RANDOMISED CONTROLLED TRIAL OF INFORMAL TEAM SPORTS FOR CARDIORESPIRATORY FITNESS AND HEALTH BENEFIT IN PACIFIC ADULTS

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Randomised controlled trial of informal team sports for cardiorespiratory fitness and health benefit in Pacific adults

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ABSTRACT

INTRODUCTION: Rates of obesity, Type 2 diabetes and cardiovascular disease are high among Pacific people in New Zealand. Physical activity is recommended in the prevention and management of these conditions. Community-based, 'small-sided game' group activities may be an effective and culturally appropriate way to promote physical activity within Pacific communities.

AIM: To assess the effectiveness of small-sided games-based exercise on fitness and health parameters among Pacific adults over four weeks.

METHODS: Twenty untrained (13 female) Pacific adults were randomised to intervention or control. Intervention participants were offered 45 minutes of small-sided games three times per week for four weeks. Control participants were offered one-month gym membership after the trial. Primary outcomes included cardiorespiratory fitness (VO_2peak) and leg strength (maximal concentric force of quadriceps at 60°/second) measured at baseline and four weeks. Secondary outcomes included glycaemia, lipid profile, blood pressure (BP), and inflammatory markers. Multivariable regression models were used to assess differences between groups, adjusting for baseline values, age and gender.

RESULTS: At baseline, mean age was 34.8 years (SD 12.6), BMI 36.3 (6.7), systolic BP 127.7 mmHg (12.1), HbA1c 6.1% (1.9), VO_2peak 2.5 L/min (0.6) and leg strength 170.0 N.m (57.4). Sixteen participants completed the trial. Change in outcomes were greater in intervention than control participants in absolute VO_2peak (0.9 L/min (p=0.003)), leg strength (17.8 N.m (p=0.04)) and HDL (0.12 mmol/L (p=0.02)). There were no other significant differences.

DISCUSSION: Small-sided games appear to be a promising means for improving the health and cardiorespiratory fitness and reducing the risk of diabetes and cardiovascular disease in Pacific adults.

KEYWORDS: Exercise; diabetes mellitus, Type 2; Pacific Islands; randomized controlled trial; health promotion

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Introduction

Rates of obesity among Pacific people in New Zealand are increasing, with recent estimates indicating that 64% of Pacific adults are classified as obese compared with approximately 23% of European and other groups.[1] Moreover, Pacific children are 5.3 times more likely to develop obesity than children from other ethnic groups.[2] The prevalence of diabetes is also much higher among Pacific people than most other ethnic groups in New Zealand, and has been estimated from a recent study to be 19.5% for Pacific adults compared with 3.9% for Europeans and 12.0% for Maori.[3] Impaired Glucose Tolerance (IGT), a precursor condition to diabetes, is present in 7.9% of Pacific people compared with 7.3% of Maori and 6.7% Europeans.[4] These statistics illustrate that diabetes and IGT inflict considerable morbidity on the New Zealand population, particularly within Pacific communities. Since diabetes and IGT are also underlying risk factors for the development of cardiovascular disease (CVD),[5,6] effective and engaging interventions are needed to address the escalating and widespread problem of diabetes within this population.

There is increasing evidence to suggest that lifestyle interventions are more effective in reducing the incidence of diabetes compared with drug treatment.[7–9] Individuals who engage in regular exercise demonstrate a lower incidence of diabetes, improved metabolic control and a reduced prospective risk for the development of diabetes.[10,11] Although the mechanisms behind this phenomenon are only partially understood,[12] there is evidence that resistance training enhances insulin sensitivity[13–15] and the control of glucose is also improved through the increased capillary-to-muscle ratio that is the result of aerobic training.[16] Therefore, glucose metabolism and metabolic control via exercise is a critical area for investigation in the high-risk pre-diabetic and diabetic population. These findings support the contention that exercise training either alone or in conjunction with diet or medication should be a fundamental component in the prevention and treatment of Type 2 diabetes.[17]

