Long-term sustainability of a physical activity and nutrition intervention for rural adults with or at risk of metabolic syndrome

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Abstract

Objective: To determine longer-term (18-month) sustainability of a six-month physical activity and nutrition intervention for 50–69-year-olds with or at risk of metabolic syndrome residing in a rural Australian community.

Methods: Participants (n=151) were followed-up at 12 and 18 months post-intervention. Changes in nutrition behaviours (fat and fibre barometer); physical activity behaviours (IPAQ); anthropometry (waist-hip ratio, weight, BMI), blood pressure, blood parameters (triglycerides, glucose, LDL-, HDL-, non-HDL, total-cholesterol) were analysed using *t*-tests and repeated measures ANOVA.

Results: Across three time points (6, 12 and 18 months) marginal decrease was observed for waist circumference (p=0.001), a modest increase was observed for diastolic blood pressure (p=0.010) and other outcome measures remained stable.

Conclusion: Maintenance and ongoing improvement of health behaviours in the longer-term is challenging. Future studies must look for ways to embed interventions into communities so they are sustainable and investigate new approaches to reduce the risk of chronic disease.

Implications for public health: Metabolic syndrome is a major health issue in Australia and worldwide. Early identification and management are required to prevent the progression to chronic disease. This 18-month follow-up showed that outcomes measures remained relatively stable; however, there is a need to investigate opportunities for embedded community interventions to support long-term health behaviour change.

Key words: chronic disease, physical activity, home-based

Older people experience a high prevalence of overweight, obesity and metabolic syndrome,[1-4] with these health issues being particularly prevalent in rural, remote and farming communities in Australia.[1,5-8] Evidence suggests that middle-aged and older Australians are at particularly high risk of these health issues, as they are typically associated with sedentary behaviour, lack of participation in non-household physical activities and low fruit and vegetable intake.[9-13] For those living outside urban areas, these factors are additionally compounded by lack of infrastructure and services, age-based stigma and reduced mobility.[14,15] Common health outcomes include significant increases in the likelihood of such individuals developing type 2 diabetes, cardiovascular issues or other chronic disabilities.[16,17] Interventions encouraging an increase in levels of physical activity and improved nutrition can reduce the likelihood of developing these diseases.[18,19]

A study undertaken with rural Western Australia adults aged 50 to 69 years who had either developed or were at risk of developing metabolic syndrome showed promising outcomes as a result of a six-month home-based physical activity and nutrition intervention.[20-23] The intervention aimed to bring the participants' nutrition and levels of physical activity closer to those recommended by the Australian Dietary Guidelines and the Physical Activity and Sedentary Behaviour Guidelines[24,25] through regular check-ins (at weeks 3, 6, 12, 18 and 24), provision of information and goal-setting with motivational interviewing.[26-28] Participants were provided with meal plans and recipes that encouraged healthy eating and a physical activity program that included aerobic, strength and flexibility exercises. They had access to a website, where they could track their progress, and a bi-monthly newsletter. At the conclusion of the six-month intervention, participants (n=151) showed significant improvements in levels of moderate-intensity physical activity and fibre and vegetable intake, as well as improvement in triglycerides, total cholesterol, non-HDL cholesterol, waist circumference, waist-to-hip ratio, weight, and body mass index (BMI) when compared to a control group.[22]

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These findings are consistent with similar intervention strategies utilised with cohort studies.[26,29-31]

Despite the reported success of this and similar physical activity and nutrition behavioural interventions of medium duration (six months),[32-36] longer-term efficacy is rarely assessed. This short-term intervention evaluation is also exhibited in programs with a diabetes focus. For example, a meta-analysis of 28 diabetes intervention programs showed significant retention of lost weight by participants; however, evaluation of health outcome maintenance was capped at an average of nine months.[37] Similarly, while longer-term interventions (both clinical and community-based) have also shown significant and sustained improvement in metrics such as weight and nutrition intake, evaluation of efficacy typically ceases at the end of the trial.[38,39] For the limited number of programs that were evaluated 12 or more months post-intervention, mean weight loss was found to decrease at 12 months (-0.6 kg to -1.7kg), compared to losses at 6 months (3.5 to 4.4 kg).[40] Additionally, a significant number of the studies included in the meta-analysis focused on peer-based or professionally delivered education as the central platform.[37] Although education can be a positive factor in promoting weight loss and improved health, it is not directly correlated with longer-term success.[41]

This longitudinal study provides an evaluation of the findings from 12-month and 18-month follow-up of a six-month home-based intervention. It aimed to determine the impact of a follow-up home-based program to improve nutrition and physical activity behaviours in 50–69-year-olds with or at risk of metabolic syndrome.

