integration with prior work, implications, transferability, and contribution(s) to the field - Short summary of main findings; explanation of how findings and conclusions connect to, support, elaborate on, or challenge conclusions of earlier scholarship; discussion of scope of application/generalizability; identification of unique contribution(s) to scholarship in a discipline or field	10-11
Limitations - Trustworthiness and limitations of findings	11

Other

Conflicts of interest - Potential sources of influence or perceived influence on study conduct and conclusions; how these were managed	12
Funding - Sources of funding and other support; role of funders in data collection, interpretation, and reporting	12

*The authors created the SRQR by searching the literature to identify guidelines, reporting standards, and critical appraisal criteria for qualitative research; reviewing the reference lists of retrieved sources; and contacting experts to gain feedback. The SRQR aims to improve the transparency of all aspects of qualitative research by providing clear standards for reporting qualitative research.

**The rationale should briefly discuss the justification for choosing that theory, approach, method, or technique rather than other options available, the assumptions and limitations implicit in those choices, and how those choices influence study conclusions and transferability. As appropriate, the rationale for several items might be discussed together.

Reference:

O'Brien BC, Harris IB, Beckman TJ, Reed DA, Cook DA. **Standards for reporting qualitative research: a synthesis of recommendations.** *Academic Medicine*, Vol. 89, No. 9 / Sept 2014
DOI: 10.1097/ACM.0000000000000388

BMJ Open

"Am I really hungry?" A qualitative exploration of patients' experience, adherence, and behaviour change during Hunger Training: A pilot study

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2019-032248.R2
Article Type:	Original research
Date Submitted by the Author:	24-Nov-2019
Complete List of Authors:	de Bruin, Willemijn ; University of Otago, Medicine Ward, Aimee; University of Otago, Medicine Taylor, Rachael; University of Otago, Medicine Jospe, Michelle; University of Otago, Medicine
Primary Subject Heading:	Nutrition and metabolism
Secondary Subject Heading:	Public health, Qualitative research
Keywords:	NUTRITION & DIETETICS, PUBLIC HEALTH, QUALITATIVE RESEARCH, OBESITY, TRANSLATIONAL RESEARCH, ADHERENCE

"Am I really hungry?" A qualitative exploration of patients' experience, adherence, and behaviour change during Hunger Training: A pilot study

Authors:
Willemijn E. de Bruin[a], Aimee L. Ward[a], Rachael W. Taylor[a] and Michelle R. Jospe[a]

Author affiliation:
[a]Dept of Medicine, University of Otago, PO Box 56, Dunedin, New Zealand, 9054
w.debruin@otago.ac.nz
aimee.ward@otago.ac.nz
rachael.taylor@otago.ac.nz
michelle.jospe@otago.ac.nz

Corresponding author:
Dr Michelle R Jospe
Dept of Medicine, University of Otago, PO Box 56, Dunedin, New Zealand, 9054
Michelle.jospe@otago.ac.nz, +64 21 037 5002

3,940 words

Data sharing: Deidentified participant data underlying published results will be available upon reasonable email request to the corresponding author.

ABSTRACT

Objectives Hunger training is an intervention designed to teach people to eat according to their hunger by connecting physical symptoms of appetite with glucose levels. Hunger training is most effective for weight loss, and improving eating behaviours when adherence is high. However, adherence is a challenge that should be explored prior to wider dissemination. The aim of this study was to explore participants' experience, and self-reported adherence and behaviour change related to hunger training.

Design A qualitative study, nested within a randomised controlled pilot study of two different methods of monitoring glucose during hunger training. Semi-structured interviews were audio-recorded, transcribed verbatim, and analysed thematically using a phenomenological approach.

Setting Single centre study with participants recruited from the local area.

Participants 40 participants began the pilot study and 38 participants (52.6% female) remained at 1 month and completed interviews.

Results Most participants felt they were able to match their hunger to their glucose levels by the end of the intervention. The main adherence barriers were the social pressure to eat, lack of time, and lack of flexibility in participants' meal schedules. Common adherence enablers were having a set routine, social support, and accountability. Participants described increased awareness of hungry versus non-hungry eating and better cognition of feelings of hunger and satiety as a result of the intervention, which in turn led to changes of food choice, portion size, and adjusted meal timing and frequency.

Conclusions Findings show that hunger training is acceptable from a patient perspective, and results can be used to inform the translation of hunger training programs to health care settings.

Trial registration ACTRN12618001257257

Strengths and limitations of study

- In-depth interviews allowed for detailed insight into participants' experiences of hunger training, including adherence barriers and enablers as well as behaviour change.
- Adherence to rigorous qualitative methods and analysis provided confidence in our findings, which are applicable to other lifestyle interventions.
- While our sample was diverse in terms of sex, age, education, and income, the New Zealand "university town" setting, as well as the predominantly European ethnicity of participants may limit extrapolation to other countries and cultures.
- As with all interviews, there was potential for response biases, however we tried to limit this by introducing two independent researchers to conduct the interviews.

INTRODUCTION

Weight management is crucial to prevent chronic diseases, however most weight loss diets prove unsustainable in the long-term.[1 2] A more viable approach may be to teach people to eat according to their appetite signals, which has been shown to benefit weight maintenance. However, they have been inconsistently effective for weight loss.[3-7] This may be because overweight and obesity is linked with difficulty sensing and responding to physiological hunger and satiety cues, decreasing awareness of appetite.[8-10]

To overcome this barrier, an intervention known as hunger training (HT) uses glucose monitoring as an indicator of hunger to help people gain greater awareness of their appetite signals, and eat accordingly.[11 12] A limited body of research has found that HT produces clinically important weight loss, and reduces emotional and external eating,[13-15] however more research into the efficacy of hunger training and the ability of participants to adhere to this novel method is needed.

