EFFECT OF AN 8-WEEK FREE PRE-PREPARED MEALS AND PRESCRIBED EXERCISE ON WEIGHT LOSS IN OBESE AND OVERWEIGHT INDIVIDUALS: HEALTHY EATING AND LIVING STUDY (HEALS) RANDOMISED CONTROLLED TRIAL.

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Summary

Good health is important for all Australians. Thr1ve is a forefront of enabling individuals to achieve good health with their Combined Health Package of exercise and food products that were scientifically designed and were independently evaluated by researchers at Queensland University of Technology. The Healthy Eating and Living Study (HEALS) is registered Randomized Controlled Trial with Australian New Zealand Clinical Trials Registry (ANZCTR; ACTRN12618000422224). The RCT had two conditions. In the experimental condition (n = 33) participants were provided with a ketogenic diet over an eight week period and completed an exercise programme under guidance of a clinical exercise physiology student. The participants in the control condition (n = 31) were provided with dietary guidelines and followed the same supervised exercise programme. At the start and end of the 8 week intervention period participants were tested for cardiorespiratory fitness, body composition (using DEXA), blood biomarkers and psychological well-being. In addition, at the end of the trial we conducted a quantitative and qualitative (semi-structured interviews) evaluation of the trial. Results showed that the participants in the experimental condition showed significantly greater increase in fitness (VO_{2peak}) and decrease in Fat Mass Index. In addition, although there was a significant decrease in fat mass for all participants, this was significantly greater in those participants in the experimental group who achieved a ketogenic state. Both group showed improvements in body composition (reduction in Total Body Fat and Visceral Adipose Tissue), their blood lipids profile with decreases in total cholesterol, total blood glucose, triglycerides and C-reactive protein. In addition, the experimental group showed greater decrease in blood glucose levels compared to the control group. All participants also showed improvements in mental well-being (significant decrease in stress and anxiety symptoms). Evaluation of the HEALS trial indicated high levels of satisfaction

with the Trial overall, namely the exercise and nutrition component and EP and Heals Team support provided. Not surprisingly the control group was less satisfied with the nutritional component of their protocol. The qualitative evaluation also provided evidence for participant's satisfaction with the HEALS Trial.

Overall, participation in the Trial was beneficial for all in terms of cardiorespiratory fitness (VO_{2peak}), body composition (reduction in Total Body Fat and Visceral Adipose Tissue), blood lipids profile, and psychological well-being. However, those in the experimental condition following a ketogenic diet achieved additional benefits in terms of improved fitness, reduced Fat Mass Index, and lower blood glucose levels. Finally, those in the experimental condition who achieved a ketogenic state showed the greatest decrease in fat mass.

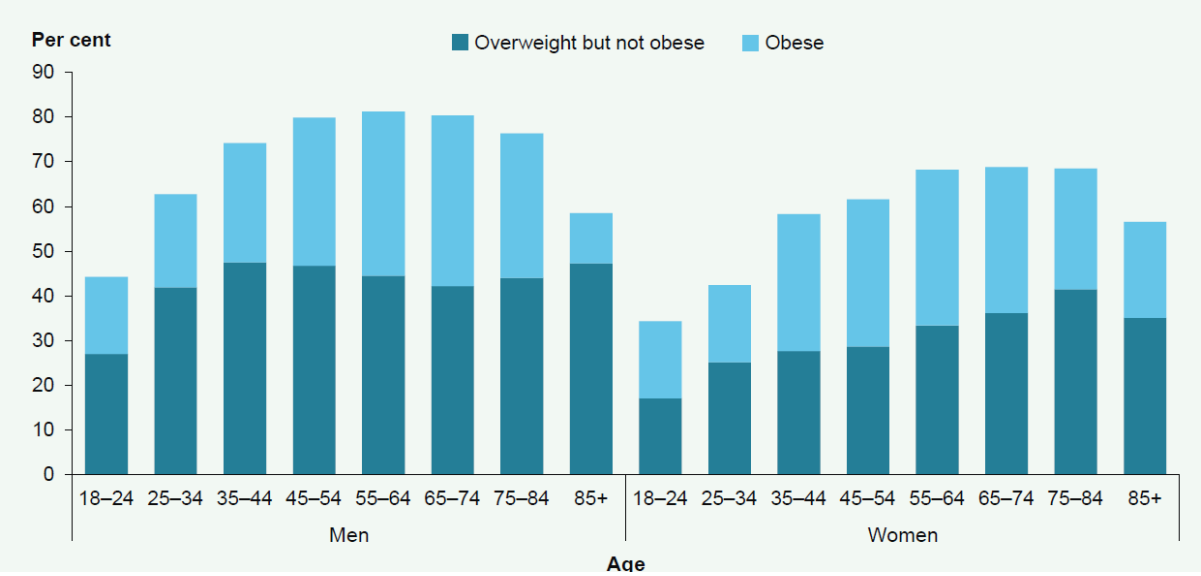
Introduction

Obesity and related co-morbidities are now major health problems across Australia (AIHW, 2017). According to the Australian Institute of Health and Welfare's 2018 report Australians' obesity rates are much higher (27.9%) than the OECD average (19.4%) in 2015. Based on BMI measurements, 63% of Australians aged 18 and over were overweight or obese. Men had higher rates of overweight and obesity (76%) than women (56%) and adults in 2014-2015 were significantly more likely to be obese than adults of the same age 20 years earlier in 1995 (see Figure 1). In 2014-2015, according to Price Waterhouse Cooper Australia's report, the obesity related health cost to the Australian economy were $8.6 billion. They forewarned that by 2024-25, there will be $87.7 billion in added costs due to obesity. Therefore, there is a clear need to find effective both commercial and non-commercial solutions that are evidence based and independently evaluated. The use and application of such products have to be sustainable and help people to take more responsibility for their own health and well-being. Obesity and solution to weight management is a key health issue for Australia.

Population based preventive measures have been found less effective than anticipated, hence there is a need for the development of effective treatment programs for those who are already overweight or clinically obese. Numerous studies have been conducted to examine the efficacy of nutrition and physical activity (PA) interventions on weight, physical and psychological well-being in overweight, obese and morbidly obese individuals (e.g., Borkoles, Clough & Polman, 2016). It is also now well accepted that the successful treatment of overweight and obese adults require both the adoption and maintenance of lifestyle behaviours related to dietary intake and PA (Academy of Nutrition & Dietetics, 2016). Poor dietary intake and physical inactivity increase the likelihood for lifestyle related non-

communicable diseases (NCD) including heart disease, stroke, diabetes and various cancers (Plotnikoff et al., 2015).

Figure 1: Proportion of overweight and obese adults (based on measured BMI), by age and sex, 2014-2015 (ABS, 2015).



Many individuals enrol in commercial weight-loss programs (Tsai & Wadden, 2005) to lose weight. Indeed, there is evidence that these commercial weight loss programmes can reduce weight and for a short- and long-term reduce fat loss (e.g., Truby et al., 2006; Rock et al., 2007; Jebb et al., 2011). In particular, studies in which participants are provided with (free) prepared meals have resulted in greater weight loss, probably due to portion size control and easy of consumption (e.g., Rock et al., 2010 & 2016; Mellor et al., 2013). Similarly, there is some evidence that high-fat in comparison to low-fat diets result in greater weight loss (Bueno, de Melo, de Oliveira & da Rocha Ataide, 2013; Tobias, Chen, Manson, Ludwig, Willett, Hu et al., 2015). However, most of these studies have only examined the effects of diet on weight loss, despite the fact that a combination of diet and exercise provides greater benefits in terms of weight loss, fat lost, %fat lost and BMI decrease (Miller et al., 1997). One study reported that commercial weight loss programs with exercise were more beneficial

than just diet based programs in overweight and obese women (Baetge et al., 2017). In addition, a recent study by Ebbeling et al. (2018) showed that a low carbohydrate diet was beneficial in increasing energy expenditure during weight loss maintenance (see also Ludwig, Willett, Volek & Neuhouser, 2018 for a review on dietary fat). To our knowledge, no study to date has timed and co-ordinated the dietary intake with an exercise programme schedule, such as recommend different kind of food consumption post exercise sessions.

There is a constant upsurge of new commercial diet products, which essentially promise weight loss by limiting calorie intake (see Makris & Foster, 2011 for an overview) and therefore are not a sustainable weight management options over time. In the past, the scientific evidence for the concurrent effect of regular exercise participation on diets have also not been considered. As such, the current study will report on the efficacy of the 'Thr1ve' protocol. The Thr1ve protocol consist of an 8 week program that matched nutritional advice to the training programme to enhance weight loss, despite improving fitness. The Thr1ve diet plan is based on a low-carbohydrate food composition matched to the timing of exercise programme (e.g. post exercise meals. There is some evidence that low carbohydrate diet enhances and maintains weight loss (e.g., Yancy et al., 2004 and Ebbeling et al., 2018).