An additional benefit of exercise, particularly cardiorespiratory exercise, is that it decreases the likelihood of conditions such as cardiovascular disease (CVD) or high blood pressure,[18,19] which are two of the leading causes of mortality and morbidity among sedentary, overweight populations.[20–22] By training the aerobic system, heart rate and vascular stiffness are reduced.[23] For overweight and obese individuals, aerobic activity will reduce the chances of CVD and can also lead to increased self-confidence and an improved quality of life.[24]

Pacific people report lower amounts of leisure activity than other New Zealanders.[25] Furthermore, Pacific people tend to be community-based and also tend to perform informal exercise in groups.[25] Exercise interventions for diabetes, and recommendations by governing bodies such as the American College of Sports Medicine, prescribe individualised exercise, such as jogging, cycling or gym-based training. In the current study, we propose that game-based activity such as touch rugby and social football may be more culturally appropriate for group-based populations, while also providing important health benefits. No study has explored whether game-based group exercise can result in health benefits within New Zealand's Pacific community. However, recent research supports the use of this type of exercise in improving health and fitness. Improvements in VO_2max, peak sprinting speed, muscle enzyme activity and cardiac adaptations including an increase in left ventricular wall thickness, were found in studies of small-sided football games among 38 middle-aged adults over 12 weeks[26] and among 21 sedentary women over 16 weeks.[27]

Therefore, the purpose of this preliminary trial was to determine whether game-based activities involving small teams ('small-sided games') in a social environment could produce improvements in cardiorespiratory fitness, strength and cardiovascular risk factors in Pacific adults, with a view to conducting a larger investigation of the impact of this intervention on Type 2 diabetes.

Individuals who engage in regular exercise demonstrate a lower incidence of diabetes, improved metabolic control and a reduced prospective risk for the development of diabetes.

Methods

This parallel, randomised controlled trial assessed whether a small-sided games exercise intervention compared with control could improve cardiorespiratory fitness, strength and diabetic and cardiovascular risk profiles over four weeks amongst Pacific adults in the Auckland Tamaki community.

Study population

Pacific adults from 16 to 65 years of age who were currently engaged in less than three planned exercise sessions per week and with no previous cardiovascular disease or contraindication to exercise, as assessed by the Physical Activity Readiness Questionnaire (PAR-Q),[28] were eligible to participate in the study. Consultation was undertaken with leaders of Pacific churches to determine the most appropriate approach to invite potential participants from the church community. Participants were recruited through local church leaders, notices in a local general practice and a local secondary school, and by word of mouth within the Tamaki community in East Auckland. Written informed consent was obtained from all participants. The trial was approved by The University of Auckland Human Participants Ethics Committee (ref. 2009/536). The trial was registered with the Australia New Zealand Clinical Trials Register (ACTRN 12610000003077).

Outcome measures

Outcome measures were assessed at baseline after informed consent and before randomisation, and again at four-week follow-up. Primary outcomes included cardiorespiratory fitness (VO_2peak) and leg strength (maximal concentric force of quadriceps at 60°/second). Secondary outcomes included fasting glucose and glycated haemoglobin (HbA1c), lipid profile, blood pressure and C-reactive protein (CRP).

Cardiorespiratory fitness was assessed using a ramp VO_2peak test on a cycle ergometer (Velotron CS 1.5).[29] The protocol followed a formula created by Hansen et al. to set appropriate clinical VO_2peak protocols for obese populations.[30] The sex, age and weight of the participant determined the initial load and incremental increase in load throughout the test. Gas analysis was performed to determine gas volume and composition (Metamax 3B).[31] Heart rate (Polar) and rate of perceived exertion (Borg Scale) was measured every minute and two minutes, respectively.[32] The cessation of the test was determined by volitional fatigue of the participant or inability to maintain cadence above 60 revolutions per minute.