Method

Study design

This 18-month prospective study followed adults aged 50 to 69 years, with or at risk of metabolic syndrome, residing in a rural area in Western Australia. Ethical approval was granted by the Human Research Ethics Committee of Curtin University (HR149-2013). The initial RCT was registered at the Australian New Zealand Clinical Trials Registry (ACTRN 12614000512628).

Participants

At the baseline recruitment of the original randomised controlled trial (RCT), participants were required to be aged between 50 and 69, physically inactive (<150 minutes of moderate-intensity physical activity per week) and meet the metabolic syndrome criteria set out by the International Diabetes Federation (IDF).[42] The IDF definition includes a large waist circumference as the minimum requirement (waist circumference ≥94 cm for men or ≥80 cm for women [Europids, Sub-Saharan Africans, Eastern Mediterranean, Middle East]; ≥90cm for men or ≥80cm for women [South Asians, Chinese, Japanese]), plus any two of the following parameters: raised triglyceride level (≥1.7 mM, or treatment for this); reduced high-density lipoprotein (HDL) cholesterol (<1.03 mM in males and <1.29 mM in females, or treatment for this); raised blood pressure (systolic ≥130 mmHg or diastolic ≥85 mmHg, or treatment of previously diagnosed hypertension); raised fasting plasma glucose (≥5.6 mM). Participants who only satisfied the central obesity and one additional criterion were included in the initial RCT and categorised as 'at risk'. Participants were excluded if they had a previous diagnosis of acquired diabetes mellitus; were undergoing blood glucose reduction treatment; were already undertaking a weight loss diet or physical activity program; had experienced weight fluctuations of >5% within the previous six months; or shared a household with other recruited participants in the RCT (to avoid contamination).

Procedure

Screening stage 1: Potential participants were initially screened via the Computer Assisted Telephone Interview system. Screening incorporated the diabetes risk factors based on AUSDRISK,[43] which identified 1,060 individuals with a high risk of developing type 2 diabetes mellitus.

Screening stage 2: Those meeting the initial selection criteria and indicating an interest in the RCT were sent information explaining the home-based intervention. An appointment was made for them to attend a central location to complete a questionnaire. Anthropometric measurements were also taken at this stage.

Screening stage 3: Participants with confirmed central obesity attended a blood collection centre for a fasting blood sample (triglycerides, glucose and cholesterol) to determine their metabolic syndrome status. In total, 201 intervention group participants entered the initial RCT at t1 and were followed up at t2 (six months), t3 (12 months) and t4 (18 months). All participants were informed of the research aim and objectives, and that confidentiality would be maintained. Information sheets and consent forms were distributed prior to entry into the program and participants were aware of their freedom to withdraw from the program at any time

Intervention

After the completion of the initial six-month home-based physical activity and nutrition intervention, data were collected at t2. A full description of the initial intervention program has been published elsewhere.[21] Two follow-ups were then completed with participants at 12 months (t3) and 18 months (t4). The follow-up intervention consisted of the same information booklet on meal planning, healthy nutrition and recommendations for safe and effective physical activity, as provided during the initial six-month intervention. Participants also received two follow-up telephone calls between t2 and t3, and t3 and t4. The control group was waitlisted and received the intervention materials at t2 and as such was not considered to be a true control group for the present study at t3 and t4. This paper therefore focused on the intervention group participants only.