Currently there is no evidence that low carbohydrate diets have negative health consequences. In a review by Makris et al. (2011) a ketogenic diet showed no negative effects on lipids, body composition or mineral density over a 2 year period. Similarly, a study by Castaldo et al. (2016) shows that a short term ketogenic diet followed by an almost carbohydrate free oral nutrition may effectively reduce body weight, waist circumference, blood pressure, and insulin resistance in clinically health obese adults. Also, Westman (2002)

argued that there is no clear requirement for dietary carbohydrates for human adults. Several studies (Feinman et al., 2003; Veech et al., 2001; & Sato et al., 1995) argue that ketosis is not harmful, except in the high levels seen in Type 1 diabetes. There are no scientific studies currently that showed the need to consume carbohydrates above minimal needs (Westman, 2002). Zinn et al. (2017) reported that endurance athletes competing at international level were keen to continue with the 10 week ketogenic diet due to enhanced well-being, improved skin conditions and reduced inflammation. However, it is acknowledged that there might be common adverse effects such as headache, constipation, fatigue, diarrhoea, insomnia, bad breath, and backache, which can last from a couple of days to a couple of weeks (Gupta et al., 2017).

Trial Objective & Purpose

The primary objective of this RCT was to compare the short-term (8 weeks) effects of the 'Thr1ve' protocol (combined effect of commercially pre-prepared meals and structured exercise programme) to standard dietary guidelines with a structured exercise programme on body composition changes (fat mass, lean body mass). The secondary objectives were to examine biological (fitness and blood profile) and psychological factors, including, facilitators, acceptability, and barriers to completing the intervention programme as intended.

The following prediction were made:

1. Participation in the experimental group (combined commercially prepared meals and structured exercise programme) will have greater reduction in fat mass (% body fat)

than participants in the control group (standard dietary advice and structured exercise programme).

2. Participation in the experimental group will result in an improved blood profile in terms of total cholesterol, HDL-C, LDL-C, triglycerides, C-reactive protein and Adiponectin compared to the control group participants.
3. Participation in the experimental group will result in improved psychosocial functioning in terms of quality of life and mental health (depression, anxiety, stress) compared to participants in the control condition.

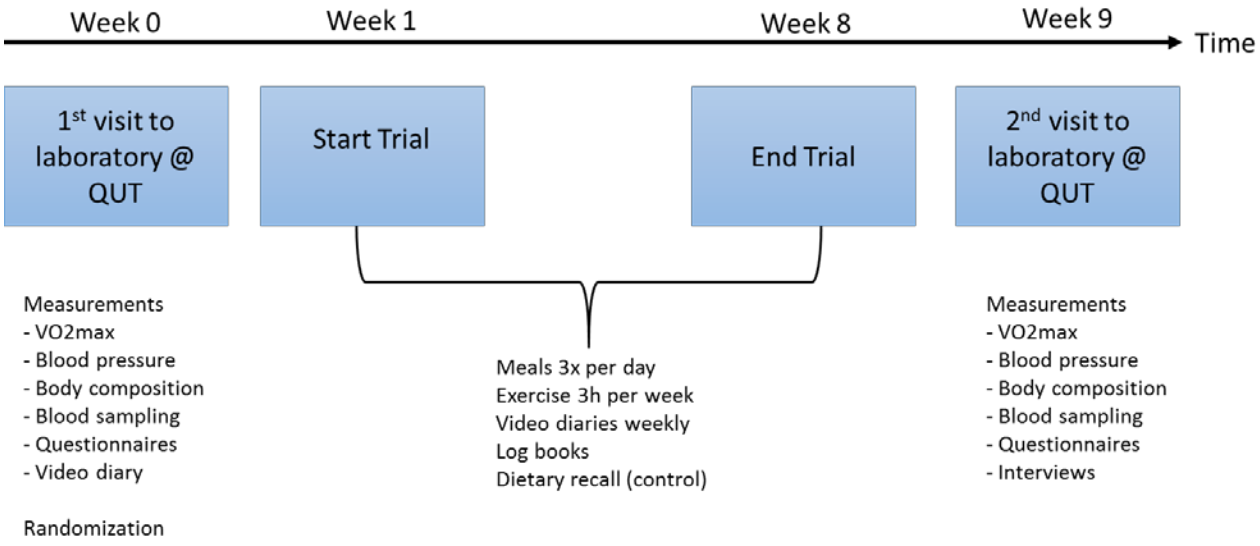
Trial Design

This proof of concept randomised controlled trial (RCT) was conducted in line with the Consort guidelines for the reporting of parallel group RCTs (Schulz, Altman, & Moher, 2009). The study had two conditions.

1. Experimental condition: Participants were provided with 3 pre-prepared meals per day and protein snacks over an 8 week period. In addition, participants followed the prescribed exercise programme as developed by Thr1ve.
2. Control arm: Participants were provided with dietary guidelines as developed by the Australian Government (www.eatforhealth.gov.au), whilst also following the Thr1ve developed prescribed exercise programme.

The exercise programme was delivered by exercise physiologists and/or exercise physiologists in training. Figure 2 provides an overview of the study design.

Figure 2: Overview of the HEALS RCT.



Trial Procedures - Methodology

Following initial telephone screening eligible participants were invited to attend the physiology laboratory at QUT Kelvin Grove campus (Week 0) for a 90 minute session. Participants who met all inclusion criteria were invited to start the 8 week trial in either the intervention (structured exercise programme + pre-prepared meals) or control (structured exercise programme + standard dietary advice) condition. All participants followed the prescribed 8 week exercise program of approximately 3 hours of active and 1 hour of leisurely (e.g. walking) exercise per week. During weeks 1 and 2 all 4 gym sessions were supported by an exercise physiologist (EP) in training. During weeks 3-8 one gym session per week was supervised by the same EP. The control group was provided with written recipe book and information on healthy eating as directed by the Australian Government National Health and Medical Research Council, whereas the intervention group were provided with 3 pre-prepared meals and snacks during trial participation. Participants picked up their meal packages at the start of the week for 8 weeks. Participants were asked to strictly follow the

experimental protocol, but were told not to go hungry and use the protein snacks if they felt hungry**.**

Randomization

Participants were randomly allocated, using envelopes, to one of the following conditions: (1) experimental (structured exercise programme + pre-prepared meals) or (2) control (structured exercise programme + standard dietary advice). Stratification by gender and couples were undertaken.

Measurements and procedures

Adult Pre-Exercise Screening

In order to minimise risk to participants, they were screened for health and injury risk prior to commencing any data collection using the Exercise and Sports Science Australia (ESSA) pre-exercise screening questionnaire. This pre-exercise screening form was used to identify known diseases or signs and symptoms of medical conditions that could contraindicate exercise participation. In the event of any health or injury risks were identified, participants were excluded from the study and advised to seek medical clearance before undertaking any high intensity exercise. Participants over 40 were asked to bring a GP clearance form if they fit the recruitment criteria.

Body composition

Body composition using DEXA and standard measurements of height (in m) and weight (kg) were taken. The DEXA scans pre- and post-intervention allowed for the estimation of changes in fat mass and lean body mass in the participants.

Blood pressure

Participants' systolic and diastolic blood pressure was assessed using standard operating procedures.

Haematological measures

Fasting blood samples were obtained from participants to measure total cholesterol, HDL-C, LDL-C, Triglycerides, C-reactive protein, adiponectin, and ketone bodies at both pre- and post-laboratory visits.

Assessment of aerobic capacity (Fitness)

Participants completed a graded exercise (cycling) test during pre- and post-testing sessions to determine maximal levels of oxygen consumption. This test provided an objective measure of participants' fitness levels.

Psychosocial measures

To capture the changes in health and psychosocial wellbeing participants completed the SF-12 (Quality of Life) and DASS21 (Depression, Anxiety and Stress) questionnaires at the start of the intervention and following its completion. Program satisfaction was assessed at the end of the program via qualitative exit interviews.

Statistical Analysis

A single-factor linear mixed model (LMM) was used to compare anthropometric characteristics, blood biomarkers and cardiorespiratory fitness between the experimental and control groups. A two-factor (group*time) LMM was used to detect differences in body composition, blood biomarkers and cardiorespiratory fitness across time (before and after trial) and between groups. Post-trial data were also analysed as percentage changes from baseline (delta %) to account for individual baseline variance. To differentiate the cohort on

the basis of the ketosis levels, participants of the experimental group were further stratified into ketogenic and non-ketogenic groups and a further two-factor (group*time) LMM sub-analysis was contacted as described above. Statistically significant interactions were further investigated with multiple comparisons using Fisher's least significant difference approach (Rothman, 1990). Analyses were conducted using the Statistical Package for Social Sciences (Version 22; IBM SPSS Inc., Chicago, IL) and statistical significance was set at $P \leq .05$. Data are presented in the text and Tables as mean and standard deviation (SD) unless otherwise stated.

Participant Characteristics

Table 1 provides an overview of the participant characteristics in the HEALS trial for the sample as a whole and for the control and experimental conditions. There were no significant differences in any of the variable at baseline.

Table 1: Characteristics of the complete cohort. Data are presented as mean ±SD; BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; V̇O2peak, peak oxygen uptake.

