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Integrating Smartphone Technology, Social Support and the Outdoor Physical Environment to Improve Fitness Among Adults at Risk of, or Diagnosed with, Type 2 Diabetes: Findings from the 'eCoFit' Randomized Controlled Trail.

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Abstract

The risk and prevalence of Type 2 Diabetes (T2D) has dramatically increased over the past decade. The aim of this study was to develop, implement and evaluate a physical activity intervention to improve aerobic and muscular fitness among adults at risk of, or diagnosed with T2D. A 20-week, assessor blinded, parallel-group Randomized Controlled Trial (RCT) was conducted at the University of Newcastle (June-December 2015). Adults were randomized to the intervention (n=42) or wait-list control group (n=42). The theory-based intervention included: Phase 1 (weeks 1-10) integrated group sessions (outdoor physical activity and cognitive mentoring), and the *eCoFit* smartphone application (app). Phase 2 (weeks 11-20) only included the *eCoFit* app. Participants were assessed at baseline, 10-weeks and 20-weeks. Linear mixed models (intention-to-treat) were used to determine group-by-time interactions at 10-weeks (primary time-point) and 20-weeks for the primary outcomes. Several secondary outcomes were also assessed. After 10-weeks, significant group-by-time effects were observed for aerobic fitness (4.5 ml/kg/min; 95% CI [1.3, 7.7], d= 0.68) and muscular fitness (lower body) (3.4 reps, 95% CI [2.7, 4.2], d=1.45). Intervention effects for secondary outcomes included significant increased physical activity (1330 steps/week), improved upper body muscular fitness (5 reps; arm-curl test), improved functionality (-1.8 secs; timed-up and go test) reduced waist circumference (2.8 cms) and systolic blood pressure (-10.4 mmHg). After 20-weeks, significant effects were observed for lower body muscular fitness and health outcomes. *eCoFit* is an innovative lifestyle intervention which integrates smartphone technology, social support, and the outdoor environment to improve aerobic and muscular fitness.

Keywords: Physical activity; smartphone application (app); resistance training, cognitive behavioral therapy strategies, parks, Type 2 Diabetes.

Trial registration: Australian New Zealand Clinical Trials Registry No: ACTRN12615000990527.

Introduction

Physical inactivity is a global pandemic and the fourth leading cause of non-communicable deaths worldwide (1). Regular participation in both aerobic and resistance-based physical activity significantly reduces the risk of numerous chronic diseases including Type 2 Diabetes (T2D) (2).

It is recommended that adults with T2D aim for 30 minutes of moderate-to-vigorous aerobic exercise at least 5 days a week, or accrue a total of 150 minutes per week, and include resistance training 2-3 times per week on nonconsecutive days (3). Despite the extensive benefits of physical activity (2, 4), the majority of adults with T2D or at risk of T2D are not sufficiently active (5). Unlike aerobic exercise (e.g., walking) resistance training is dependent on the knowledge of correct technique, availability of equipment, and often requires additional instruction for effectiveness and safety. Due to these barriers, many people do not include resistance training (6, 7).

Researchers have investigated a variety of strategies to encourage individuals with T2D/pre-diabetes to become more active using face-to-face sessions, virtual technology (e.g., websites, smartphone application, online or phone counselling), or integrations of both. Despite the variability in current strategies, it appears community-based behavioral interventions are appropriate for promoting physical activity in adults with T2D, as they can be more practical than clinical interventions, have demonstrated long-term effectiveness, and have the potential to reach a large proportion of individuals who are most in need of treatment (8, 9). Although there is evidence showing the efficacy of physical activity interventions (10, 11), few programs have specifically targeted both aerobic and resistance training among those with T2D/pre-diabetes. Moreover, few studies have identified feasible strategies to support aerobic- and resistance-based activity at the broader community level.

Supporting physical activity behavior change among individuals at risk of or with T2D is complex and there is a clear need for innovative approaches. Technology-based interventions utilizing website and apps have the potential to increase physical activity by facilitating the use of behavioral skills such as goal setting, action planning, coping planning and self-monitoring (12). Social support via group-based programs, has also been reported to enhance physical activity for individuals with chronic diseases (13)

Additionally, research has shown that engaging in physical activity in an outdoor environment not only contributes to better physical health outcomes, but also improves psychological functioning and well-being (14). There is however, a gap in the literature regarding the promotion of resistance training activities in the outdoor built environment.