Quadriceps strength was assessed using a Biodex machine (Biodex System 2). Isokinetic strength was measured at eight different speeds (30, 60, 90, 120, 150, 210, 270, 330°/sec). Participants performed two repetitions of maximal extension at each speed with their right leg. Peak torque of the quadriceps muscles was subsequently recorded at each speed.

Assessments were undertaken at the Unisports exercise laboratory at The University of Auckland. Early morning fasting venous blood was also taken at the Unisports laboratory and delivered to an accredited laboratory in Auckland (Diagnostic Medlab) for analysis. Blood pressure was assessed using the mean of the second and third measurement from three consecutive recordings. Other variables measured include weight, height and waist circumference. Weight was measured using the laboratory scales (Seca) while height and waist circumference were determined using a tape measure. Waist circumference was measured midway between the last rib and iliac crest.

Participants were also given the opportunity to provide written feedback about the intervention at the end of the trial.

Randomisation and blinding

Computer-generated 1:1 randomisation was carried out using STATA 9.1, and preparation of numbered, opaque, sealed envelopes was undertaken by a researcher (CRE) who was not

WHAT GAP THIS FILLS

What we already know: The prevalence of obesity and Type 2 diabetes is high in the New Zealand Pacific community. Increasing physical fitness helps prevent and reduce obesity and Type 2 diabetes.

What this study adds: Community-based group activities may be an appropriate way to promote regular physical activity in Pacific communities in New Zealand. Community-based, small-sided games activities offered three times per week improved cardiorespiratory fitness and strength compared with control (no organised activities) among less active adults in a local Pacific community over a four-week period.

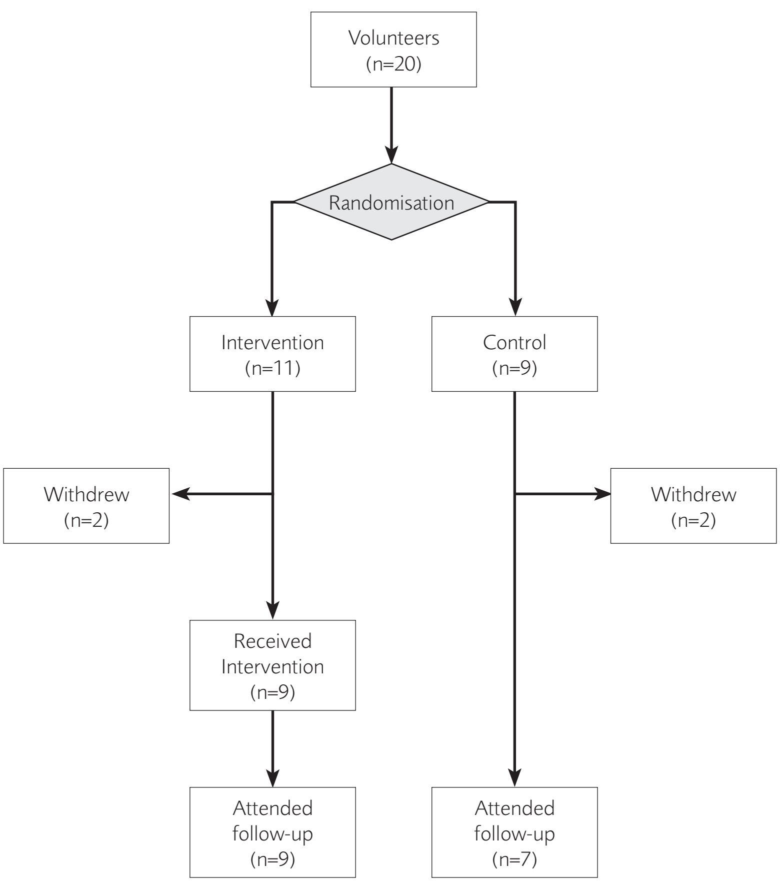
Table 1. Baseline characteristics of study participants