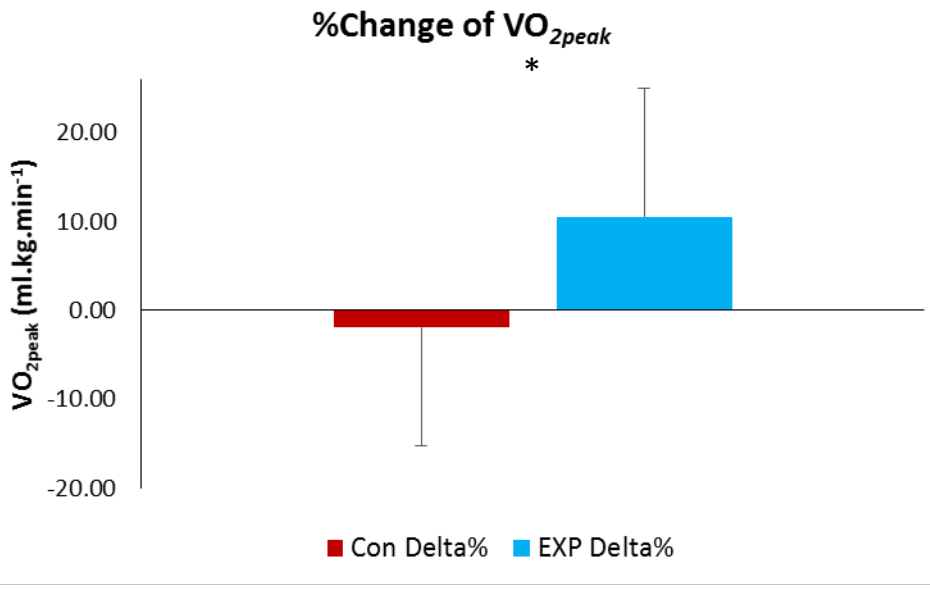
	All (n = 64)	**Control (n = 33)**	**Experimental (n = 31)**	***P* value**
Participant characteristics				
Age (years)	35.3±9	34.2±8	35.1±6	0.45
Height (m)	1.74±0.3	1.75 ± 0.1	1.77 ± 3.1	0.16
Weight (kg)	87.7±15	74 ± 6	72 ± 5	0.20
BMI (kg.m^{-2})	30.3±3	29.8±4	31.2±3	0.17
Body fat (%)	41.4±6	40.0 ± 7	40.8 ± 6	0.27
Brachial SBP (mmHg)	125 ± 6	125 ± 1	125 ± 7	0.26
Brachial DBP (mmHg)	81 ± 7	79 ± 2	83 ± 9	0.79
Blood biomarkers				
Total Cholesterol (mmol/L) *4.0-5.5 mmol/L*	4.84±0.89	4.82±0.77	4.90±0.99	0.52
Blood Glucose (mmol/L) *4.0-5.4 mmol/L*	5.48±0.39	5.37±0.35	5.57±0.47	0.61
HDL(mmol/L) *1.0-1.5 mmol/L*	1.30±0.37	1.22±0.82	1.37±0.39	0.32
LDL(mmol/L) *2.6-3.4 mmol/L*	2.92±0.88	2.94±0.82	2.81±0.77	0.85
Triglycerides(mmol/L) *<1.7 mmol/L*	1.38±0.70	1.32±0.48	1.43±0.87	0.21
CRP(mmol/L) *Low risk <1.0 mmol/L Average risk 1-3 mmol/L High risk >3.0 mmol/L*	1.89±2.42	1.37±2.16	2.09±2.56	0.15
Maximal incremental cycling test				
Absolute $\dot{V}O_{2peak}$, L.min^{-1}	2.38 ± 0.8	2.41 ± 6	2.39 ± 0.7	0.35
Relative $\dot{V}O_{2peak}$, mL.kg^{-1}.min^{-1}	27.9 ± 6	28.7 ± 6	27.4 ± 6	0.46

Quantitative Results

Cardiorespiratory Fitness

Cardiorespiratory fitness (VO_{2peak}) significantly increased in both groups after trial completion compared to baseline ($p<0.05$). The percentage change of VO_{2peak} was however significantly greater in the experimental when compared with the control group ($P < 0.05$, see Figure 3).

Figure 3: Percentage change of cardiorespiratory fitness (VO_{2peak}) in response to trial intervention of Control (red column) and Experimental (blue column) groups.

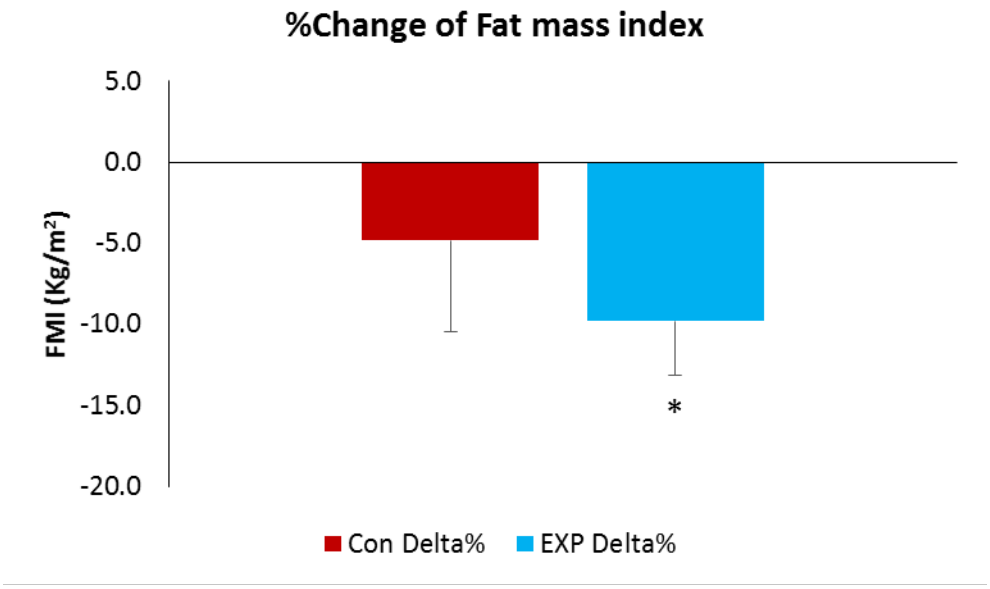


Data are presented as mean and SD; VO_{2peak}, Peak Oxygen Consumption. *Significantly different to control; $P < 0.05$.

Body composition

Mean levels of Total Body Fat (BF), Visceral Adipose Tissue (VAT) and Fat Mass Index (FMI, body fat mass divided by height squared) significantly reduced in both groups after trial completion compared to baseline ($P < 0.05$). The percentage change in FMI was significantly greater in the experimental group compared to the control group ($P < 0.05$, see Figure 4).

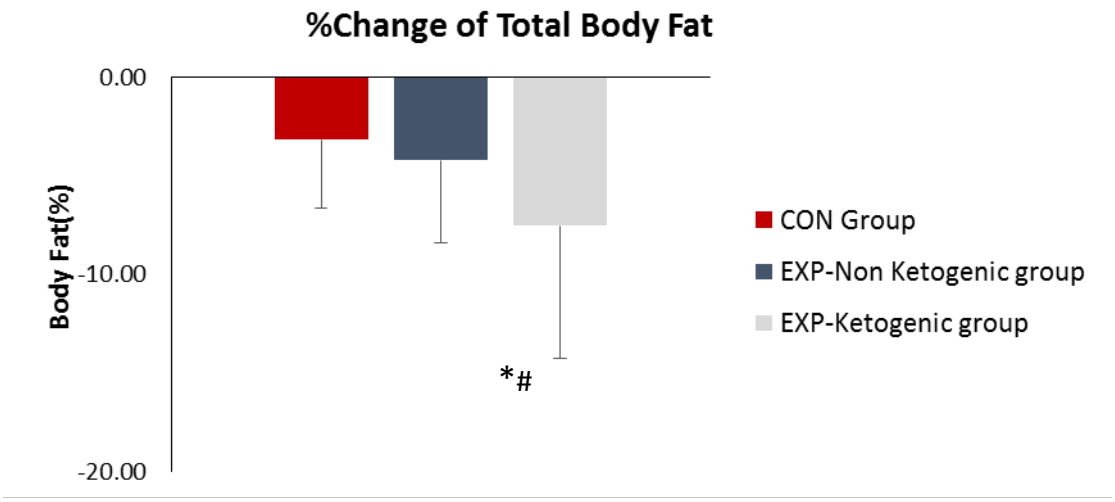
Figure 4: Percentage change of Fat Mass Index (FMI) in response to trial intervention of Control (red column) and Experimental (blue column) groups.



Data are presented as mean and SD; FMI, Fat Mass Index. *Significantly different to control; $P < 0.05$.

There was no difference after the trial in body fat (BF) change between groups. However, in a sub-analysis, participants who were under ketosis (beta-hydroxybutyrate> 0.3mmol/L) demonstrated a significantly greater loss of BF compared to the control group and to participants in the experimental group who had normal ketone blood levels ($P < 0.05$, see Figure 5). This partially supported our a priori predictions.