The aim of the current study was to determine the efficacy of an innovative, lifestyle program known as *'eCoFit'*, which integrates smartphone technology, social support and the outdoor physical environment to improve health-related fitness among adults at risk of, or diagnosed with, T2D. We hypothesized the *eCoFit* intervention group would achieve clinically meaningful improvements in aerobic fitness and lower body muscular strength (primary outcomes) and a range of secondary outcomes at 10-week (primary end-point) and 20-weeks post baseline compared with the waitlist control group.

Methods

The *eCoFit* study protocol is described in detail elsewhere (15). The trial was evaluated using a two-arm RCT design. Participants randomized to the intervention group received the *eCoFit* program, which included 2 Phases.

Participants

Eligible participants were stratified for T2D group (at risk of, or diagnosed with T2D), and sex and individually randomized to either the 20-week *eCoFit* intervention group or a waitlist control group. The trial was approved by a University Human Research Ethics Committee. The trial is registered with the Australian New Zealand Clinical Trail Registry (ACTRN12615000990527). The design, conduct and reporting adheres to the CONSORT guidelines (16).

The study recruited adults from the Newcastle region (N=84), New South Wales, Australia through a variety of strategies (e.g., local television, radio stations, recruitment flyers, and newspapers). There was no racial or gender bias in the selection of participants. Participant inclusion criteria included: being overweight or obese (BMI ranging from 25 to 40 kg/m^2); or at 'high' risk of T2D (score of ≥12 from the Australian Diabetes Risk (AUSDRISK) Tool; scoring includes questions based on age, sex, ethnicity, family history of diabetes, history of abnormal glucose metabolism, smoking status, current hypertensive treatment, physical activity, fruit and vegetable consumption, and waist circumference (17)); or currently diagnosed with T2D (determined by an HbA1c level of >7.0, as diagnosed by the individual's general practitioner [GP]); aged 18-80 years; not currently meeting the physical activity guidelines as assessed by the Godin Leisure-Time Exercise Questionnaire (18); passed the Adult Pre-exercising Screening Tool; and, smartphone ownership. Participants completed an online eligibility questionnaire, which included a pre-exercise screening tool (17). All participants who were identified as having medical issues from the screening tool were required to obtain clearance from their GP prior to participating in the study. Participants were excluded from the study if they had a medical condition that might adversely affect them by increasing physical activity, were currently participating in an alternative physical activity program, were intending to participate in other physical activity program during the study period, or not available for assessment sessions. Eligible participants were then sent an information statement detailing the study requirements and a consent form. All participants were required to provide written informed consent prior to being enrolled into the trial.

Sample size and power. The sample size calculation assumed power at 80% and as there were two primary outcomes (i.e., aerobic fitness and lower body muscular fitness), the alpha levels were set at $p < .025$. Between-group differences in estimated maximal oxygen uptake of 3 mL/kg/min and three repetitions for the chair stand test were considered to be achievable and clinically significant (19, 20). A sample of 70 participants would provide sufficient power, assuming standard deviations of four (21) and three (19) for the submaximal fitness and chair stand tests, respectively. Therefore, our sample size was inflated to 88 participants to account for an anticipated 25% dropout rate. Participants were enrolled and individually randomized to the intervention or control group after baseline assessments by a research assistant. Random allocation to the wait-list control group or the intervention group was performed using a computer-based random number producing algorithm by a researcher not involved in the present study.