Characteristic*	Control n=9 n (%)	Intervention n=11 n (%)	Total n=20 n (%)
Age, years	34 (17.4)	35.1 (7.8)	34.8 (12.6)
Female n (%)	6 (66.7)	7 (63.6)	13 (65)
BMI, kg/m²	33.1 (6.4)	38.9 (5.9)	36.3 (6.7)
Waist (cm)	98.7 (10.0)	114.7 (15.5)	107.5 (15.3)
HbA1c, mmol/mol	43.3 (25.2)	43.9 (16.9)	43.6 (20.3)
HbA1c, %	6.1 (2.3)	6.2 (1.5)	6.1 (1.9)
Systolic BP, mmHg	124.8 (11.2)	130.0 (12.9)	127.7 (12.1)
Diastolic BP, mmHg	80.8 (10.2)	84.0 (9.7)	82.6 (9.8)
VO_2peak (absolute), L/min	2.5 (0.7)	2.4 (0.6)	2.5 (0.6)
Strength ext quad 60° Nm†	154.7 (57.2)	182.6 (57.2)	170.0 (57.4)

* Mean (standard deviation) unless otherwise indicated

† Strength of quadriceps extension at 60° in Newton metres

Figure 1. Consort diagram of the randomised controlled trial of small-sided games versus control



involved in enrolment or assessment. Participant enrolment and baseline assessment were undertaken by postgraduate exercise science students (GV, AM and GB) and the principal investigator (HE). Assessors remained blind to allocation of intervention until after baseline assessment when numbered envelopes were opened consecutively to determine group allocation. Blinding of assessors was not possible at follow-up assessment. Objective measures were used where possible (e.g. blood results) and fitness measures were carried out using a standard protocol and consistent feedback. Blinding of participants was not possible.

Intervention

The participants in the intervention group were encouraged to attend three training sessions per week over four weeks. The sessions comprised various small-sided games including soccer, basketball, volleyball, touch rugby, cricket and other non-conventional games such as 'chain tag', 'rob the nest' and 'bullrush'. All sessions were carried out at The University of Auckland Tamaki campus grounds (outside) or in the university gym for volleyball when the weather was wet. Each session lasted 45 minutes and included a 10-minute warm-up period and regular rest periods. The sessions were supervised and conducted by the three sports and exercise postgraduate students. Basic technical advice was given to the participants for safety reasons.

Control

Control participants were instructed to maintain their normal lifestyle and were offered four weeks' gym membership once they had completed their follow-up assessment.

Sample size calculations

Means and standard deviations from previous research undertaken by JE (principal investigator) were used in sample size estimate calculations.[33,34]

VO_2peak (mL/kg/min)

Fifteen participants per group would be required, using mean difference in change of 7.2 (SD 6.9).[33]

Table 2. Changes in outcomes of intervention compared with control participants over four weeks