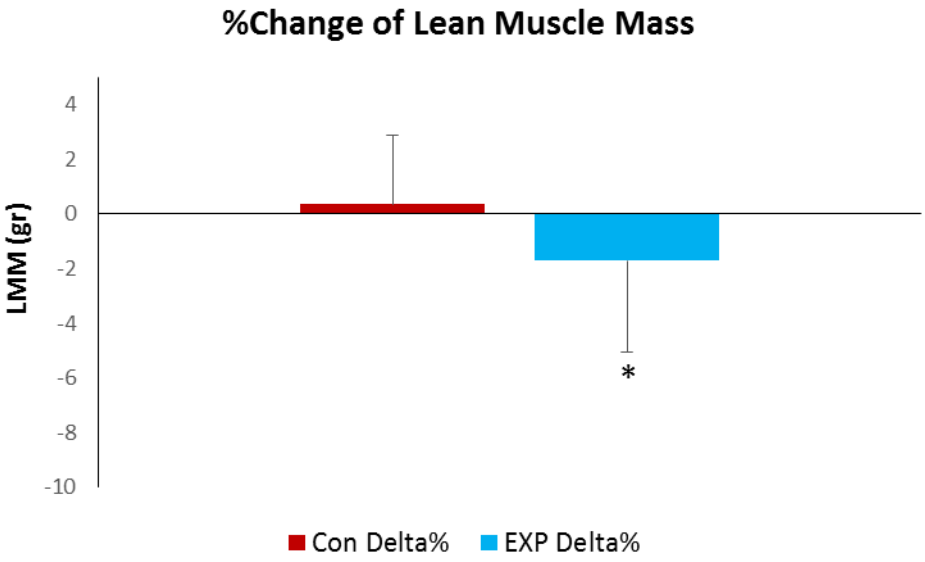
Figure 5: Percentage change of Total Body Fat in response to trial intervention of Control (red column), Experimental- Non Ketogenic (blue column) and Experimental (Ketogenic) group.



Data are presented as mean and SD; *Significantly different to control; # Significantly different to experimental non-ketogenic group; $P < 0.05$.

Lean Muscle Mass (LMM) remained unchanged after trial compared to baseline in the control group, whilst there was an observed decrease in this parameter for the experimental group ($P < 0.05$). This was also evident when the percentage change was explored, where LMM in the experimental group was significantly lower to the control group ($P < 0.05$, see Figure 6).

Figure 6: Percentage change of Lean Muscle Mass (LMM) in response to trial intervention of Control (red column) and Experimental (blue column) groups.



Data are presented as mean and SD; LMM, Lean Muscle Mass. *Significantly different to control; $P < 0.05$.

Haematological measures

Haematological results of the complete cohort and comparisons between groups are shown in Table 2.

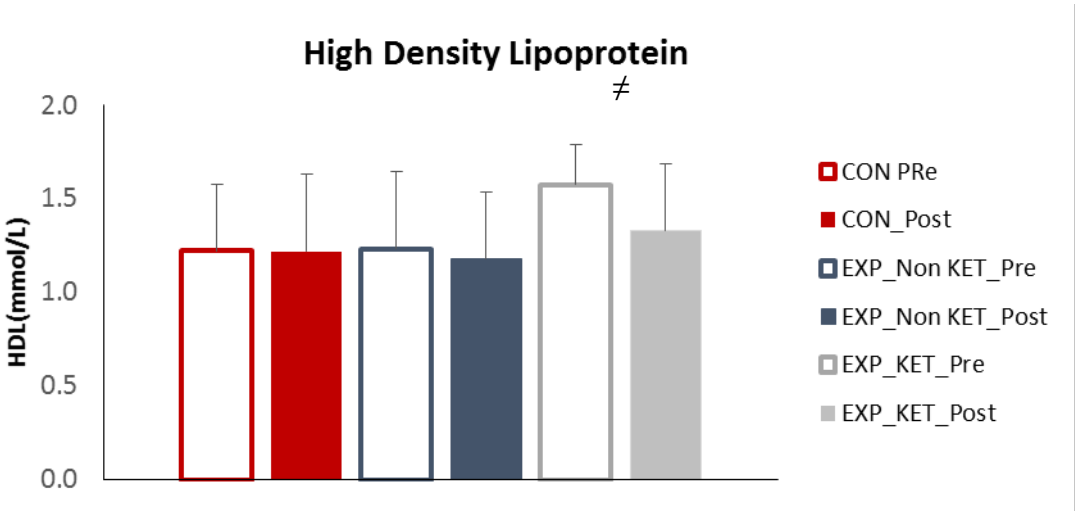
Table 2: Examined Variables before (Pre) and after (Post) Trial. Normal fasting range of blood biomarkers is presented under each variable (data presented as means and standard deviation (SD).

Variable	Group		Pre-Trial	Post-Trial	P value
Total Cholesterol (mmol/L) *4.0-5.5 mmol/L*	**CON**	**Mean**	4.82	4.56	<0.05
		SD	0.77	0.75	
	EXP	**Mean**	4.90	4.62	<0.05
		SD	0.99	0.92	
Blood Glucose (mmol/L) *4.0-5.4 mmol/L*	**CON**	**Mean**	5.37	5.24	<0.05
		SD	0.35	0.34	
	EXP	**Mean**	5.57	5.42	<0.05
		SD	0.40	0.47	
HDL(mmol/L) *1.0-1.5 mmol/L*	**CON**	**Mean**	1.22	1.22	0.321
		SD	0.35	0.39	
	EXP	**Mean**	1.37	1.34	0.221
		SD	0.39	0.39	
LDL(mmol/L) *2.6-3.4 mmol/L*	**CON**	**Mean**	2.94	2.81	0.345
		SD	0.82	0.77	
	EXP	**Mean**	2.87	2.78	0.521
		SD	0.96	0.86	
Triglycerides (mmol/L) *<1.7 mmol/L*	**CON**	**Mean**	1.32	1.17	<0.05
		SD	0.49	0.47	
	EXP	**Mean**	1.43	1.07	<0.05
		SD	0.87	0.39	
CRP(mmol/L) *Low risk <1.0 mmol/L* *Average risk 1-3 mmol/L* *High risk >3.0 mmol/L*	**CON**	**Mean**	1.37	1.10	<0.05
		SD	2.16	1.70	
	EXP	**Mean**	2.09	1.07	<0.05
		SD	2.56	0.39	

Blood Lipids

Mean circulating levels of Total Cholesterol (TC) and Triglycerides (TG) significantly reduced in both groups after trial completion compared to baseline ($P < 0.05$, see Table 3). In a further sub-analysis, no differences were observed for high-density lipoprotein (HDL) between the control and experimental-non ketogenic group compared to baseline. However, HDL significantly decreased compared with baseline jn those participants who were under ketosis ($P < 0.05$, see Figure 5).

Figure 5: High Density Lipoprotein (HDL) at baseline (empty bars) and after trial intervention (coloured bars) of Control (red column), Experimental- Non Ketogenic (blue column) and Experimental (Ketogenic) group.

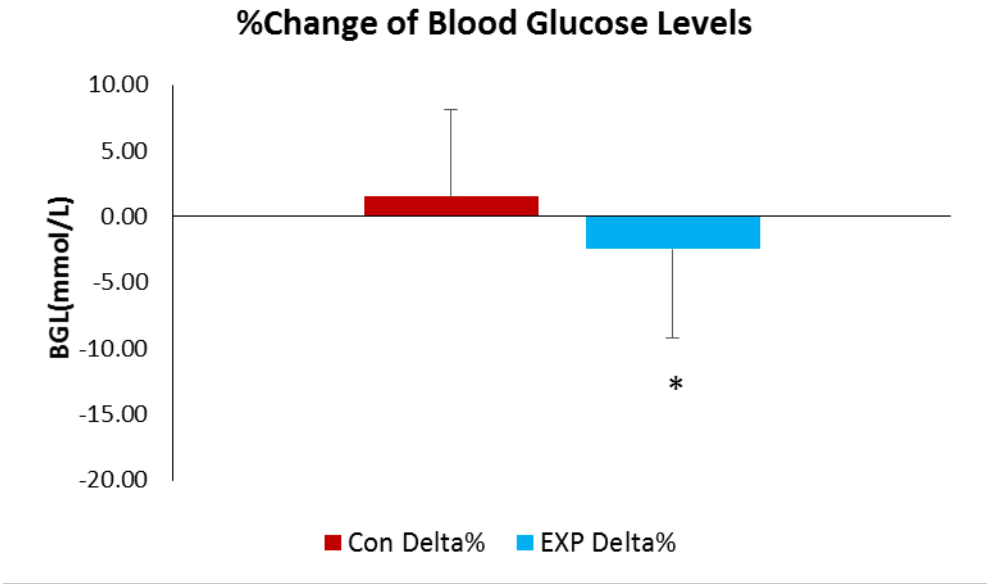


Data are presented as mean and SD; HDL, High Density Lipoprotein. ≠Significantly different to Pre; P<0.05.

Blood glucose levels

Mean levels of Blood Glucose Levels (BGL) significantly reduced in both groups after trial compared to baseline ($P < 0.05$, see Table 1). When the percentage change was explored, BGL demonstrated a significant reduction in the experimental group compared to the control group ($P < 0.05$, see Figure 6).