The combination of the minimal human resources required for the delivery of HT, and the potential of sustainable weight management makes it a promising intervention for primary health care. However, as with most health interventions, adherence is a challenge that must be investigated prior to wider dissemination.[16 17] Previous work has shown that benefits of HT are greater for participants with higher adherence, and that only about one-third of participants sufficiently adhere to experience a clinically beneficial effect.[15] Before HT can be implemented widely, the underlying mechanisms that contribute to the effectiveness of HT and the barriers and enablers to adherence must be determined. We recently undertook a randomised controlled pilot study of two different methods of monitoring glucose during HT, which included the theoretical approach of phenomenology to qualitatively examine personal participant experiences to arrive at a better understanding of how HT affected their behaviour as a whole.[18] The aim of this manuscript was to qualitatively explore, from the participants' perspective, their overall experiences with HT, their personal practice in adhering to HT, and any resulting behaviour change they observed after experiencing HT, in order to inform translation of HT from research to practice, including whether any differences arose as a consequence of the different glucose monitoring methods.

METHODS

Study design and participants

This study was approved by the New Zealand Southern Health and Disability Ethics Committee (18/STH/105) and was registered with the Australian New Zealand Clinical Trials Registry (ACTRN12618001257257). All participants provided written informed consent.

Forty adults were recruited from Aug–Oct 2018 from the local community through social media channels and local advertisement, and were included if they were 18 years of age or

older, had a body mass index (BMI) of 30 kg/m^2 or higher, and were willing to measure their glucose by fingerprick blood sample and wear a continuous glucose monitor. Exclusion criteria were use of medication that affects weight; pregnancy or breastfeeding; allergy to surgical adhesive; skin changes or disease on the upper arm; or imaging appointments scheduled during the study.

Patient and public involvement

No patient or public were involved in the development of the research question, interpretation of the results, or writing of this document. The results will be disseminated to participants via email.

Randomisation and procedures

Participants were randomized to one of two groups using computerized block randomisation with random length blocks after stratification for sex. The "fingerpricking" group measured their capillary glucose from a fingerprick sample by portable glucometer (Abbott Freestyle Optium Glucose Meter, Australia, Figure 1a). The "scanning" group used the Freestyle Libre Flash Glucose Monitoring system (Abbott Diabetes Care, Australia, Figure 1b), which continuously measures interstitial glucose every 15 minutes. A thin water-resistant sensor was inserted just under the skin on the back of the arm, and remained there for 14 days, then replaced. When the participant wanted to test their glucose, they passed a reader over their arm to display current glucose levels. Both HT groups received the same guidance and support.

Hunger training intervention

Participants were instructed to only eat or drink a caloric beverage if their glucose concentration was below their individualised cut-off, which was based on the average of fasting glucose from their first two mornings. If participants' glucose was above their cut-off value, they were instructed to wait at least 20 minutes before retesting.

Alongside glucose monitoring, participants were asked to rate their hunger level (Figure 2), and to note their glucose level and whether they ate, every time they wanted to consume food or caloric drink. Participants attended three HT appointments. At baseline, participants were introduced to HT and taught how to measure their glucose, based on their randomisation. At the day 14 visit, participants could ask questions and discuss challenges and successes, and were provided with a reading on intuitive eating using glucose monitoring.[19] On the last visit (at one month), participants returned their equipment and participated in a semi-structured interview with an independent interviewer (WEdB or ALW) not previously known to the participants.

Data collection

Researchers conducted in-depth interviews with each participant at the last visit. A semi-structured interview guide (see supplementary file) was developed to explore 1)

participants' experiences of HT; 2) perceived behaviour change due to HT; 3) self-reported adherence to the intervention; 4) future expectations; and 5) intervention feedback. All interviews were digitally recorded, and professionally transcribed verbatim. Transcripts were processed anonymously. After reviewing the transcribed interviews, it was clear that saturation had been reached and it was deemed unlikely that new topics would arise.[20 21]

Data analysis

The transcribed interviews were systematically scrutinized to guide coding development, key to employing grounded theory in analysing qualitative work.[22 23] Codes were first piloted and refined using a subset of interviews; each interview was coded for themes by two researchers using NVivo.[24] The thematic analyses took an inductive approach and included familiarisation with the interviews and transcripts, development of codes, coding of transcript, and a convening meeting to dicuss coded content, to collate codes into themes and to reconsolidate any disagreements.[23 25] Researchers conducting analyses (WEdB, ALW and MRJ) were blind to any participant classifications at the time of analyses.

The results section includes the use of qualifiers that have been adapted from previous studies.[26-28] When an issue was discussed by 1 to 9 participants, we referred to a 'few'; for between 10 and 20 participants, we referred to 'some'; for between 21 and 30 participants we referred to 'most'; for between 31 and 37 we referred to 'almost all'; and for 38 we referred to 'all'.