Intervention

Phase 1 (weeks 1-10)

Face-to-face group sessions were delivered fortnightly over 10-weeks (see Table 2). Each of the five face-to-face group session lasted for 90 minutes and consisted of 30 minutes of cognitive group mentoring (delivered by a qualified psychologist), and 60 minutes of small group outdoor training (delivered by qualified personal trainer). The aim of the cognitive group mentoring was to educate participants about strategies to overcome barriers and increase motivation to engage and maintain physical activity. The emphasis was placed on overcoming negative, sabotaging thoughts related with physical activity. The topics and strategies used during these sessions were based on Bandura`s Social Cognitive Theory (SCT) (22) Cognitive Behavior Therapy strategies adapted for physical activity, (23) and the Health Action Process Approach Model (HAPA) (24, 25). The key constructs of the SCT (i.e. self-efficacy, goal setting, outcome expectations, and social support) and HAPA (i.e. action and coping planning) were operationalized in face-to-face component of the intervention. Sessions with the psychologist focused on the following topics/strategies: automatic thoughts and goal setting cognitive and behavioural motivational strategies, unhelpful thinking styles, time management, action and coping planning, and problem solving. The content of the *eCoFit* sessions is described in detail elsewhere (15). The following physical activity behavior change techniques were employed: instruction on how to perform behaviors; feedback on behaviors; modeling of behaviors; self-monitoring of behaviors; action planning; problem solving/coping planning; goal setting; social support; self-talk; verbal persuasion to boost self-efficacy; restructuring the physical and social environment; reattribution; and self-assessment of affective consequences (26).

The aim of the small group outdoor training sessions was to provide participants with the confidence and skills to participate in sessions using the outdoor physical environment (e.g., benches, stairs) to increase muscular strength and aerobic fitness. The goal was to implement unfamiliar RT exercises in a new environment within eCoFit program. The sessions involved approximately 50% of aerobic and 50% of resistance training; moderate-to-vigorous intensity equal to or greater than 3 METs (metabolic equivalent; one MET is defined as 1 kcal/ kg/hour and is roughly equivalent to the energy cost of sitting quietly) and were focused on learning the proper technique of six resistance training exercises: abdominal strengthening, external rotations, knee lifts, pulls-ups, push-ups, and squats. These exercises had six levels of difficulty, covered all major muscle groups and were able to be easily performed in the outdoor setting (without any equipment). Participants could self-select the level of difficulty based on their perceived physical ability and personal trainer recommendations.

Social support in the *eCoFit* study was delivered through informational, emotional and companionship support provided during group face-to-face sessions (e.g., advice, guidance, useful information, acceptance, encouragement, companionship in shared group physical activities).

eCoFit smartphone app. The *eCoFit* smartphone app was designed to support physical activity participation through the use of the outdoor environment in the city of Newcastle. The app included workout circuits ("*eCoFit* Challenge") tailored for a range of geographic locations around the city of Newcastle, and included a description of where and how to use the outdoor physical environment to be more physically active (content was aligned to the group sessions). The pre-designed "*eCoFit* Challenges" were located in 11 park locations and were based on a standardized 3km course, integrating aerobic activity [i.e., walking or running] and two sets of six pre-determined resistance training exercises (six levels of difficulty). Additionally, the app included a time tracer, a map of each location, visual instructions (GIFs and photos) of exercises, an option to complete workout at home, goals setting (when, where, with whom, and what I will do to make it happen), self-monitoring function; "FitMind Challenges" (short cognitive tasks to overcome barriers), and a link to social media (Facebook). See appendix 1.

Phase 2 (weeks 11-20)

In the second phase, the face-to-face sessions were discontinued and participants only had access to the "*eCoFit* app".

Measures

Outcome measures are described briefly here and more comprehensively in the trial protocol (15). In short, data collection occurred at baseline (June/July 2015), 10-weeks (primary end-point; September/October 2015) and 20-weeks (secondary end-point; November/December 2015) post-baseline. Trained research assistants followed standardized protocols. Questionnaires were completed in exam-like conditions prior to the physical assessments.

Primary Outcomes

Aerobic fitness (VO2max, mL/kg/minute) which has been used to assess aerobic fitness among individuals with T2D (27), was assessed using a validated single stage submaximal treadmill walking test and associated estimation equation (28). Lower body muscular fitness was measured using the chair stand test (maximum repetitions within 30 seconds) (29) and has been used in previous studies for people with obesity and T2D (30, 31)

Secondary Outcomes

Aerobic physical activity was objectively measured using pedometers (Yamax, model: Digi-Walker Electronic Pedometer; pedometers were worn by participants for seven consecutive days). Muscular fitness (upper body) was assessed using the validated arm curl test (32) (maximum arm curls within 30 seconds). Functional mobility was tested using the Timed Up and Go Test (33). This test is used to assess a person's mobility and static and dynamic balance. Waist circumference was measured to the nearest 0.1cm using a non-extensible steel tape against the skin in line with the umbilicus. Blood pressure was assessed using a standard digital automatic blood pressure monitor. Weight was measured to the nearest 0.1 kg without shoes in light clothing, and height was measured to the nearest 0.1 cm using a combined portable digital scale and stadiometer (Automatic BMI Stadiometer model: BSM370). BMI was calculated using the standard equation (weight [kg] / height $[m]^2$).