		Control [n=9]			Intervention [n=11]			Difference in change*	p-value
		Baseline	Follow-up Means (SD)	Change	Baseline	Follow-up Means (SD)	Change		
Primary outcomes	VO_2peak absolute (L/min)	2.5 (0.7)	2.4 (0.8)	-0.1 (0.6)	2.4 (0.6)	3.3 (1)	0.9 (0.7)	0.9 (0.3)	0.003
	VO_2peak relative† (mL/Kg/min)	26.4 (7.1)	27 (6.8)	0.6 (4.5)	21.9 (4.4)	29.3 (6.1)	7.4 (4.7)	4.1 (2.2)	0.09
	Strength ext quad 60° (Nm)‡	154.7 (57.2)	152.7 (45.7)	-2 (20.6)	182.6 (57.2)	188.7 (63.8)	6.2 (23.7)	17.8 (7.8)	0.04
Secondary outcomes	Fasting glucose (mmol/L)	6.5 (3.8)	6.3 (3.6)	0.0 (0.2)	6.0 (2.6)	5.2 (1)	-0.8 (2.5)	-0.99 (0.81)	0.2
	HbA1c (%)	6.1 (2.3)	6.0 (2.2)	0.0 (0.1)	6.2 (1.5)	5.5 (0.5)	-0.7 (1.4)	-0.7 (0.5)	0.1
	Total cholesterol (mmol/L)	5.4 (1.4)	4.9 (1.5)	-0.3 (0.5)	5.6 (1.4)	4.9 (1.1)	-0.6 (0.6)	-0.2 (0.2)	0.2
	HDL (mmol/L)	1.3 (0.3)	1.1 (0.3)	-0.1 (0.1)	1.2 (0.3)	1.2 (0.2)	0.0 (0.1)	0.12 (0.04)	0.02
	LDL (mmol/L)	3.0 (0.9)	2.7 (0.7)	-0.2 (0.5)	3.1 (0.9)	2.9 (0.8)	-0.1 (0.4)	0.09 (0.23)	0.7
	Triglycerides (mmol/L)	1.9 (1.6)	2 (1.5)	0 (0.5)	3.9 (4.2)	2.1 (1.5)	-1.7 (3.6)	-0.3 (0.6)	0.6
	Systolic BP (mmHg)	124.8 (11.2)	116.9 (12.1)	-7.9 (9.8)	130.0 (12.9)	124.8 (9.4)	-5.2 (11)	5.2 (4.3)	0.2
	Diastolic BP (mmHg)	80.8 (10.2)	80.1 (10.2)	-0.7 (7.2)	84.0 (9.7)	84.2 (8.8)	0.1 (11.7)	2.2 (3.9)	0.6
	C-reactive protein (mmol/L)	2.3 (1.1)	2.7 (1.2)	0.5 (0.9)	2.7 (2.5)	4.1 (5)	1.6 (3.4)	0.8 (1.2)	0.5

* Mean (standard deviation) difference in change and adjusted for gender, age and baseline value.

† Adjusted for weight.

‡ Strength of quadriceps extension at 60° in Newton metres

Leg press strength (kg)

Eight participants per group would be required, using mean difference in change of 45 (SD 31)[34] (alpha=0.05, p=0.8).

Analyses

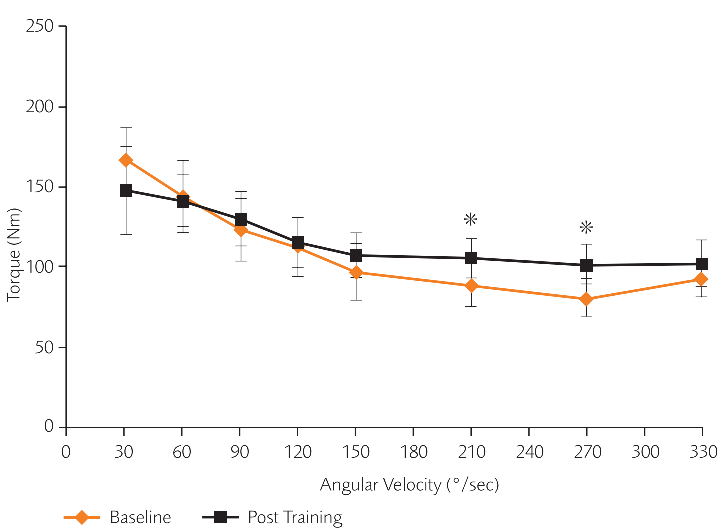
Means and standard deviations of participant characteristics were calculated by group allocation. To evaluate the effect of the intervention, differences between the control and intervention groups were examined using multiple regression analyses adjusting for baseline values, age and gender. Intention to treat analysis was undertaken. Data missing at follow-up were imputed using the last value carried forward. Per-protocol analyses were also carried out as a sensitivity analysis including only those who completed the trial to assess whether this changed results.