RESULTS

The research team conducted a total of 38 semi-structured interviews with HT participants; two participants dropped out of the study before their interview. Participants ranged in age from 20 to 78 years, had an HbA1c between 28 and 100 mmol/mol, and an individualised glucose cut-off between 4.0 and 14.0 mmol/L (Table 1). Participants lost an average of 4 kg (SD 6.7 kg) at six months, with similar results between scanners and fingerprickers.

Table 1. Baseline characteristics of participants

Variable	All (n=38)
Randomised to scanning, n (%)	19 (50.0)
Female, n (%)	20 (52.6)
Age (years)	45.0 (13.0)
HbA1C (mmol/mol) (median, IQR)	37.0 (34-42)
Glucose cut-off (mmol/L)	6.1 (1.9)
Diabetes status, n (%)	
Non-diabetic	27 (71.1)
Pre-diabetic	8 (21.1)
Type 2 diabetes	3 (7.9)
Body mass index (kg/m^2)	38.3 (7.4)
Education, n (%)	
School only	12 (31.6)
Post-secondary	4 (10.5)
University	22 (57.9)
Ethnicity, n (%)[a]	
New Zealand European	36 (94.7)
Māori	4 (10.5)
Samoan	2 (5.3)
Other	3 (7.9)
Partnered, n (%)	25 (65.8)
Household income (New Zealand Dollar), n (%)	
<50k	14 (36.8)
50-100k	11 (28.9)
100-150k	12 (31.6)
>150k	1 (2.6)
Depression Anxiety Stress Scale (DASS-21)	
Stress	12.2 (8.7)
Depression	9.1 (9.3)
Anxiety	7.7 (5.7)

Values are mean (standard deviation) unless otherwise indicated. [a]Multiple options are possible therefore responses surpass 100%.

Participants' experiences with hunger training

Glucose measuring experience and self-reported adherence

Participants explained that is was useful to have an objective measure of their hunger; *"It was helpful to see an actual concrete measurement of 'Was I actually hungry? Or was I just imagining that kind of thing?' […] it was actually something quite tangible." - #25, female, scanner.* A few participants commented that HT increased their self-efficacy; *"I was unprepared to feel empowered by taking that modicum of control. So that was really cool. - #63, male, scanner.*

Almost all participants described situations where they were unable to adhere to the HT protocol, and ate without measuring their glucose levels or ate when their glucose was above their cut-off. Some reasons for not measuring were because they forgot equipment or forgot to measure; were too busy; or were in social situations that made measuring difficult. Reasons for eating above cut-off included social pressure to eat, feeling extremely hungry, a lack of flexibility to eat at different times, illness and eating out of habit.

Most participants discussed the social pressure to eat; *"In a dinner situation where you've got to eat when everyone else is eating. You can't not eat, can't just say 'sorry, I'm checking my glucose'."* - *#72, male, scanner.* Participants also described the cultural importance of food in their families or social groups as reasons for not adhering.

There was a clear distinction in experiences and adherence barriers between participants randomized to fingerpricking compared to those who were randomized to scanning. Most of those who were ambivalent, and all three participants who were outspokenly negative about their glucose measuring experience, were randomised to fingerpricking. Almost all fingerprickers addressed the pain and inconvenience of testing, such as spilling blood, difficulty in obtaining sufficient blood, having to wash hands before pricking and disposing the lancets safely. A few explained that they were initially hindered by the pain but that they got used to it over time, whereas others thought that pain got worse. A few also explained the pain and inconvenience helped them be mindful; "*That pain and inconvenience did help me, it set the routine because it's like ok to eat I have to do this very inconvenient thing and cause myself a little bit of pain, do I really want to go ahead with that, is that chocolate biscuit really worth that and often the answer was no." - #9, female, fingerpricker.* Those in the fingerpricking group were more likely to describe social situations in which they did not adhere since measuring their glucose made them feel self-conscious and a few expressed worries about being stigmatized.

Those who used the scanner were generally more positive about their glucose measuring experience. Almost all said scanning was quick, easy, discreet, and convenient, which allowed for frequent checking.

For the remaining themes, no clear differences were apparent between participants randomised to the different methods of gluicose measuring.

Booklet experience and self-reported adherence

A few participants explained the booklet helped them discover a pattern between their hunger and glucose and be more aware of food intake. A few explained how the hunger scale helped them understand hunger and fullness.

A few participants explained they occasionally forgot to complete the booklet, that it was impractical, and that it was "just another thing to carry around". Hence, some participants explained that they only completed the booklet retrospectively. Several participants suggested developing a smartphone app to replace the booklet.

A few felt that the hunger scale should be personalized, or reflect feelings instead of numbers. Participants also talked about additional information that could be included in the booklet, including exercise and dietary recommendations, mindfulness and adherence techniques, and coping strategies for cravings.

Adherence enablers

Some participants stated that daily structure and normal routine helped them comply. Social support and accountability was another adherence enabler for some participants, specifically that provided by family and friends who helped them stick to the routine of checking their glucose and eating appropriately. A few mentioned their doctors expressed interest in the study and were supportive, providing another level of accountability.