A range of process data (via questionnaires) were collected at the end of the study to complement the outcome data (i.e., satisfaction with the app, training and cognitive sessions, and the *eCoFit* app). Results were recorded for the intervention group on 5-point Likert scales, ranging from ‘Strongly disagree’ (1) to ‘Strongly agree’ (5). Data from the *eCoFit* app regarding app usage were analyzed to assess the frequency of using the smartphone to improve physical activity and help in overcoming the cognitive barriers related with physical activity.

Analysis

Statistical analyses for the primary and secondary outcomes were conducted using linear mixed models in IBM SPSS Statistics for Mac, Version 22.0. Mixed models follow the intention-to-treat principle with the estimation approach that data are missing at random. Demographic and baseline characteristics for the intervention and control groups are reported Table 1. Data are presented as Means (SD) or Mean and 95% CIs for continuous variables and as counts (percentage) for categorical variables. Linear mixed models (intention-to-treat), were used to assess intervention efficacy for both primary and secondary outcomes. The primary outcomes of aerobic fitness and muscular fitness (lower body) were assessed for the impact of the treatment (intervention versus control), time (treated as a categorical variable; baseline, 10-weeks, 20-weeks) and the group-by-time interaction. The primary time-point was 10-weeks (immediate post program). The coefficient and *p*-value testing the difference between groups (changes from baseline to 10-weeks and 20-weeks) were used to determine the effect of the intervention on the co-primary outcomes (significance level, $p<0.025$). Effect sizes were calculated using the equation: Cohen’s $d = (M_{1\ \text{change score}} - M_{2\ \text{change score}}) / SD_{\text{pooled [change score]}}$. Descriptive statistics were used to examine the process measures of the study components to improve aerobic and muscular fitness. Results were recorded on 5-point Likert scales, ranging from ‘Strongly disagree’ (1) to ‘Strongly agree’ (5).

Results

The online eligibility screening was completed by 163 people and 84 (42 in each of the intervention and control groups) completed the baseline assessment (see Figure 1). Participant retention was 79% at 10-weeks (mid-program) and 71% at 20-weeks (see Figure 1), and 70% of the intervention group attended at least 3 of the face-to-face sessions.

The baseline characteristics for the control and intervention groups are described in Table 1. Mean (SD) age for the control and intervention group was 45.1 (14.7) and 44.2 (13.5) respectively. The majority (70%) of participants were born in Australia.

The results for the primary and secondary outcomes are presented in Table 3. After 10-weeks, significant improvements were observed for the primary outcomes of aerobic fitness (4.50 ml/kg/min; 95% CI 1.30, 7.70, Cohen`s *d*= 0.68) and lower body muscular fitness (3 repetitions; 95% CI 3, 4, *d*= 1.45) and a host of secondary outcomes including reduced waist circumference (-2.8 cm, CI -4.7, -0.8, *d*= -0.66), increased physical activity (1330 steps, CI 59, 2600, *d*= 0.67), upper body muscular fitness (5 reps, CI 4, 6, *d*= 1.46) improved functional mobility (-1.8 secs, CI -2.8, -1.2, *d*= -1.16) and improved systolic blood pressure (-10.4 mmHg, CI -18.7. -2.2, *d*= -0.70*)* (see Table 3.). After 20-weeks, the effect for the intervention group (vs control) approached significance (p= 0.062) for aerobic fitness (2.81 ml/kg/min; CI -0.14, 5.76, *d*= 0.43), and sustained significant effect for lower body (4 repetitions, CI 3, 5, *d*= 1.37) and upper body (5 repetitions, CI 4, 6, *d*= 1.36), muscular fitness, functional mobility (-1.69 secs, CI -2.2, -1.1, *d*= -1.21), and systolic blood pressure (-11.3 mmHg, CI -20.6, -1.9, *d*= -0.67). Waist circumference approached significance (-2.14, CI -4.08, -0.20, *d*= -0.60, p=0.058) at the 20-week follow up. No significant group-by-time effects were observed for diastolic blood pressure, BMI, or physical activity.