Measures and statistical analysis

Several approaches were used to evaluate participants' behaviours and physiological metrics. A self-report questionnaire was completed by participants at all four time points (t1–t4), comprising the International Physical Activity Questionnaire (IPAQ),[44] which has undergone reliability and validity testing and is specifically designed for population-based physical activity studies;[44] and the fat and fibre barometer (FFB), a brief food behaviour questionnaire (20 items) that has been found to have good internal consistency (α=0.86) and test-retest reliability (r=0.92). The validity of the instrument has been assessed by comparing it to the food frequency questionnaire, which indicated fair to moderate agreement.[45] Blood samples were taken by a phlebotomist at t1, t2 and t4 to measure a range of markers. Fasting plasma glucose was measured to assess insulin sensitivity. Fasting lipid levels were also determined to assess lipid profile and CVD risk. The concentrations of triglycerides, total cholesterol and HDL cholesterol were measured allowing assessment of total, LDL-,

HDL-, and non-HDL-cholesterol levels.[46,47] Anthropometric measurements were undertaken by a certified anthropometrist at all four time points (t1–t4), which included height, weight, waist and hip circumference using a portable stadiometer, weight scale and tape measures, respectively.[48,49] Blood pressure was measured at all four time points (t1–t4) using an Omron M5-1 electronic sphygmomanometer. A mean value was obtained after taking three consecutive measurements. See Figure 1 for a summary of data collection at the four time points.

Descriptive statistics were first applied to summarise the baseline characteristics of the intervention group participants. Paired sample t-tests and repeated measures ANOVA were performed to determine if significant changes in: a) the physical activity and nutrition outcomes and anthropometric (including blood pressure) measurements had occurred from post-program at t2 to follow-up at t3 and t4 of data collection; and b) the blood parameters had occurred between t2 and follow-up at t4. Wilcoxon signed-rank tests were applied to those variables exhibiting skewed distributions. The SPSS package version 25 was used to perform all statistical analyses.

Results

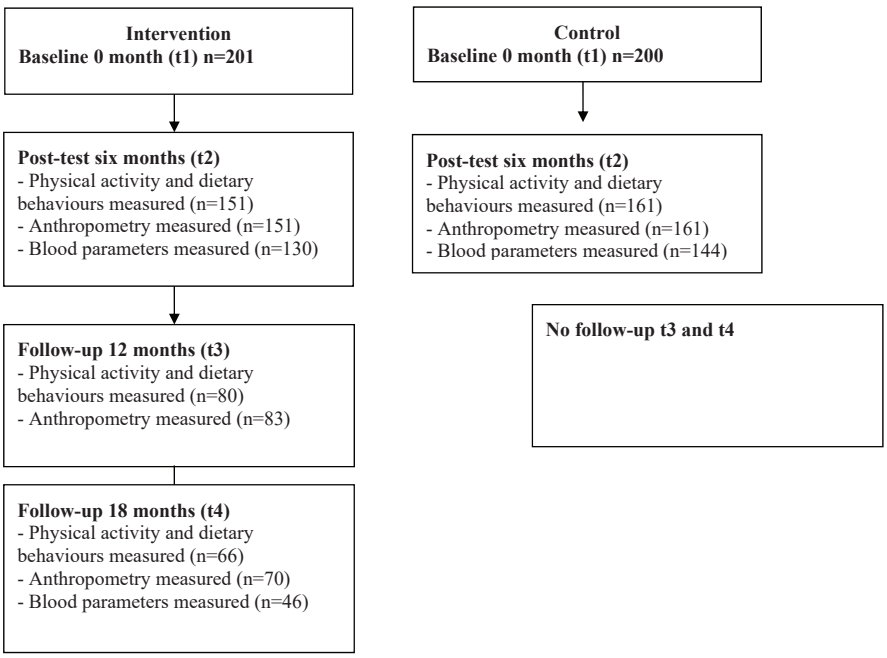
The study progress chart (Figure 1) shows the sample sizes at t1, t2, t3 and t4 for the corresponding outcomes. The overall retention rate from t2 to t4 was 43.7%. Table 1 shows the demographics of participants at t2 for the present study. The intervention group contained mostly female participants (66.2%) with a mean age of 61 years (SD = 5.64).