Others indicated that adherence became easier; *"I think it got easier as time's gone on because as I was more mindful about eating breakfast and I guess doing preparations for lunch, knowing what's coming and how to fit it in with the [glucose] levels." - #37, male, scanner.*

Association between glucose and hunger

Most participants were able to determine a clear association between their glucose levels and hunger; *"I noticed that […] when I was feeling really hungry, stomach growling, that my glucose was under four, which was like my threshold. I kind of almost got intuitive about it." – #38, female, scanner.* Those who were able to detect an association described a learning curve, with the association became clearer over time; *"Yeah, and I had the data in front of me that just said, well logically you're not hungry. You don't feel hungry with that grade of 1 to 10, your glucose says you're not hungry because you've still got obviously some sugars in your system providing energy, and I just thought 'well alright then, I'll have a drink'. And then I just got in the habit of doing it and I found that really helpful." - #39, female, fingerpricker.*

A few were unable to recognise an association and felt confused. While there was no clear delineation between groups regarding the association between glucose levels and hunger, confusion was slightly more common among fingerprickers. Common reasons for confusion were when glucose levels were high before breakfast, after physical activity, and when they felt very hungry. Some recognised that glucose readings were elevated when they were busy, stressed, or unwell.

Awareness of hunger

The majority of participants reported that they became better at recognising hunger. This made HT different from other weight management strategies they had previously attempted; *"I've tried listening to people, I've tried following routines, I've tried all that sort of thing and I occasionally lose [a few] kilos and then I go straight back to square one because I don't know how to... read my body. I didn't know what it felt like to be hungry. I didn't know that the way I felt was actually what it feels like to be full. So, I was keeping myself constantly full." - #42, female, scanner.* The HT scale opened their eyes to the fact there was a continuum of hunger sensations

Some struggled to identify with the provided descriptors of each of the hunger levels on the hunger scale. A few overcame this by personalising their scale and/or using half points. However, others referred to initially being unfamiliar with some cues but then experiencing them for the first time during the study; *"I've been married 11 years and my wife heard my stomach rumble and she was like 'I've never heard that before!'" – #64, male,*

fingerpricker. Only a few participants felt that HT did not improve their ability to recognise real hunger.

Awareness of non-hungry eating

Almost all participants reported they learned to tell the difference between hungry and non-hungry eating; *"It was interesting to start to find out whether there was an actual need for food from the blood glucose reading versus whether it was a mind thing. I was actually quite quick to adjust to it and it gave a good chance to understand the feelings of hunger that you get, whether it might be physical or psychological, or just the environment you're in." – #37, male, scanner.* Some were surprised to discover that they regularly ate when they were not hungry; *"I didn't think that I would be susceptible, like at the start of the study they talked about eating when you're bored, or eating when you're emotional and I totally expected to be above all of that petty human [stuff] because I'm intelligent. It was really eye opening, especially in the first two weeks of the study, just how programmed or routine a lot of my eating is." - #63, male, scanner.*

Once aware of their non-hungry eating, participants generally avoided it; *"If I have anything now, even if blood glucose is fine, that's going to affect my ability to have something, a meal later on when I'm really hungry and I then my blood glucose would be more than likely too high to allow me to eat when I wanted to later on" - #9, female, fingerpricker.*

The most popular reason for non-hungry eating was boredom; *"I'd say I was a bored eater. Like I'd be at home, what do I want to do? Uh, I don't really know, I'm just walking around the kitchen, just open up the pantry for no reason, and […], I'm here, so I'll grab something." - #79, male, fingerpricker.* A few turned to food when stressed or upset. Some believed that if they didn't eat regularly, their body would go into "starvation mode"; *"Well, often people tell you if you ate too little that you will put your body into starvation mode and then it will hold onto the fat." - #42, female, scanner.*

In terms of physical symptoms, some realised that they had confused hunger and thirst. Others realised they ate when tired, in order to give them energy. For a few, non-hungry cravings reduced once they stopped responding to them.

A few mentioned they ate when they were not hungry because of their environment; *"I walked down past the café this morning, I went, 'Ah, food'. It was really good to go to my brain, 'No, you're not hungry, this is just your body pretending'." – #62, female, scanner.* A lot mentioned they used to eat out of habit or routine, related to time of day; *"Eat when I'm hungry, rather than eat because it's 12 o'clock." - #22, female, fingerpricker*, or activity; *"Have chips and dip and watch the rugby" – #69, male, scanner.*

Participants developed strategies when faced with triggers. The most common coping mechanism to avoid non-hungry eating was to drink water or another sugar-free beverage. Some diverted themselves with chores, a walk, or other activities. Participants dealt with social eating by planning ahead; *"There's another gathering this Saturday, so if I'm going to go and don't feel like I'm really hungry to eat, I can take the food and do a takeaway and*

say, 'oh I'll take this and I'll have it later'." – #76, male, scanner. One participant used strategies she used when quitting smoking; *"I'd implement the breathing like you would have [when] you were having a cigarette. I would talk to someone or talk to myself if no one was around, 'you know what this is you know that this is a craving, you just have to ride through it.'" – #42, female, scanner.*

Awareness of fullness

A couple of participants randomised to the scanner connected their physical sensations with their glucose; *"I could scan myself within half an hour of a heavy meal and be able to go see 'you're full, look what that's done' and show myself that actually this is what your body needs versus what it wants." - #42, female, scanner*. Participants also used the hunger scale to identify their satiety, however, they expressed they were less confident about recognising fullness.

Some participants became aware of feeling uncomfortable from overeating, especially after their evening meal. A couple of participants noticed their sleep improved after reducing overeating.

Behaviour change

The main self-reported behaviour changes were changing their portions, food choices, and timing and frequency of meals (Table 2).