Evaluation surveys conducted at the end of the intervention (see Table 4) showed positive overall feedback from participants for the group cognitive sessions (M= 4.7, SD= 0.5), outdoor training (M=4.9, SD= 0.3), and the *eCoFit* app (M=4.3, SD=0.6).

Data from the *eCoFit* app revealed participants completed an average of 18 (SD=31) *eCoFit* Challenges, and 6 (SD=5) FitMind Challenges during Phase 1. Goals, which were set for the weekly completion of physical and mental trainings, were completed in 72% for *eCoFit* Challenges and 50% for FitMind Challenges. During Phase 2, app usage declined. Seven participants continued to use the app for *eCoFit* Challenges and four people completed FitMind Challenges. Within this group, on average 16 (SD=14) *eCoFit* Challenges and 5 (SD=3) FitMind Challenges were completed. These results accounted for 53% of the assumed goals for the completion of the *eCoFit* Challenges and 42% for the completion of FitMind Tasks.

Discussion

The aim of the study was to determine the efficacy and feasibility of a multi-component intervention to increase physical activity in a population at risk of, or diagnosed with, T2D. A key objective of the intervention was to promote use of the local public environment for aerobic and resistance activity, thus eliminating many of the common financial and motivational barriers to participation. After 10-weeks, the intervention group demonstrated significant improvements in the primary (aerobic fitness, lower body muscular strength) and secondary outcomes (steps, functional mobility, upper body muscular strength, systolic blood pressure, and waist circumference) in comparison to the control group. After 20-weeks, significant sustained effects were observed upper and lower body strength, blood pressure (systolic), and functional mobility. To the authors' knowledge, this is the first randomized controlled trial integrating smartphone technology, social support, face-to-face sessions, and the outdoor physical environment to improve muscular and aerobic fitness among a population at risk of, or diagnosed with T2D.

Results from the current study are consistent with recent reviews. A meta-analysis of structured exercise training on fitness outcomes for T2D (34) showed that aerobic exercises (with small components of resistance training activities) led to clinically important improvements in VO_2max. The intensity of exercise prescribed in the studies included in this meta-analysis ranged from 50%-70% of VO_2 max. Results revealed an 11.8% increase in VO_2max for the intervention group and a 1.0% decrease in the control condition. In the present trial, increases in VO_2 max of 14% and 8.7% were observed after 10- and 20-weeks (approaching significance), respectively (in comparison to the control group). A review on resistance training effects for adults with T2D (35) revealed that combining aerobic and resistance training activities significantly improved muscle quality, muscle density, muscular strength and VO_2 max. After 10 and 20 weeks, participants from the *eCoFit* intervention group improved their lower body muscular strength (study co-primary outcome) by approximately 35% in comparison to their baseline score.

With regards to the secondary outcomes, participants in the intervention group significantly improved their clinical and fitness outcomes (i.e., upper body muscular strength, waist circumference, blood pressure) increased their physical activity, and reported better daily functioning.

The majority of improved health-related outcomes at 10-weeks were sustained at 20-weeks. This suggests participants continued physical activity during Phase 2 of our study, otherwise a greater decline would be observed for fitness/health outcomes at the 20-week follow-up.

Our detailed process evaluation revealed participants rated each of the intervention components very highly (see Table 4). It is possible that increasing the number of sessions and longer time period may contribute to greater health and social benefits for this population and further research on this would be fruitful Participants were highly satisfied with the *eCoFit* app, although frequency of usage reduced from 10-weeks to 20-weeks. The lower app usage at the end of Phase 2 may be also explained by the possibility participants gained experience and knowledge over the intervention period on how to exercise in the outdoor setting (without the assistance of the app). Participation in outdoor workout was retained despite variable weather conditions (e.g., temperature in the study period ranged from 7.3°C to 25.8°C).