Table 2 shows physical activity and dietary outcomes over three time points (t2, t3, t4). There were no significant differences in physical activity levels between any of the time points. A marginal decrease in fruit intake was reported from t2 to t3 (p=0.042).

Table 3 provides the changes in blood parameters between the two time points (t2, t4). An apparent increase in glucose (+0.15 mM, p=0.001) and a marginal decrease in HDL cholesterol (-0.04 mM, p=0.039) was observed between t2 and t4. There were no significant changes in other blood parameters.

Table 4 shows the changes in anthropometric measurements and blood pressure in three time points. Marginal increases in weight (+0.20 kg, p=0.049), body fat (0.20%, p=0.035) and diastolic blood pressure (+3.49 mmHg, p=0.007) were observed between t2 and t3. At 18-month follow-up, the intervention participants had a lower body fat percentage (-0.55%, p=0.012) relative to the 12-month measurement. Across the three time points, a marginal decrease was observed for waist circumference (p=0.001) and an increase was observed for diastolic blood pressure (p=0.010).

Figure 1: Flowchart of progress from the RCT (baseline and six month post-test) to the 12- and 18-month follow-ups for the intervention group.



Discussion

This prospective follow-up study examined the sustainability of an intervention that aimed to improve nutrition intake and levels of physical activity of rural adults, aged 50 to 69 years, who were at risk of or had metabolic syndrome. Over the follow-up period, there was a reasonable level of attrition (t2, n=151; t3, n=83; t4, n=70), with the retention rate from t2 to t4 being 46.3%. This is a less-than optimal-retention rate when compared to some other programs;[50] however, interventions with long-term follow-up show similar levels of participant attrition.[51-55]

The results at 18 months post-program indicate that waist circumference continued to decrease but diastolic blood pressure increased marginally. All other outcome measures remained stable between the three time points in the 18-month follow-up period. Although participants achieved significant improvements from baseline (t1) to six months (t2) in a number of outcome variables,[20] many of these outcomes remained stable between t2 and t4 (18 months). Despite the initial improvement from t1 to t2, this did not continue, although the observed maintenance from t2 to t4 for most outcome measures is a promising result. Results from a large cross-sectional

Table 1: Demographic characteristics of intervention participants at six months post-program (t2).

Variable	Intervention group (n=151)
Age: mean (SD) years	60.5 (5.64)
Gender: Female	100 (66.2%)
Employment status:	
Full-time	78 (51.7%)
Part-time	24 (15.9%)
Unemployed	5 (3.3%)
Retired	44 (29.1%)
Education:	
Primary school	3 (2.0%)
Secondary school	55 (36.4%)
Technical/Diploma	52 (34.4%)
University	41 (27.2%)
Relationship status: with partner	124 (82.1%)
Smoking status	
Never	84 (55.6%)
Former	52 (34.4%)
Occasional smoker	3 (2.0%)
Daily smoker	12 (7.9%)
Co-morbidity[a]: yes	92 (60.9%)
Alcohol drinking: yes	99 (65.6%)

Note:
a: Presence of at least one of eight common health problems

Norwegian population study showed that the prevalence for metabolic syndrome increased linearly with age in both males and females across the age range of participants in this study.[56] Furthermore, age remains a non-modifiable independent risk factor for cardiovascular disease, however, this risk can be augmented by other factors, such as lower blood pressure and total cholesterol and absence of glucose intolerance.[57]

Table 2: Physical activity and dietary outcomes of intervention participants post-program – 6-months (t2) (n=151), follow-up–12 months (t3) (n=80), and follow-up–18 months (t4) (n=66).