322 **Table 2.** Behaviour changes due to hunger training

Theme description	Representative quotes
Portion size reduction	
Most participants reduced the amount of food they ate at a given meal	*"This could show me in a physical way that you're not actually starving yourself eating this small amount. I learned really quickly that actually if I get a six-inch subway sandwich, I'm just as full and satisfied for just as long a time period as I am if I have [the amount] that I'd normally get."- #42, female, scanner*
Some specifically reduced their portions of unhealthy foods, or foods that spiked their glucose	*"Instead of buying a decent size cake of chocolate I bought the little bars and that was because I had in my mind the spike that would then come and associated the spike with what then is happening in your body." - #25, female, scanner* *"I'd actually stop and think before I ate. So in the past I would have my cup of tea and just automatically reach for the biscuit tin. And maybe have two or three, instead of stopping at one. It's like 'I only need that one, I'm fine now'. So definitely changed, my behaviors there. Even just being aware of when I was eating, of having that sensation of fullness, instead of just carrying on eating." - #57, female, fingerpricker*
Others reduced their intake in order to be able to eat when desired	*"I've noticed that if I'm having less at lunch […] then I'm able to eat my dinner at dinner time versus having a huge lunch and then my blood sugar is still so high that I couldn't have dinner." – #38, female, scanner.*
A few participants noticed their evening meal influenced morning glucose levels, often modifying their evening meal to eat breakfast at a convenient time	*"We had a friend round and I had a dessert. I had to wait 20 minutes or longer in the morning. But I don't have 20 minutes in the morning. So, I was like, 'okay, let's not do that'." - #79, female, fingerpricker.*
Food choice	
Participants from both groups found particular foods delayed their next subsequent meals due to being over their glucose cut-offs, and those wearing the scanner reported seeing a spike in glucose levels after consuming certain foods (or "spikey" foods). People also noticed which foods kept them satisfied for longer, which they viewed as positive.	*"It made me acutely aware of what foods lasted me longer before the start growl [stomach growl] level was achieved." - #50, male, scanner.*
Reduced intake of "sugary foods" and "sweet stuff", bread, chips, biscuits, chocolate, cakes, takeaways and fast food, sugar-sweetened beverages (SSBs), and alcohol.	*"It was more around the drinking because I take a lot of convincing that things [are] right loaded with sugar and if I can't see it, I'm probably not going to believe a word you say. So, it was good to see it […] After [I drank] I pricked my finger and saw it did shoot up, I would think a bit and have a look at what I was drinking and what was in it." – #40, female, fingerpricker.*
Increased intake of vegetables, salads, homemade meals, nuts, eggs, water, and coffee.	*"Especially on a day off if I go up into the hills. I tend to bring things like muesli bars and just keep snacking all day, whereas now I'm not doing that. I'm waiting 'til I'm hungry and have a proper sit down. I'm drinking a lot more water, as well." - #20, male, fingerpricker*
Increased planning of meals	*"Actually I probably have thought about planning my day out meal wise a little bit more 'cause I'd just grab whatever and just eat till I was full or you know, it used to be I'd come home from work and grab a snack and have dinner some time after that and yeah, I don't snack anymore." - #9, female, fingerpricker*
Timing and frequency of meals	
Most reduced their number of eating occasions by eliminating snacking. The majority of this group changed their habit of grazing to eating a fixed number of meals a day, because they realised that they were not hungry, did not want to delay their next meal, and/or to avoid fingerpricking. Most chose to have a sugar-free beverage	*I would amalgamate [a snack] into a meal. So, this last weekend we were away so you know, we'd have a handful of chips, one or two crackers, some bits and pieces […], and then you go, okay well I've had it. Now the old me, prior to this [study], would be having it a bit later on when the blood sugar would still be high and two, I'd*

instead of food; a few combined their snack food with their main meal.	*probably be having the entire pack – #64, male, fingerpricker.*
For most, monitoring their glucose confirmed their normal morning food pattern. However, some had glucose levels that were too high to eat breakfast at their usual time. For these participants, elevated morning glucose was frustrating. Some ate later, and others ignored their glucose and ate anyway.	*"Because based on my monitoring, I'm pretty good, and I don't need to have breakfast, which was a relief, because I'm not a fan of breakfast to begin with." - #62, female, scanner*

Note: Themes listed in order of frequency

Future expectations

Almost all participants expressed they were motivated and hopeful about continuing with their recent behaviour changes; *"It seems an easy way to do it, 'cause it's not a diet. It's just eating sensibly and just waiting 'til your body's ready to eat. Rather than just eating for the sake of eating." - #20, male, fingerpricker.* A few explained they would have liked to measure their glucose for longer to gain confidence about their hunger levels and some (mostly those who scanned) expressed concern about being without their equipment. This feeling of concern generally revolved around the fact that they would be without immediate feedback. On the contrary, other participants were happy and confident to leave their equipment behind. A few participants reflected that following HT without equipment would be the next step.