Figure 6: Percentage change of Blood Glucose Levels (BGL) in response to trial intervention of Control (red column) and Experimental (blue column) groups.



Data are presented as mean and SD; BGL, Blood Glucose Levels. *Significantly different to control; $P < 0.05$.

Inflammation levels

Mean levels of C-reactive protein (CRP) significantly reduced in both groups after trial compared to baseline ($P < 0.05$, see Table 1). However, no significant differences were observed between the two groups.

Psychological well being

Table 3 provides an overview of the DASS (Depression[1], Anxiety, & Stress Survey) scores for the experimental and control group at the start and end of the HEALS trial. The cohort as a whole showed significant decreases in symptoms of stress ($P < .001$) and anxiety ($P = .05$) with a large effect for stress ($\eta p^2 = .28$) and a medium effect for anxiety ($\eta p^2 = .08$). Depression symptoms also showed a downwards trend but this did not reach significance. Overall, participation in the HEALS trial seem to have improved their mental health.

Table 3: Mean scores and standard deviation for the DASS for the experimental and control condition at the pre- and post-test.

	Experimental (n = 25)		Control (n = 22)	
	Pre-test	Post-test	Pre-test	Post-test
Depression	2.72 (2.89)	2.20 (3.24)	1.91 (1.72)	1.23 (2.02)
Anxiety	2.04 (2.56)	1.52 (1.73)	1.45 (2.28)	1.00 (1.48)
Stress	4.68 (3.08)	3.08 (3.12)	3.64 (3.17)	3.05 (1.99)

Participant satisfaction with HEALS trial

Overall the participants in both the experimental and control groups were satisfied with the programme. The exercise component and the support provided showed that more than 85% of participants were very satisfied or satisfied (see Tables 4 and 5) with their experiences in the HEALS Trial. Not surprisingly, the experimental group was significantly more satisfied with the nutritional component of the Trial when compared to the control group ($P = .001$).

[1] N.B. Depression refers here number of symptoms, but it is not a clinical definition.

Table 4: Results of the survey assessing participants satisfaction with the HEALS trial. Reported are the frequencies and percentage for each response category.

	Experimental (n = 30)		Control (n = 27)	
Q1: Overall satisfaction with the Programme				
Very Satisfied	16	53.3%	11	40.7%
Satisfied	12	40.0%	12	44.4%
Ok	2	6.7%	3	11.1%
Dissatisfied	0	0%	1	3.7%
Very Dissatisfied	0	0%	0	0%
Q2: Satisfaction with the delivery of the exercise component of the programme				
Very Satisfied	18	60.0%	17	63.0%
Satisfied	8	26.7%	7	25.9%
Ok	4	13.3%	2	7.4%
Dissatisfied	0	0%	1	3.7%
Very Dissatisfied	0	0%	0	0%
Q3: Satisfaction with the delivery of the nutrition component of the programme				
Very Satisfied	17	56.7%	5	18.5%
Satisfied	9	30.0%	10	37.0%
Ok	3	10.0%	8	29.6%
Dissatisfied	1	3.3%	2	7.4%
Very Dissatisfied	0	0%	2	7.4%
Q4: Satisfaction with the support provided throughout the programme				
Very Satisfied	15	50.0%	13	48.1%
Satisfied	12	40.0%	10	37.0%
Ok	2	6.7%	2	7.4%
Dissatisfied	1	3.3%	2	7.4%
Very Dissatisfied	0	0%	0	0%

Table 5: Mean and standard deviation for the 4 programme evaluation questions and the results of the independent t-test.

	Experimental	Control	t(55)	P value
Q1 overall satisfaction	1.53 (0.63)	1.78 (0.80)	-1.29	.20
Q2 Satisfaction exercise	1.53 (0.73)	1.52 (0.80)	-0.07	.94
Q3 Satisfaction nutrition	1.60 (0.81)	2.48 (1.12)	-3.42	.001
Q4 Satisfaction support	1.63 (0.76)	1.74 (0.90)	-0.49	.63

Qualitative Results

Desired Quality dimension outcomes were:

- The Thr1ve product is:
    - Effective
    - Appropriate
    - Efficient
    - Safe
    - Accessible and
    - Sustainable
- The Thr1ve approach is:
    - Educates individuals to become self-reliant and engaged with their health, resulting in improved physical, mental, and social outcomes.
    - Contributes to improving the health of Australian through their products.

Qualitative Insights as per Desired Outcomes.

Evaluation Design

Evaluation trial exit interviews were conducted with 60 (94%) out of 64 participants. Four participants were not able to participate in these interviews due to personal reasons, such as illness and moving abroad. The interviews were conducted at the Institute of Health and Biomedical Sciences' laboratories, QUT. The average time of interviews were 42 minutes.

Description of Participants

As indicated in Table 1 A total of 64 participated completed the HEALS Randomized Controlled Trial, which were mainly recruited from the Kelvin Grove area and the CBD of Brisbane. The mean age of the participants was 35.3 years and their mean Body Mass Index

(BMI) was 30.3 kg/m^2, which categorises the cohort as clinically obese. Participants in both arms of the HEALS Trial in general were struggling to manage their weight and their lifestyles. They reported environmental (e.g. being on night duty as a nurse/driver) and cultural (e.g. huge consumption of sweets and rice) influences on their lifestyles. On the whole, they were unhappy about their poor lifestyles and many reported poor body image perceptions. The HEALS Trial, as oppose to the majority of weight management trials considered participants experiences in the trial. The focus of their experiences has helped them to become more self-reliant and showed good engagement with the Trial.

Exercise: All participants were inactive 6 month prior their recruitment to the Trial. In general they reported to have had poor understanding of how to exercise effectively, even those who had been members of a gym at some point in their lives. The majority of participants have held gym membership, but didn't use them due to lack of confidence, such as not knowing how to use the equipment, not sure of progression, fear of injury, not knowing the gym culture and felt intimidated by fitter and more regular gym users. They had poor understanding of how to train, even those who engaged in competitive sport previously.

Eating behaviours: All participants wanted to manage their weight and change their lifestyles when asked why they've wanted to participate in the study. They reported poor eating behaviours, such as consuming large portion sizes, 'eating the wrong food', 'having extras', feeling pressured to eat unhealthy food when visiting relatives, drinking socially (which is a big part of Australian culture), chronic dieting, lack of cooking skills, lack of cooking facilities at home, lack of meal preparation for the week ahead and being caught out with fast food when time pressured.

Outcomes – Overall perceptions

Exercise: All participants, regardless of randomisation, found the exercise program effective. The delivery of the program was crucial in achieving the aims of the HEALS Trial. In particular working with Exercise Physiologists (EP) was greatly valued by the participants. The EPs delivered the Thr1ve exercise program tailored to the needs and capabilities of the participants at the time of recruitment. Participants reported adaptations that fitted their personal needs, but without losing the effectiveness and overall content of the program. They unanimously reported improved fitness, which is also reflected in their Trial results. They also reported understanding of exercise principles, gained confidence in using the gym and their ability to complete their Thr1ve exercise routines independently. Post-Trial, they reported to feel comfortable to ask for help in the gym if they wanted someone to spot for them and/or take their place in the queue for equipment. For participants who had a regular exercise history it took on average of 2 weeks (3x a week working out with the EP) to learn the Thr1ve exercise routine. For participants who never had formal training, or participated in sport, on average it took about 4-5 weeks to learn the exercise program (8-10 sessions with the EP).

Eating behaviours: Participants in the Experimental Group in general found the meals acceptable to their needs, but many struggled with fully adhering to consuming the pre-prepared meals over the 8 week period. Most commonly cited issues were: the freshness of the food over the week; some difficulties in freezing the meal packages; not having a microwave or heating facilities at work; travelling for work; and not having cooking skills prevented some from cooking from the cookbook. The major barrier to adhering to consuming the pre-prepared meals were: blandness of food, lack of fresh vegetables,

boredom with consuming the same food more or less all the time, especially breakfast, and social occasions. As per the quantitative data shows, many of the participants in the experimental arm of the Trial fully adhered to program as they were in a ketogenic state.

Outcomes – Effectiveness of the Thr1ve lifestyle program and its delivery

Participants in the HEALS Trial were inactive and clinically obese at the start of the 8 week program, but all had become more active, therefore the HEALS Trial achieved all of its' Trial goals, which includes all of the participants' perceptions of their own success in the program. Those in the Experimental arm of the Trial, who adhered to the protocol according to their own adherence rating of 7 or above all had gained significant physiological and psychological benefits from the Thr1ve program.

> "I was really sporty a long time ago, but the consistency and the commitment and the extra motivation that the EP provided was great. I was really exciting to see from the beginning to end how much fitter we got".

> "We followed the whole program. I was size 14-16 and now I am 10-12.
> "I now ride to the gym 2-3 times a week. At first, I couldn't get up on the bridge on the bike, but now I don't get off it at all".

> "Exercise makes you really sharp. I was really interested in exercise and how it will affect you later. A lot of my relatives fall over and they never recover".