Results

Advertising and recruitment to the study were undertaken from mid-November 2009 to mid-January 2010. Twenty untrained (13 female and 7 male) Pacific adults volunteered to participate in the study during the recruitment phase. All were assessed as eligible and enrolled in the study. Baseline assessments and randomisation into intervention or control groups were carried out during one week mid-January 2010 (Figure 1). At baseline, mean age was 34.8 years (SD 12.6), with participants ranging from 16 years to 64 years (Table 1). Mean weight was 103.7kg (SD 20.4) (ranging from 73 to 136 kg) and mean body mass index (BMI) was 36.3 (SD 6.7). While some characteristics were balanced at baseline, the control group had lower mean BMI, waist circumference, blood pressure and strength than the intervention group, despite random allocation. In total, 16 participants completed the trial (nine intervention and seven control). The nine intervention participants completed between 10 and 12 training sessions over the four-week period. Follow-up assessments were undertaken during one week mid-February 2010.

Table 2 displays the results of the primary and secondary outcome measures. There were significant improvements in both primary outcomes of cardiorespiratory fitness (VO_2peak absolute (p=0.003) but not relative (p=0.09)) and quadriceps strength (p=0.04) in the intervention group compared with the control. The only significant difference found between the groups in secondary outcomes was in HDL, which reduced slightly in the control and was maintained in the intervention group (p=0.02). Results did not change significantly when analyses were undertaken on data from those who completed the trial only (n=16).

Figure 2. Peak torque (Nm†) during right knee extension at baseline and follow-up of participants in the control group who completed the study.



(Values are means ± SE; Control group n=7)

* denotes significant change p=<0.05

† Nm denotes Newton metres

Significant increases in quadriceps strength were seen at almost all angles in the intervention group, but less so in the control group, as demonstrated in strength power curves for leg extension (Figures 2 and 3).

Written responses from the intervention participants to the question, "Do you think the small-sided games were beneficial in improving your health and wellbeing?" were generally positive:

> "Definitely, awesome, really enjoyed all of the games"

> "Yes it really benefited me and improved my health and wellbeing"

Examples of other comments included:

> "I really enjoyed every game that the instructors had for us. It was great fun and at the same time getting fit"

> "The fun games took the torture out of our fitness"

> "I have signed up to do some cardio-boxing and zumba"

Discussion

Summary of findings

This four-week randomised controlled trial of a small-sided games exercise intervention found improved cardiorespiratory fitness (absolute VO_2peak), quadriceps strength and serum HDL compared with the control group. The informal group-based approach to the exercise intervention was well received by participants. This is the first time that physiological improvements as a result of a small-sided games–based intervention have been observed in such a short training period, and within a group of Pacific adults who represent an ethnic group at high risk of obesity, cardiovascular disease and glucose intolerance. These results have valuable implications, as increasing cardiorespiratory fitness is associated with reduced risk of diabetes and cardiovascular events, as well as reduced all-cause mortality.[10,20,21]

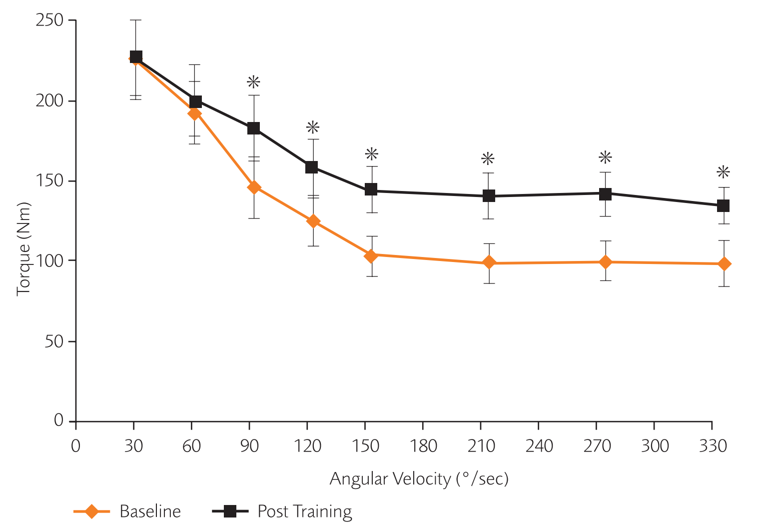
Compared with the literature

A previous trial of small-sided soccer games involving middle-aged untrained males and sedentary women over a 16-week period, found improved VO_2max, peak sprinting speed, elevated muscle enzyme activity and significant cardiac adaptations, such as an increase in left ventricular wall thickness, end diastolic volume and systolic and diastolic performance, compared with control.[26,27]