DISCUSSION

Our use of pheonomenology to explore the experience of participants using HT provided rich descriptions that aided our understanding of the daily lived experiences of those monitoring their glucose on a regular basis. Most participants had a positive experience of HT, and were able to match their hunger to their glucose levels by the end of the study, which is consistent with other findings[29] and our previous results.[14] While the majority found an association between hunger and glucose, some experienced confusion, which is likely related to the homeostatic control of glucose.[12]

The main adherence barriers of social pressure to eat, lack of time, and lack of flexibility in meal schedule, and the main enablers of routine, social support, and accountability, are consistent with those of a systematic review of determinants of adherence to lifestyle interventions in adults with obesity.[16] Participants realised that they were previously unaware of feelings of appetite, supporting the theory that some with overweight/obesity have blunted sensations of hunger and satiety.[8-10] Participants primarily changed their behaviour by becoming aware of hungry versus non-hungry eating, recognising feelings of hunger and satiety, reducing their number of meals, and exploring the effect of different types of foods on their glucose. This is in line with a review of mindful and intuitive eating interventions wherein participants became more aware of and reduced non-hungry eating.[30] Although historically HT enhances recognition of hunger rather than satiety,[29] our results indicate our participants felt they learned to recognize feelings of fullness. Whether this translated to long-term behaviour change is unknown.

Participants randomised to use the scanners generally described fewer negative experiences and less adherence barriers, and were more inclined to try different foods to see the effects on their glucose, due to the ease of scanning. However, those randomised to fingerpricking may have become more mindful of their hunger, since they carefully considered their hunger before submitting to the effort and discomfort of fingerpricking. Fingerprickers were more confident returning their glucose measuring equipment, perhaps due to their established awareness of hunger. As suggested by our participants, a mobile app instead of a paper booklet, and including nutrition and exercise recommendations, and strategies to cope with emotional and social eating may increase adherence, and this agrees with current recommendations.[31] Social support and involving family and friends may improve adherence and benefits, as demonstrated elsewhere.[32-34]

Our analysis was robust; the researchers were blinded for participant characteristics, all transcripts were double-coded, and the results were analysed and interpreted by three researchers. As with all interviews there is potential for response bias, with a chance of study participants providing socially desirable answers to appease researchers.[35] We tried to reduce this by introducing an independent researcher for the interviews. Our study also has some limitations, principally related to the limited diversity obtained in our sample. Our participants were highly educated, perhaps in part a consequence of recruitment occurring in a university town, were predominantly European, and a smaller proportion of participants were diabetic than was anticipated.[36] Anecdotal feedback indicated that diabetic patients were unwilling to be involved in research that might require additional blood glucose testing than was already required by their condition. Given the limited nature of our sample it is possible that different findings would be evident in a more diverse range of participants, particularly had we been able to recruit a significant number of diabetics with varying levels of glycaemic control. It is possible that participants reported on HT experiences that were intertwined with their own past struggles with other weight loss programs. Thus it is impossible to know if participants' self-reported experiences here are a result solely of the HT protocol, or exposure to weight management strategies in general. This would be a relevant topic for further research.

Our interviews allowed insight into how participants undergoing HT felt it influenced their eating behaviour, and suggestions for how to better support participants in establishing healthy eating routines, both of which can be used to inform future HT programs and other healthy eating interventions in both primary care and public health settings.

DECLARATIONS

Author Contributions: Conceptualization, W.E.dB., A.L.W., R.W.T. and M.R.J; Methodology, W.E.dB., A.L.W. and M.R.J; Formal Analysis, W.E.dB., A.L.W. and M.R.J; Resources, M.R.J; Data Curation, W.E.dB., A.L.W. and M.R.J; Writing-Original Draft Preparation, W.E.dB and M.R.J; Writing-Review & Editing, W.E.dB., A.L.W., R.W.T. and

M.R.J; Visualization, M.R.J; Project Administration, W.E.dB. and M.R.J; Funding Acquisition, R.W.T. and M.R.J.

Funding: This research was supported by a University of Otago Research Grant.

Acknowledgments: We would like to thank all participants involved in the hunger training pilot study (ACTRN12618001257257). Thank you to Associate Professor Ben Wheeler and Dr Sara Boucher for sharing their expertise with the Freestyle Libre Flash Glucose Monitoring system.

Conflicts of Interest: The authors declare no conflict of interest.

List of Abbreviations: BMI: Body Mass Index, DASS-21: Depression Anxiety Stress Scale, HbA1c: Hemoglobine A1c, HT: Hunger Training, IQR: Inter-Quartile Range, SSBs: Sugar-Sweetened Beverages.

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FIGURE CAPTIONS

Figure 1. Glucose measuring equipment, (a) the Freestyle Optium Glucose Meter (Abbott Freestyle Optium Glucose Meter, Australia), test strip and lancet used by the "fingerpricking" group; (b) the Freestyle Libre Flash Glucose Monitoring system (Abbott Diabetes Care, Australia), worn by the "scanner" group.