Outcome	Time point	Mean (SD)	*p*
Walking MET min/week	t2	577.50 (742.50)	(0.513[a])
	t3	495.00 (1188.00)	(0.877[b])
	t4	552.75 (767.25)	0.376[c]
Moderate MET min/week	t2	480.00 (850.00)	(0.819[a])
	t3	540.00 (1275.00)	(0.576[b])
	t4	480.00 (1410.00)	0.444[c]
Vigorous MET min/week	t2	217.52 (460.19)	(0.676[a])
	t3	285.00 (571.36)	(0.186[b])
	t4	499.11 (1302.62)	0.120[c]
Total MET min/week	t2	1332.00 (1624.88)	(0.615[a])
	t3	1687.50 (2783.38)	(0.534[b])
	t4	1439.50 (3114.00)	0.418[c]
Strength min/week	t2	53.52 (124.20)	(0.560[a])
	t3	57.59 (150.42	(0.844[b])
	t4	47.56 (103.67)	0.334[c]
Sitting minutes/day	t2	319.66 (162.71)	0.111[a]
	t3	308.98 (152.77)	0.261[b]
	t4	338.18 (169.26)	0.068[c]
Fibre intake score	t2	24.88 (4.08)	0.408[a]
	t3	24.50 (4.12)	0.311[b]
	t4	25.38 (3.69)	0.136c
Fat intake score	t2	32.27 (3.93)	0.819[a]
	t3	32.33 (4.01)	0.838[b]
	t4	32.04 (3.89)	0.071[c]
Fruit intake (serves/day)	t2	2.00 (1.36)	(0.042[a])
	t3	1.71 (1.11)	(0.379[b])
	t4	2.00 (1.32)	0.685[c]
Vegetable intake (serves/day)	t2	3.42 (1.93)	(0.434[a])
	t3	3.00 (2.18)	(0.079[b])
	t4	4.00 (2.07)	0.344[c]

Notes:
SD: standard deviation;
a: t2 versus t3 using paired samples t-test (Wilcoxon signed-rank test);
b: t3 versus t4 using paired samples t-test (Wilcoxon signed-rank test);
c: repeated measures ANOVA

Table 3: Blood parameters of intervention participants post-program – 6-months (t2) (n=130) and follow-up – 8 months (t4) (n46).

Outcome	Time point	Mean (SD)	*p*[a]
Triglycerides (mM)	t2	1.20 (0.62)	(0.131)
	t4	1.20 (0.60)	
Glucose (mM)	t2	5.06 (0.53)	0.001
	t4	5.21 (0.59)	
HDL cholesterol (mM)	t2	1.45 (0.39)	0.039
	t4	1.41 (0.41)	
Total cholesterol (mM)	t2	5.47 (1.02)	0.780
	t4	5.36 (1.02)	
LDL cholesterol (mM)	t2	3.34 (0.95)	0.607
	t4	3.30 (0.93)	
Non-HDL cholesterol (mM)	t2	4.02 (0.96)	0.874
	t4	3.94 (1.07)	

Notes:
SD: standard deviation;
a: t2 versus t4 using paired samples t-test (Wilcoxon signed-rank test)

Increased fruit and vegetable serves were maintained, which is consistent with findings from studies with other adult demographics (specific occupations, i.e. construction workers, students; people under the age of 50; people living in urban environments). These studies used counselling, education and/or boosters as part of their framework.[58-60] Similarly, physical activity levels were maintained at 18 months (t4) but did not increase from t2 to t4. Other studies have found that low-impact interventions have resulted in a decreased but still statistically significant upkeep of certain health behaviours or metrics, such as the maintenance of exercise/fitness levels (increased METs:12.74%; increased maximal heart rate:12.8 minutes), improved glycaemic control (-0.36%), decreased systolic (-7.3 to -7.5 mmHg; -2.97 to 5.33mmHg) and diastolic blood pressure (-3.9 to 4.2 mmHg; 2.48 to 2.92 mmHg) and resting heart rate (-4 to 4.2 beats per minute).[61,62]

Factors affecting longer-term improvements in nutrition and levels of physical activity tend to revolve around social support and frequent points of contact, alongside a structured focus on developing behavioural and cognitive self-regulation.[23,63-66] This intervention did provide these types of supports through the provision of resources and regular telephone contact. However, there were certain restrictions on socialisation, namely, no support for participant interaction and people who shared a home being prevented from participating, which may have negatively impacted the outcomes. This is supported by the qualitative findings from the study's process evaluation paper, which indicated that participants viewed additional contact and social support as a way of improving the intervention.[23] It is also worth noting that other more successful interventions provide strategies that address the person's home food environment.[67,68] Ultimately, while goal setting, motivational interviewing and the initial education-based interventions produced positive results, new and motivating booster strategies may need to be introduced to maintain participant interest and produce ongoing improvements in outcomes.[40]