> "By the middle of the Trial, I could see everything had been changing. Everything was squeezed in. Over 8 weeks, I lost 6kgs. I didn't expect to lose this much weight".

> "We were quite strict with ourselves. Alcohol, only had red wine when I drank. No sugar, which was really hard initially not to have sugar in my tea and coffee – 3 cups a day with a spoonful a day. I wouldn't go back to have sugar now. I didn't get

headaches. If I got a reason I'll do it. Having a focus and this is what I had to do, I'll do it. The structure of the program helped with the discipline. Someone else saying not me, so I'll do it. The food was really acceptable."

Outcomes – Appropriateness of the Thr1ve lifestyle program and its delivery

The majority of the participants reported that the Thr1ve lifestyle program was appropriate to their needs.

"I learnt a lot of new exercises. Just started planking on Week 1 for 15 seconds on my knees, but now I can do 1 and half minute on my toes."

"For me, my weakness was sugar. Sugar was my problem and I didn't even see it. For the first week I kept crying. I was really cranky."

"Maybe more variation in the exercise program, but it was consistent and I learnt to get those exercises right. The harder exercises. I wouldn't have started on my own. I wouldn't have been confident without the trainer to do that. It was a good mix, it really worked. Not something that I would have chosen myself, but I could see exactly why the program works. I could tell what worked and why I've got those quick results. Exactly why it's programed like that and what it supposed to do".

Outcomes – Efficiency of the Thr1ve lifestyle program and its delivery

The Thr1ve lifestyle program was efficient. Participants receiving the pre-prepared meals found the meals delivery and the product efficient, which suited their needs. The exercise program required a lot of planning, but the majority of participants were willing to invest their time, as they quickly saw and felt results they were aspiring to achieve.

"I've done really well, but you can only do so much in 8 weeks."

"We are doing the Trial, it has been really good for us so far. Need that encouragements and you've got support there and everything is there. When is the next Trial?"

"I did cook a couple of things from the book too. It made it very easy. Especially, I am very busy. Another thing I didn't have to think about it. When the food runs out, it wouldn't be hard to transition to that food. Enough variations in there. Addicted to sweet potato chips. Easy stuff to cook. I cooked for everyone for the family. I didn't eat the pancakes and much of the breakfast, substituted them for boiled eggs. The food was good and it was easy. Swapped in some other meals."

"The meals were just easy. The meat was good. It was moist. Enough variety of vegetables. If this food was available, I would buy that food. A week on and a week off. The breakfast was a bit difficult for me – more variety. One cheat day a week please."

"We are in a good routine now. I'll try to fit the stuff I will do for myself. I enjoyed the stuff I've been cooking and would like to do more cooking. Planning ahead. Plan the day around and prioritized the food and exercise. Not to be caught out, when you get busy and you've not thought about what's in the fridge. There is nothing there that I can eat. Being prepared."

Outcomes – Safety of the Thr1ve lifestyle program and its delivery

QUT exercise physiology and sport science students were recruited to help participant to learn to exercise safely, using the correct exercise techniques. The Research Team provided continuous support to participants with all of their queries.

"I was quite shy to go to a gym. I was going to classes before and I really hurt myself. It took me six month to recover. The EP made sure that I'm not going to hurt myself. It was great."

"I feel safe and confident doing the exercise program."

Outcomes – Accessibility of the Thr1ve lifestyle program and its delivery

The HEALS Trial was accessible to participants. They were recruited from the local Kelvin Grove and Brisbane CBD area making it convenient for them to attend to the weekly exercise sessions and pick up their food packages.

"I appreciate it the support was free. I don't have the money for the gym, it's a luxury for myself."

"I was really happy that I didn't have to cook. Just heat the meals up".

"Everyone was really supportive within the Trial. Our experience was really good and we got lots of support and the EP was great. Our experience was really good. Everyone made it very easy for us. We were encouraged".

"It was all really hard and each week we pushed ourselves, it never got easy or enjoyable as such, but it was convenient to go to Kelvin Grove."

Outcomes – Sustainability of the Thr1ve lifestyle program and its delivery

What makes the Thr1ve programme sustainable?

- Working with an EP for sufficient time to improve exercise skills and confidence of participants; working out with a partner; following a set program with adaptation and progression; participants choosing to adhere for their personal reasons that are multi-

factorial; education, and support from the researchers for queries about a wide ranging questions about the Trial.

- Availability of pre-prepared meals at an affordable price was also important to the participants. Many expressed that they would be happy to buy the meals as a substitute for take-away meals, especially due to lack of food planning and time pressures.
- Most participants preferred if the meat was sold separately from the vegetables, as it was easier to freeze, because then they can consume fresh vegetables and salads.
- Many participants reported difficulties to adhering the pre-prepared meals and reduced alcohol intake due to social occasions. They suggested that the company would develop 'social meal' packages that they could take to such events.
- Participants reported to be more organised in scheduling exercise sessions into their busy lives and planning for weekly meals helped them to adhere to the Trial protocol.
- Many reported that initially, meeting the EP in the gym motivated them to attend, even though they may have wanted to skip a session. However, this has changed about 4 weeks into the Trial, when most felt more confident in their abilities to conduct their exercise prescriptions independently if needed.

"Having a friend to do it with was really good. We wanted to get better and stronger".

"I am motivated by the feedback I get from others, such as 'you've lost so much weight".

Some participants wanted to be told what to do:

"My commitment was to you that I participate and do what you told me to do. The program was designed for us and it has worked. You have to stick to the food and you have to stick to the exercise. It works. If you stick to it, it work. It would be impossible to do an 8 week training and to eat the food that we had and not see the difference. I lost a stone. I think I needed this trial to get off sugar."

"Now I am looking at the 32 week program. I feel like I am a third way through. All for nothing. All you have to do it. It's a great opportunity for anyone to improve their longevity."

"Having buddy support was essential to be able to keep to the Trial protocol, going to exercise and during socialising."

"Enjoyed working with an EP, as she motivated me and made me push myself more, and gaining more confidence in my skills".

"I have kids and run my own business, so it was hard to juggle and make sure that we put times in, we scheduled those sessions in."

"I had to priorities myself, and having that accountability was important."

"Flexibility in the EP and make time to fit in with client's schedule."

Discussion of the study findings

We will discuss the main physiological, body composition, haematological and qualitative findings of the HEALS trial below.

Cardiorespiratory fitness

Nutritional practices have been shown to have a significant influence on resting metabolic rate and training adaptation (Hawley & Burke, 2010). For example, there have been suggestions that low carbohydrate levels in daily nutritional intake enhance training adaptation (Hansen et al., 2005). To this end, studies have examined the efficacy of high fat, low carbohydrate diets (ketogenic diet) on exercise metabolism and training adaptations. Although results are still equivocal, ketogenic diets have not been shown to compromise aerobic endurance (Lambert et al., 1994) or strength (Paoli et al., 2012). If anything, research suggests that for endurance athletes' ketogenic diets slowed down carbohydrate utilization during prolonged exercise, enhancing their performance outcomes.

Despite following a similar exercise protocol, the experimental group demonstrated a greater post-trial improvement in the VO_{2peak} compared to the control group (see Figure 3). Three possible explanations may explain this finding. First, this might be due to a greater post-trial reduction in overall body composition for the experimental group. This was indexed by greater reduction in Fat Mass Index in the experimental group (-2% compared to the control group +0.5%). Although not significant, the experimental group also showed a greater reduction in total body fat. Overall, body composition is an important determinant of cardiorespiratory fitness. Secondly, increased fat oxidation induced by ketogenic diet has been shown to improve circulation and oxygen transport to the working muscles (e.g., Helge et al., 2001), and also to reduce lactate concentration during maximal effort (Zajec et al.,

2014). Finally, there have been suggestions that a ketogenic diet changes sympathetic activation (Havemann et al., 2005). However, from the results of the HEALS trial it is not possible to establish which mechanisms are most likely to account for this finding.

A study by Brinkworth et al. (2008) examined the effect of an 8 week low carbohydrate diet on aerobic capacity in normal weight (mean age 49.2 years) and obese individuals (BMI between 26 and 43 kg/m^2). This study showed that the low carbohydrate diet resulted in greater fat oxidation during exercise. This shift in fuel utilisation, however, did not influence maximal or submaximal aerobic performance in that study. Therefore, the authors recommended to investigate the interaction between low carbohydrate diet with regular exercise training. The HEALS Trial added new knowledge to this field by demonstrating that VO_{2peak} increased nearly 11% in the experimental group who followed a structured exercise programme and a ketogenic diet.

Body composition

The HEALS trial demonstrated a significant decrease in Total Body Fat and Visceral Adipose Tissue in both groups compared with baseline values. However, the experimental group showed a significantly greater decrease in Fat Mass Index compared with the control group (-2% vs. +0.5%). Importantly, those who strictly adhered to the experimental condition's protocol (i.e., those who achieved ketosis as indexed by a beta-hydroxybutyrate level > 0.3 mmol/L) showed the greatest change in total body fat (see Figure 5). This suggest that adherence to the protocol was important. However, it also shows that in the experimental group those who did not strictly followed the ketogenic diet also benefitted and lost significant levels of body fat.