Figure 2. A page spread from the hunger training booklet

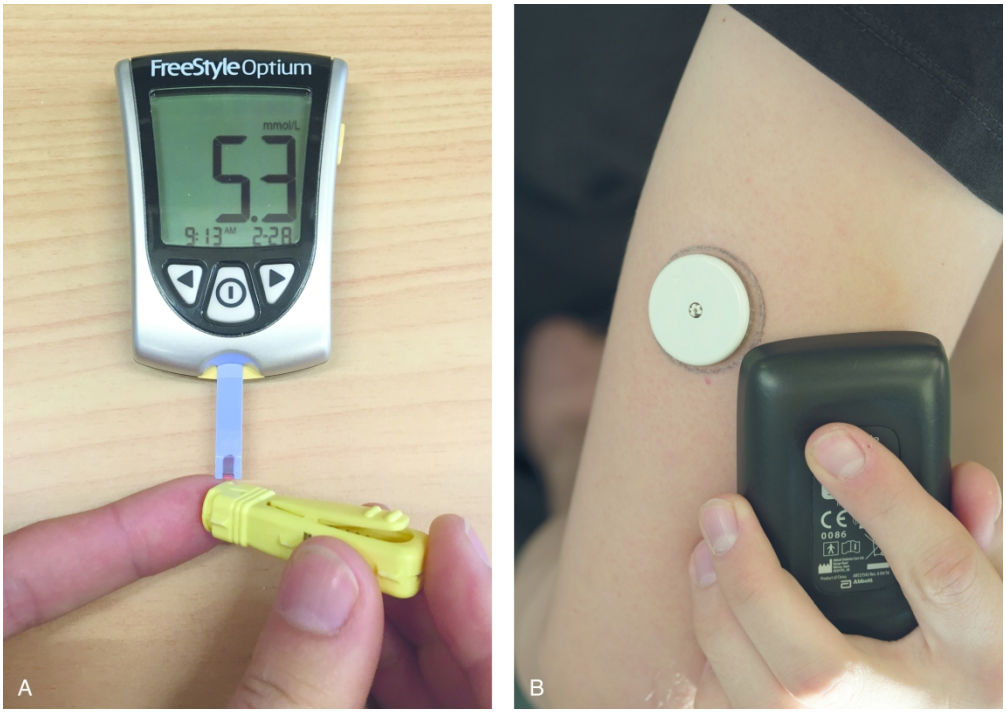

Figure 1. Glucose measuring equipment, (a) the Freestyle Optium Glucose Meter (Abbott Freestyle Optium Glucose Meter, Australia), test strip and lancet used by the "fingerpricking" group; (b) the Freestyle Libre Flash Glucose Monitoring system (Abbott Diabetes Care, Australia), worn by the "scanner" group. Photo by Thirunavukkarasye-Raveendran [CC BY 4.0 (https://creativecommons.org/licenses/by/4.0)]

189x133mm (300 x 300 DPI)

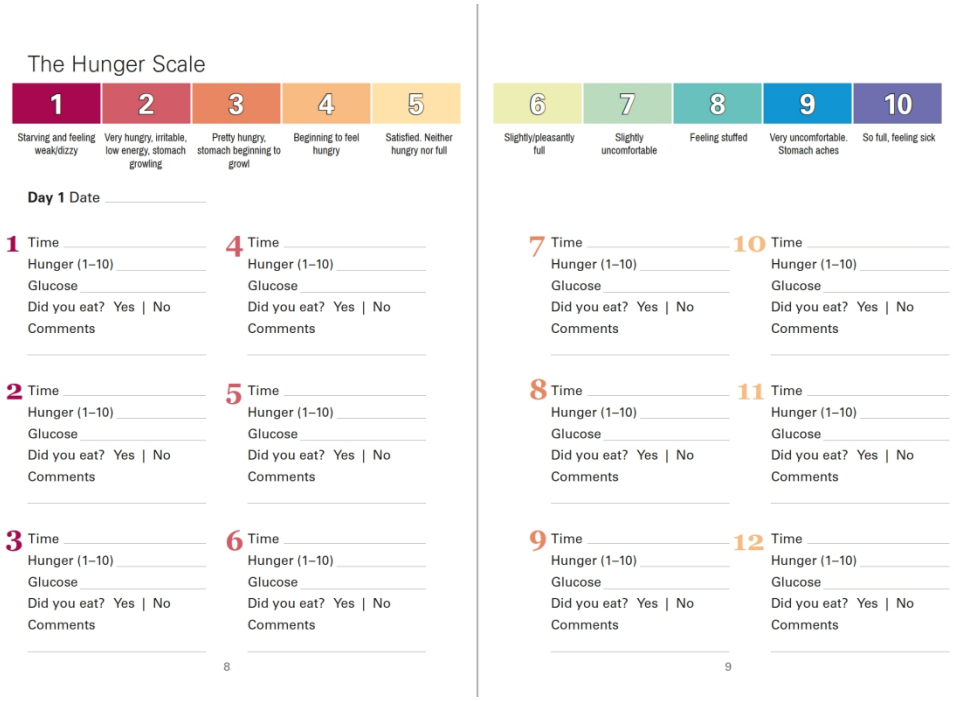

Figure 2. A page spread from the hunger training booklet

SUPPLEMENTARY FILE

Semi-structured interview guide

1. What was it like to measure your **glucose** over the past month?
    a. Could you tell me something about what you **liked** about measuring your glucose?
    b. Could you tell me something about what you **disliked** about measuring your glucose?
2. What was it like to **fill in the booklet** over the past month?
    a. Can you tell something about what you **liked** about filling in the booklet?
    b. Can you tell something about what you **disliked** about filling in the booklet?
3. Did you see a pattern between your hunger and glucose?
    a. If no, how much of a problem was this?
    b. If yes, could you tell a bit more about what you learned?
4. Can you please let me know whether you have **experienced any changes in your behavior** in the past month?
    a. Do you think this changed because of hunger training?
    b. You told me something about …. , were there any other changes because of hunger training?
        i. Possible topics for discussion: routine, number of eating occasions (e.g. number of meals), avoidance of eating due to pain, food choice, awareness of hunger/recognizing when body needs food, previous non-hungry eating (e.g. eating because of routine, emotions, environment), awareness of fullness/satiety (e.g. doesn't have to eat as much as previously thought), awareness of social pressure to eat, physical activity or coping mechanisms (e.g. ways to distract yourself when "hungry" but not allowed to eat).
5. We asked you to measure your glucose every time you felt like eating, and to only eat if your glucose was under your cut-off. How did this work out for you?
    a. We can imagine this was not always easy, can you tell me why it was sometimes **difficult**?
        i. Can you please tell me about situations that you **didn't measure** your glucose before eating (if any)?
        ii. Can you please tell me about situations that your **glucose was too high to eat**, but you ate anyways (if any)?
    b. Some days it may have **been easier** to follow our instructions than others, can you tell me why?