Despite improvements in cardiorespiratory fitness, quadriceps strength and HDL in the current study, there were no statistically significant differences between intervention and control in other clinical parameters. Previous trials of aerobic exercise interventions have also found differences in HDL without changes in other lipids or blood pressure.[35] Even so, a reduction in blood pressure was hypothesised, as moderate intensity aerobic exercise interventions of only four days' duration for 40 minutes per day have been shown to produce significant reductions in blood pressure in previous studies of patients with hypertension.[36,37] A previous meta-analysis has also found significant reductions in blood pressure with aerobic exercise interventions, although changes are usually most marked in hypertensive individuals and less so in normotensive individuals.[18] The mean blood pressure of participants in the current study was low, so exercise-induced reductions were less likely.

The current study was not specifically powered to detect changes in the secondary clinical outcomes, which were included in a more exploratory capacity. However, non-significant trends in HbA1c and fasting glucose were promising. A larger sample size may have detected these changes as statistically significant. HbA1c concentrations in diabetic patients have been shown to decrease with exercise in a previous eight-week training programme.[38] A recent meta-analysis has found that structured aerobic exercise programmes, particularly those training for more than 150 minutes per week, were associated with 0.7% (95% CI 0.8%–0.5%) reduction in HbA1c, which is consistent with the trend in this study.[39]

Figure 3. Peak torque (Nm†) during right knee extension at baseline and follow-up of participants in the intervention group who completed the study.



(Values are means ± SE; Intervention group n=9)

* denotes significant change p=<0.05

† Nm denotes Newton metres

Strengths and limitations

Strengths of this study include its real-life local community context, consultation and involvement of local Pacific community, inclusion of culturally relevant popular game-based activities within the intervention, and the use of a rigorous randomised controlled trial study design to assess effectiveness. Anecdotal feedback from participants indicated that they enjoyed the training immensely and would like to continue the training with other members of their community.

One limitation of the study was that the study did not reach its target sample size of 30. The timeframe of the study was constrained by the duration of the project, which was conducted as a University of Auckland summer student project and in conjunction with the Tamaki Transformation Project community initiative. Despite this, significant differences were found in the primary outcomes. Sample size calculations were only carried out for the primary outcomes. Therefore, this study was likely to be under-powered to detect differences in the secondary (clinical) outcomes. This study was also designed as a preliminary to a subsequent larger study that would investigate longer-term effects of small-sided games, should this small trial demonstrate promising results, which it has.

Blinding was difficult in this trial. However, baseline assessments were carried out prior to randomisation and outcome measures were undertaken according to standardised protocols or using objective measures, such as blood tests. Mean blood pressure, BMI and strength were lower in the control group than in the intervention group at baseline, despite random allocation. This may have influenced the change in outcomes in response to exercise. However, analyses were adjusted for baseline values to help address this. Also, participants were from a small area, which may limit generalisability of findings to the wider Pacific communities in New Zealand.

Implications

The findings from this study may have important implications for improving the health and well-being of Pacific adults living in New Zealand. A larger trial with a longer training period and follow-up would be a more rigorous test of long-term effectiveness of small-sided games for improved fitness, strength and health outcomes. A comparison of small-sided games with individual gym-based programmes would also inform choices about the best exercise promotion strategies to use in the Pacific community. A third gym-based arm of the trial had also been planned, but the small sample size precluded this in the current study. If small-sided games were shown to be as effective as individual exercise programmes, then this would provide strong justification to include small-sided games as an alternative form of exercise training in guidelines for increasing physical activity levels in New Zealand.

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COMPETING INTERESTS

None declared.