Behaviour change is possible, as shown by the positive impact of the initial 6-month home-based physical activity and nutrition intervention. Other studies have also demonstrated efficacy in other populations with the use of strategies to encourage

social interaction, such as buddy systems, whereby people are paired up to provide support for behaviour change; and network support systems, such as family, friends and peers that are encouraged to offer informational, emotional and instrumental support.[69-71] In addition to ongoing and targeted professional support, both face-to-face and group-based settings[72,73] could be considered.

This study examined the longer-term outcomes of an intervention to improve nutrition intake and levels of physical activity in a rural area. Despite the lack of ongoing improvements in most outcome measures, these findings were not unexpected, as a number of other studies have shown similar longer-term outcomes.[74,75] The findings indicate the benefits of the intervention to support ongoing behaviour change.

Limitations

Limitations of this follow-up study included the lack of a true control group at 12 and 18 months. There were also no blood parameter measurements at 12 months due to limited resources. However, the blood parameters were collected at 18 months, providing longer-term follow-up data on the impact of the intervention. In addition, the attrition rate throughout the intervention was high (53.7%), which would have affected the outcomes, although this attrition rate is similar to other longer-term interventions.[55] Also, we acknowledge that the lack of sensitivity and multivariable analysis is a major limitation of this study. Indeed, in view of the small sample size at t4 and the large number of confounders, and since some of the repeated outcomes are mutually correlated, we preferred to take a cautious approach and did not proceed with intention-to-treat analysis and regression modelling based on missing data imputation, to avoid potentially misleading inferences and over-interpretation.

This was a unique 18-month follow-up study of older adults after they had participated in an initial six-month physical activity and nutrition intervention in a rural setting. Few similar intervention studies of this duration have been undertaken. There were significant improvements recorded, with the majority of statistically significant improvements occurring after the first six months (t1–t2) of the intervention, although many of the outcomes remained stable over the course of the follow-up. Maintaining behaviour change is a challenge in the current environment. Future studies must look for ways to embed booster interventions and investigate new social support approaches to addressing chronic disease risk for disadvantaged populations.

Table 4: Anthropometric measurements of intervention participants post-program 6-months (t2) (n=151), follow-up – 12 months (t3) (n=83), and follow-up – 18 months (t4) (n=70).

Outcome	Time point	Mean (SD)	*p*
Waist circumference (cm)	t2	100.56 (13.84)	0.891[a]
	t3	100.23 (12.91)	0.271[b]
	t4	99.04 (12.76)	0.001[c]
Hip (cm)	t2	111.13 (12.04)	0.914[a]
	t3	111.16 (12.21)	0.612[b]
	t4	110.00 (10.90)	0.257[c]
Waist-to-hip ratio (waist/hip)	t2	0.90 (0.08)	0.809[a]
	t3	0.90 (0.08)	0.562[b]
	t4	0.90 (0.08)	0.098[c]
Weight (kg)	t2	84.50 (23.70)	(0.049[a])
	t3	84.70 (22.70)	(0.700[b])
	t4	83.30 (23.17)	0.510[c]
Systolic blood pressure (mm Hg)	t2	133.30 (14.85)	0.326[a]
	t3	136.18 (14.81)	0.430[b]
	t4	133.76 (14.90)	0.134[c]
Diastolic blood pressure (mm Hg)	t2	84.87 (9.19)	0.007[a]
	t3	88.36 (10.28)	0.314[b]
	t4	86.56 (9.56)	0.010[c]

Notes:
SD: standard deviation;
a: t2 versus t3 using paired samples t-test (Wilcoxon signed-rank test);
b: t3 versus t4 using paired samples t-test (Wilcoxon signed-rank test);
c: repeated measures ANOVA

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