A unique component of *eCoFit* is its practicality to engage in physical activity in the public space (using benches, railings, and stairs). The intervention reduced the economic barrier of performing RT by promoting the usage of the outdoor physical environment and green spaces. It has also been reported that individuals who are active in the natural setting are less depressed, have lower rates of anger, stress and feel more positive about physical activity (14). The *eCoFit* program, as a free gym alternative, has the potential to be highly beneficial for the community and represents an efficacious and scalable method for supporting RT participation among the broader adult population.

The study strengths include the RCT design, assessor blinding, and an objective measure of physical activity. Additional to the primary outcomes a comprehensive range of secondary outcomes were examined. The retention rate was fairly high, with 71% at 20-week follow-up. Notably, no incentives were provided to encourage participants to return for the follow-up assessments.

The trial also has some limitations. The *eCoFit* app was a web-based app which can only be used with adequate phone reception and sufficient internet data. The study design was unable to isolate the specific effects for each component of the intervention. Further, males were under-represented and the duration of the study limits the long-term interpretation of these findings. A large-scale community based trial might help to establish the generalizability of the program for other populations, with and without chronic disease, from different cultural background, education level and socioeconomic position.

Conclusion

eCoFit is an innovative, lifestyle program which has similar or greater magnitude of effects compared to previous research in this area (8, 9, 34, 36). This is an important finding, as the intervention has the potential to reduce many cost-related barriers and facilitate the dissemination of a more active lifestyle by using public spaces and supportive technological and social strategies to engage in and maintain physical activity.

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Table 1

Baseline characteristics of *eCoFit* participants randomized to the control and intervention groups; the intervention was conducted in 2015 at the University of Newcastle, NSW, Australia.

Characteristics	Control (n=42) M (SD)	Intervention (n=42) M (SD)	Total (n=84) M (SD)
Age (years)	45.1 (14.7)	44.2 (13.5)	44.7 (14.0)
BMI (kg/m^2)	31.7 (5.1)	35.0 (5.9)	33.3 (5.7)
Waist circumference	107.7 (12.3)	115.7 (14.1)	111.7 (13.7)
Systolic blood pressure (mmHg)	136.9 (18.7)	143.7 (17.5)	140.2 (18.3)
Diastolic blood pressure (mmHg)	93.2 (17.0)	91.3 (13.0)	92.3 (15.1)
Aerobic fitness, the single stage treadmill walking test (mL/kg/min)	33.6 (8.2)	30.5 (8.2)	32.0 (8.3)
Muscular fitness (lower body), chair stand test (reps)	10.3 (2.4)	10.1 (1.9)	10.2 (2.2)
Functional mobility (sec)	9.1 (2.1)	8.6 (1.5)	8.9 (1.8)
Muscular fitness (upper body)	12.4 (4.0)	11.0 (2.7)	11.7 (3.5)
Physical activity (pedometer steps/day)	6117 (3203)	6799 (3730)	6453 (3468)
	n (%)	n (%)	n (%)
Sex			
Female	29 (69.0)	30 (71.4)	59 (70.2)
Male	13 (31.0)	12 (28.6)	25 (29.8)
T2D	4 (9.5)	6 (14.3)	10 (11.9)
High Risk of T2D	9 (21.4)	11 (26.2)	20 (23.8)
Overweight/Obese	29 (69.0)	25 (59.5)	54 (64.3)
Ethnicity			
Australian	33 (78.6)	37 (88.1)	70 (83.3)
Asian	2 (4.8)	1 (2.4)	3 (3.6)
European	4 (9.5)	3 (7.1)	7 (8.3)
African	0	1 (2.4)	1 (1.2)
Other	3 (7.1)	0	3 (3.6)

Table 2

Intervention components, and behavior change techniques in the eCoFit intervention; the intervention was conducted in 2015 at the University of Newcastle, NSW, Australia.