A meta-analysis (Miller et al., 1997) found that a diet and exercise programmes need to be over an average period of 13.4 weeks to be effective, with an average of 7.3% body fat loss. The findings from this study also showed that diet alone interventions were associated with 6.0% (average 15.1 weeks) and exercise alone with 3.5% (average of 20.9 weeks) decrease in fat mass. Participants in the HEALS Trial achieved similar reductions despite having a much shorter period of intervention of 8 weeks, which is also much more cost effective.

Similar to other studies the HEALS trial found that the ketogenic diet was associated with a significant reduction in Lean Body Mass (see Figure 6). For example, Noakes et al. (2006) found a 2.6% decrease in lean mass following an 8-week low carbohydrate diet in middle aged (mean age 48 years) obese (mean BMI 33 kg/m^2) individuals. On the other hand, Volek et al. (2002) found that a 6-week carbohydrate restricted diet in normal weight men (mean age 36.7 years) resulted in 17.6% body fat loss and a 1.8% increase in lean body mass.

A ketogenic diet should provide sufficient levels of proteins and calories for muscle protein synthesis, however, it has been also suggested that a ketogenic diet influences metabolic pathways and molecular processes because of the induction of a state akin to fasting (Vargas et al., 2018). The above may explain why to date results regarding the role of a ketogenic diet on muscle hypertrophy are still equivocal.

To date, most studies have either not included exercise in their protocols or have utilised only aerobic exercise interventions. Few studies have examined the role of a ketogenic diet with resistance training or a combination of aerobic and resistance training (as the HEALS Trial does). To this end, findings in the present study, in which participants followed a ketogenic diet and engaged in both aerobic and resistance training, are similar to a study by Vargas et al. (2018). They found that trained young men (mean age 30 years; BMI 23.4 kg/m2)

following a ketogenic diet and intensive resistance training programme over an 8-week period decreased fat mass (-8.1%) and visceral adipose tissue (-14%) but did not increase lean body mass. Similar results were reported by Paoli et al. (2012) in elite male artistic gymnasts (mean age 20.9 years), in which a ketogenic diet was associated with reduced body weight and fat but did not affect lean body mass nor did it influence strength performance.

A combination of aerobic and resistance training is more likely to result in meaningful body composition changes in overweight or obese individuals (Wills et al., 2012). However, when combining this with a ketogenic diet there is a need to closely monitor protein consumption and a caloric surplus whilst engaging in exercise to ensure the maintenance or enhancement of lean body mass.

Blood Lipids

There is an abundance of evidence that lifestyle changes like exercise and diet have a positive influence on blood lipids (e.g. Carroll et al., 2007). The HEALS trial found that both conditions lowered their Total Cholesterol (control = - 4.8%; experimental = -5.7%) and Triglycerides (control = -11.4% and experimental = -25.2%) levels significantly. Total cholesterol is a strong predictor for cardiovascular disease with higher risk for men compared to women (Peters et al., 2016). Ideal levels of total cholesterol levels in the blood are < 5 mmol/L. On average, the participants in the HEALS trial were below this level although the mean at the pre-trial for the experimental group was close to 5 mmol/L, indicating high risk for diabetes and cardiovascular disease. Other studies that have implemented a ketogenic diet (but not exercise) have not reported significant decreases in Total Cholesterol levels. For example, in the study by Noakes et al. (2006), no changes were reported and the average Total Cholesterol for the low carbohydrate condition in this study remained above 5 mmol/L.

As such it might be that exercise attenuates a reduction in Total Cholesterol whilst following a ketogenic diet.

High levels of Triglycerides are associated with the metabolic syndrome (e.g., Grundy, 2016). Normal levels are below 1.7 mmol/L. Similarly to Total Cholesterol the mean Triglycerides levels for both groups in the HEALS trial were within the normal range at the start of the trial (although higher for the experimental group). The significant decrease observed was similar to Noakes et al.'s study (2006). Another study by Yancy et al. (2004) examining the effect of a ketogenic diet in hyperlipidemic overweight middle aged individuals resulted in a 48% reduction in Triglycerides levels after 24 weeks. However, in a study assessing the efficacy of Jenny Craig diet no differences were found at 6 or 12 months in overweight or obese women (Rock et al. 2007). Baetage et al. (2017), in a 12 week diet intervention programme with obese women (mean age = 47 years; mean BMI = 35 kg/m^2) also did not find changes in Triglyceride levels when testing the Jenny Craig or Nutrisystem programme. However, this study showed decrease in Triglycerides levels in the Weight Watchers and Curves programme arms.

In the HEALS Trial, blood glucose levels also decreased in both conditions although significantly more in the experimental group (-2.4% vs. -2.7%). Australian guidelines suggest that fasting blood glucose levels should be between 4-7.8 mmol/L. This was the case for both groups. The study by Baetage et al. (2017), which compared four commercially available weight loss programs (Curves, Weight Watchers, Jenny Craig, Nutrisystem) did not find significant changes following the 12 week intervention.

The decrease in Total Cholesterol, Triglycerides and fasting Blood Glucose are important for the future health of the participants by reducing the risk of developing chronic diseases.

These improvements in blood lipids seem to be more pronounced when following a ketogenic diet whilst engaging in regular aerobic and resistance exercise.

The HEALS trial did not find significant changes in LDL or HDL levels. A sub-analysis, however, revealed that those who adhered best in the experimental condition showed a decrease in HDL levels. In principle, higher levels of HDL are desirably. Inspection of Figure 5 shows that those high on adherence in the experimental group had higher initial HDL levels. As such, it could be argued that they returned to the same levels as the other participants in the study. Studies using ketogenic diets have reported no changes in HDL or LDL (e.g., Yancy et al., 2017) or an increase in LDL (Noakes et al., 2006). Similarly, in the study by Rock et al. (2017) comparing four commercial weight loss programmes no changes in LDL were observed, whereas HDL decreased in Jenny Craig and Nutrisystem arms of the study.

Finally, there was a significant decrease in inflammation levels indexed by significantly lower C-reactive protein levels. This was the case in both the control and experimental condition. This suggest that it is the regular participation in aerobic and resistance exercise which helped to reduce inflammation levels. This is supported by the study of Rock et al. (2010) in which overweight or obese women (BMI 25-40; mean age = 44 years) did not result in a change in C-reactive protein concentrations.

Psychological well-being

All participants in the HEALS trial showed a significant decrease in their stress and anxiety levels. This finding is not surprising. Regular exercise participation has been shown to have a positive influence on mental well-being. In addition, weight loss itself has been associated

with improved well-being (Swencionis et al, 2013). Overall, these findings indicate that participation in the HEALS trial was beneficial to the mental well-being of all participants.

Trial delivery and participant perceptions of the HEALS Trial

The HEAL's Trial protocol followed evidence based practice guidelines to maximise adherence and engagement with the Thr1ve product. The HEALS Team recruited trainee exercise physiologists (EPs) to cue, monitor, and create a personalised experience for the participants (Jeffrey et al., 1998). This was an extremely important part of the Trial, as it served the purpose of engagement, accountability, injury prevention, and as an incentive to engage fully with the Trial. For example, the value of the EPs is clearly illustrated in the quote below:

> "I think there is one thing I probably shouldn't have done, it was my own thinking, because I wanted to achieve the best I could, the maximum I could, every week, I was doing more exercise then prescribed and increased my reps and weight, but when increasing the weight, you also have to have the correct form, and I've noticed that my shoulder, after putting the dumbbell down, after bench press, I've noticed that my shoulder at the front started to hurt, so then on I told my trainer, who said, don't do that. Go up to a more reasonable training weight. We will get to higher weights when you are stronger and able to keep the correct form. I didn't know that. I thought more weight was good. I didn't know that. I was just trying to get into it. So the correct form is the right thing. I guess, the only thing that happened. That's probably a great thing that personal trainers do. Light weights and correct form is important especially in the beginning".

The EP in the above example prevented a serious injury to occur, especially if the participant did carry on with those non-evidence based 'enthusiastic training add ons', which is very typical when someone who has been really fit and had 10 years out of exercise will try to do when they are returning to regular training. Therefore, the direct manipulation of the environment as per the HEALS Team' protocol is good practice (Jeffrey et al., 1998), and resulted in good attendance and compliance rates. The combination of such support by the wider HEALS Team and the EPs, resulted in a significant increase of motivation to participate and improved participants' self-reported self-regulatory skills (e.g., willing to re-organise work and home schedules, planning for meals out of house and the week ahead, planning for exercise sessions, organising child caring duties, and financial planning). For example, they no longer prioritised work commitments without considering their own exercise and food consumption needs. Participants were further motivated by experiencing weight loss and/or changing body shape and composition in spite of significant weight loss. Experiencing better mental and physical health from about the 3-4th week of the Trial was noteworthy in improving participants' motivation to succeed. Through their weekly audio diaries and the regular feedback on these diary contents from the HEALS Team resulted in development of self-regulatory skills. Participants were able to find their own solutions to their eating and exercise issues with the guidance of the Team. Participants recognised that that HEALS Team truly cared about their well-being, which was reflected in all of the evaluation narratives and quantitative evaluation of the trial. Future studies would benefit from additional planning for supporting participants further after a trial completion. If Thr1ve packages the combined program, than the addition of program instructions/guidance as to how consumers can continue with their health quests following completion of the 8-week programme would be a welcome addition. Participants described how gym PTs or even

regular ones had limited expertise compared to the experiences they've had with the EPs. This would make sense, given that they are trained for 4 years at university level. Participants no longer had a fear of gym use, such as asking to use an equipment, knowing how to use the gym and become comfortable with using any equipment in other gyms than the Trial gym setting. They were also able to continue with the Thrive exercise plan and were confident to adapt it to their own needs. Thr1ve might consider to develop modular health units that are adaptable with regular follow ups. Weight loss and fitness mattered to participants, but they couldn't do it alone, as per their previous experiences, when they failed without support. The HEALS Trial, provided that initial support and flexibility, which then resulted in a very high engagement.