6. Now that you're finished the first month of hunger training, you are no longer going to measure glucose to help you figure out when to eat. You'll continue to fill in the booklet, but only for one week every month. What do you **expect** to happen over the next 5 months?
    a. Do you feel like you have trained yourself to recognize when you are hungry?
    b. Do yourself to know when to eat without being able to measure your glucose?
7. Do you have any suggestions for us on how we can **improve** hunger training?
    a. Length of time of measuring glucose,
    b. Communication (e.g. appointments, reminders)
    c. Equipment
    d. Booklet/instructions

Standards for Reporting Qualitative Research (SRQR)*

http://www.equator-network.org/reporting-guidelines/srqr/

	Page/line no(s).
Title and abstract	
Title - Concise description of the nature and topic of the study Identifying the study as qualitative or indicating the approach (e.g., ethnography, grounded theory) or data collection methods (e.g., interview, focus group) is recommended	1
Abstract - Summary of key elements of the study using the abstract format of the intended publication; typically includes background, purpose, methods, results, and conclusions	2
Introduction	
Problem formulation - Description and significance of the problem/phenomenon studied; review of relevant theory and empirical work; problem statement	3
Purpose or research question - Purpose of the study and specific objectives or questions	3
Methods	
Qualitative approach and research paradigm - Qualitative approach (e.g., ethnography, grounded theory, case study, phenomenology, narrative research) and guiding theory if appropriate; identifying the research paradigm (e.g., postpositivist, constructivist/ interpretivist) is also recommended; rationale**	4-5
Researcher characteristics and reflexivity - Researchers' characteristics that may influence the research, including personal attributes, qualifications/experience, relationship with participants, assumptions, and/or presuppositions; potential or actual interaction between researchers' characteristics and the research questions, approach, methods, results, and/or transferability	4
Context - Setting/site and salient contextual factors; rationale**	4
Sampling strategy - How and why research participants, documents, or events were selected; criteria for deciding when no further sampling was necessary (e.g., sampling saturation); rationale**	4
Ethical issues pertaining to human subjects - Documentation of approval by an appropriate ethics review board and participant consent, or explanation for lack thereof; other confidentiality and data security issues	3
Data collection methods - Types of data collected; details of data collection procedures including (as appropriate) start and stop dates of data collection and analysis, iterative process, triangulation of sources/methods, and modification of procedures in response to evolving study findings; rationale**	4

Data collection instruments and technologies - Description of instruments (e.g., interview guides, questionnaires) and devices (e.g., audio recorders) used for data collection; if/how the instrument(s) changed over the course of the study	4
Units of study - Number and relevant characteristics of participants, documents, or events included in the study; level of participation (could be reported in results)	5
Data processing - Methods for processing data prior to and during analysis, including transcription, data entry, data management and security, verification of data integrity, data coding, and anonymization/de-identification of excerpts	4
Data analysis - Process by which inferences, themes, etc., were identified and developed, including the researchers involved in data analysis; usually references a specific paradigm or approach; rationale**	4-5
Techniques to enhance trustworthiness - Techniques to enhance trustworthiness and credibility of data analysis (e.g., member checking, audit trail, triangulation); rationale**	4

Results/findings

Synthesis and interpretation - Main findings (e.g., interpretations, inferences, and themes); might include development of a theory or model, or integration with prior research or theory	5-10
Links to empirical data - Evidence (e.g., quotes, field notes, text excerpts, photographs) to substantiate analytic findings	5-10

Discussion

Integration with prior work, implications, transferability, and contribution(s) to the field - Short summary of main findings; explanation of how findings and conclusions connect to, support, elaborate on, or challenge conclusions of earlier scholarship; discussion of scope of application/generalizability; identification of unique contribution(s) to scholarship in a discipline or field	10-11
Limitations - Trustworthiness and limitations of findings	11

Other

Conflicts of interest - Potential sources of influence or perceived influence on study conduct and conclusions; how these were managed	12
Funding - Sources of funding and other support; role of funders in data collection, interpretation, and reporting	12

*The authors created the SRQR by searching the literature to identify guidelines, reporting standards, and critical appraisal criteria for qualitative research; reviewing the reference lists of retrieved sources; and contacting experts to gain feedback. The SRQR aims to improve the transparency of all aspects of qualitative research by providing clear standards for reporting qualitative research.

**The rationale should briefly discuss the justification for choosing that theory, approach, method, or technique rather than other options available, the assumptions and limitations implicit in those choices, and how those choices influence study conclusions and transferability. As appropriate, the rationale for several items might be discussed together.

Reference:

O'Brien BC, Harris IB, Beckman TJ, Reed DA, Cook DA. **Standards for reporting qualitative research: a synthesis of recommendations.** *Academic Medicine*, Vol. 89, No. 9 / Sept 2014
DOI: 10.1097/ACM.0000000000000388