Psychological flexibility, which is defined as "an ability to focus on the present moment and, depending on what the situation affords, to persist with or change one's behaviour in the pursuit of goals and values" (Elina et al., 2012, p. 1) was a key aspect of engagement. This skill can be taught and the HEALS Team coached participants through their weekly video/audio reflections how to think about their own training and eating habits differently. This might be important to Thr1ve to consider. Flexibility in the protocol delivery was key to meeting the needs of the participants.

Limitations

Like any research project this study is not without some limitations. Recent evidence demonstrate that pre-prepared meals result in greater weight and fat loss than a standard self-selected diet (Rock et al., 2016). However, due to feasibility reasons this study was able to only provide the intervention group with pre-prepared meals, therefore the control group was provided with dietary advice only. That said, in the real world it would be unsustainable to

provide participants with food and ultimately individuals will have to take responsibility for their own nutritional practices. Not providing the control group with pre-prepared food in this instance does enhance the ecological validity of the research design. Another limitation is the lack of detailed dietary intake data from the control group. Participants were encouraged to self-monitor dietary intake through daily log book reports. However, adherence this protocol by this cohort was poor, but not unexpected. Studies have reported consistent poor compliance with weekly logbooks and self-reported dietary surveys, which are also have well recognised limitations in accuracy, such as underreporting and misreporting especially among overweight and obese individuals (Howat, Mohan, Champagne, Monlezum, Wozniak & Bray, 1994, Vance, Woodruff, McCargar et al., 2009).

Both study groups demonstrated significant reductions in body fat however, a greater body fat reduction was observed in those assigned to pre-prepared meals. This could be due to the reduced total energy intake induced by the portion controlled pre-prepared meals provided to the experimental group compared to the standard self-selected diet that control participants underwent. Lastly, pre-prepared meals were provided without cost to the participants, as is also the case in other similar trials (e.g. Unick et al., 2015; Ebbeling et al., 2018), which may affect generalisability.

Conclusion

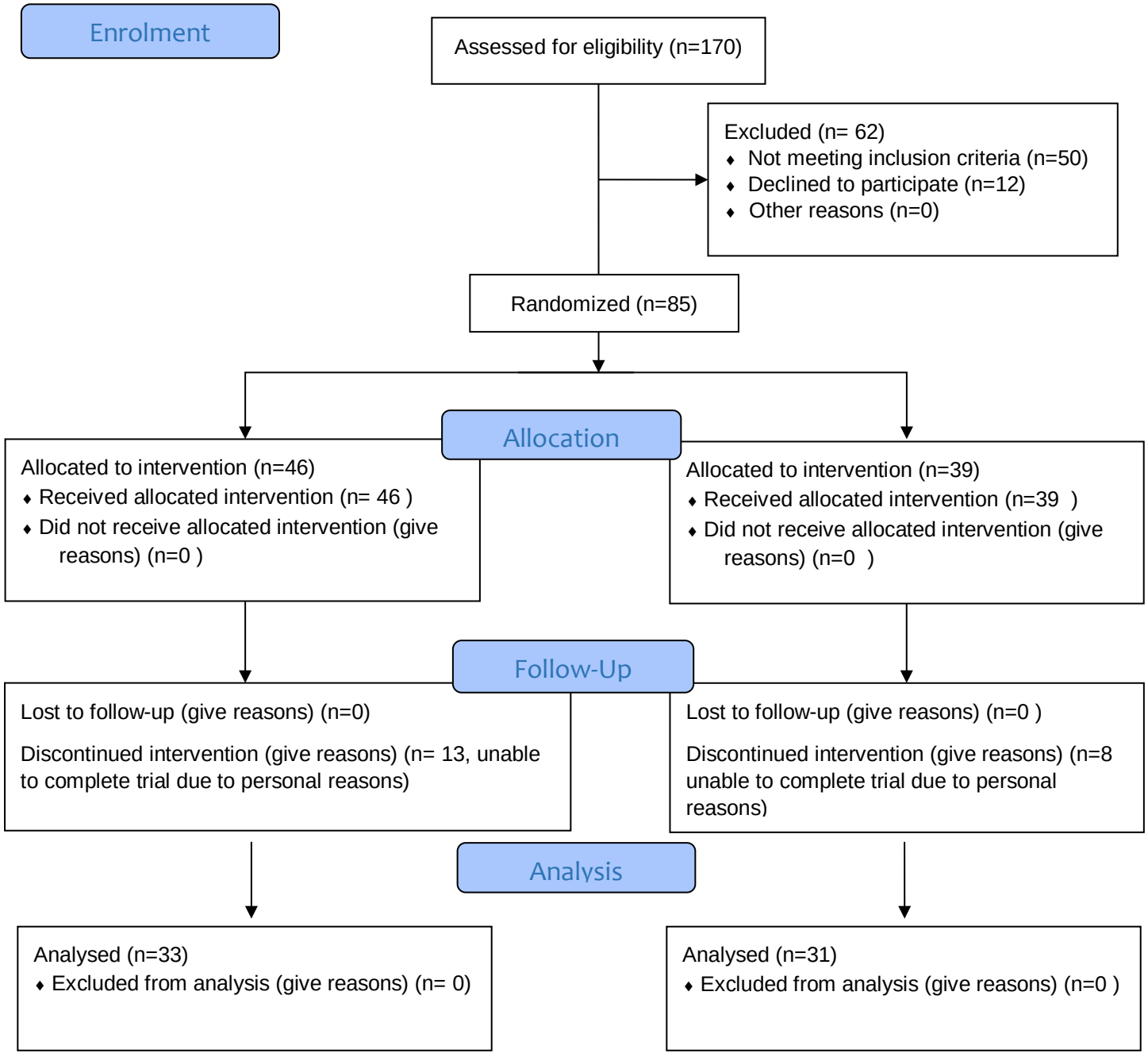
The Thr1ve combined product of exercise matched with ketogenic nutritional diet provision has benefitted participants' health in a number of ways. Both groups improved their overall health, but the experimental group benefitted significantly more from the Trial. The key aspect of the Thr1ve product is its holistic nature. An exercise program that is suited all levels of ability when delivered and taught by exercise physiologist, who made adaptions and

personalised the program to the participants' needs. This can be also achieved by personal trainers (PTs), but the key elements that PTs don't usually do are the following: Client centeredness (e.g. help the client what they want and can do); building exercise and gym use confidence, constant feedback and explanation on skill, form, and condition of participants in a session and throughout the Trial, flexibility in arranging times to meet with participants, and most importantly providing alternatives to exercises they cannot do. The HEALS Trial cohort had not been exercising for at least 6 months prior to the participation in the Trial, and were clinically obese. Therefore, the Thr1ve exercise product has been shown to make a significant difference in obese clients' physical and mental health, at least over the 8 week period. This is key when working with health providers and insurers and something that the company could explore in more detail.

The ketogenic diet provided to the experimental group which was matched to participants exercise routine resulted in some additional benefits. Although it is inherently difficult to follow a pre-packaged meal plan for 8 weeks, most participants, as per objective blood measures, were in ketogenic state at the end of 8-weeks. Participants were required to go through a significant behaviour change process. They weren't the motivated, super fit cohort that usually would look for a product such as Thr1ve's. Their obesity levels and the weekly video/voice records clearly indicated their struggles to change their behaviours, especially curbing their sugar and high carb habits, such as having sugar in tea and coffee. It would be beneficial for Thr1ve to have a behavioural scientist working in their teams to help participants to find solutions to their own eating behaviour habits. The quality of food in general was well received, but there were some issues around the food being blend, freshness of vegetables and some packages didn't freeze well. However, this must be considered in the context of this Trial only, as individuals wouldn't normally follow such a strict trial protocol

in real life. It can be concluded that participants want to have the product as part of their regular eating habits and as alternatives to ‘usual take out meals’ when time poor. The meat alone without vegetables would work well. Also, there needs to be more guidance about breakfast and fruit consumption to consumers in the future. Again, the HEALS Trial showed the clear health benefits of ketogenic diet for obese clients (in terms of increased fitness, reduction in Fat Mass Index, and reduction in percentage body fat in those achieving a ketogenic state), which can be a key selling point of the Thr1ve product.

Appendix A: CONSORT Flow Diagram



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