Intervention component	Dose	Description	Behavior change strategies
Phase 1 (Weeks 1-10)			
Face-to-face group sessions			
i) Cognitive mentoring sessions	Weeks 1-10 5 sessions 1 x 30 min session per fortnight	Delivered by a clinical psychologist: Participants were educated on strategies to overcome barriers and increase their motivation for and adherence to PA.	Increase motivation Change negative outcome expectancies related to PA Increase self-efficacy, self-reward Provide strategies for overcoming barriers Provide planning and coping planning strategies Implement problem solving strategies Help change unhelpful automatic thoughts Self-efficacy reinforcement Provide self-monitoring strategies Social support
ii) Outdoor PA sessions	Weeks 1-10 5 sessions 1 x 60 min session per fortnight	Delivered by a qualified personal trainer: Participants were educated on and participate in sessions using the outdoor physical environment (e.g., parks, benches) to increase muscular strength and aerobic fitness.	Provide instruction Model or demonstrate behavior Provide feedback on performance Social support Increase motivation Behavior reinforcement General encouragement

eCoFit smartphone App	Weeks 1-10	The App, included: a) A description of where and how to use the outdoor physical environment (e.g., park benches) to be physically active. b) 'eCoFit Challenges' in 11 different park locations. c) 'Indoor Challenges' which provided aerobic and RT PA sessions that can be completed indoors or at home. d) A function to set weekly PA goals (options: when, where, with whom, and what I will do to make it happen) and self-monitor the progress; e) 'FitMind Challenges' which involved short tasks to increase motivation, overcome barriers, and develop positive PA behaviors; and f) Links to social media.	Provide information about eCoFit Challenges Provide instruction Promote outdoor environment for RT and aerobic activities Goal setting Self-monitoring Provide planning and coping planning strategies Social support Provide cognitive strategies to increase motivation and PA maintenance Progress tracking
Phase 2 (Weeks 11–20)			
eCoFit smartphone App	Weeks 11-20 (Continuation)	As described in above section 'eCoFit smartphone App'.	As described in above section 'eCoFit smartphone App'.

Table 3
Mean change in outcomes within groups and differences between groups over time (intention-to-treat-population).

		Change from Baseline, M (95% CI)[a]				
Primary outcomes	Week	Control Group (n=42)	Intervention group (n=42)	Difference between groups, M (95% CI)[b]	*p*-value	Effect size (Cohen`s *d*)
Aerobic fitness (mL/kg/minute)	10	-1.3 (-3.6, 0.9)	3.1 (0.9, 5.4)	4.50 (1.30, 7.70)	0.007*	0.68
	20	-0.2 (-2.3, 1.8)	2.6 (0.5, 4.7)	2.81 (-0.14, 5.76)	0.062	0.43
Lower body muscular fitness, Chair stand test (reps)	10	-1.7 (-2.2, -1.1)	1.8 (1.2, 2.3)	3.43 (2.67, 4.20)	0.000*	1.45
	20	-1.2 (1.9, -0.5)	2.7 (2.0, 3.4)	3.88 (2.86, 4.90)	0.000*	1.37
Secondary outcomes	Week	Control Group (n=42)	Intervention group (n=42)	Difference between groups, M (95% CI)	*p*-value	Effect size (Cohen`s *d*)
Physical activity (pedometer steps/day)	10	-160 (-1040, 720)	1170 (254, 2086)	1330 (59, 2600)	0.043*	0.67
	20	720 (-543, 1983)	1449 (115, 2782)	728 (-1108, 2565)	0.073	0.56
Functional mobility (sec)	10	1.1 (0.7, 1.6)	-0.6 (-1.0, -0.2)	-1.77 (-2.37, -1.17)	0.000*	-1.16
	20	0.8 (0.5, 1.2)	-0.9 (-1.2, -0.5)	-1.69 (-2.24, -1.15)	0.000*	-1.21
Upper body muscular fitness, Arm curl test (reps)	10	-2.4 (-3.1, -1.6)	2.6 (1.9, 3.4)	4.95 (3.89, 6.02)	0.000*	1.46
	20	-2.0 (-2.9, -1.1)	3.1 (2.1, 4.0)	5.05 (3.77, 6.33)	0.000*	1.36
Waist circumference (cm)	10	0.2 (-1.1, 1.6)	-2.5 (-4.0, -1.1)	-2.76 (-4.71, -0.80)	0.006*	-0.66
	20	-1.4 (-2.7, -0.0)	-3.5 (-4.9, -2.1)	-2.14 (-4.08, -0.20)	0.058	-0.60
BMI (kg/m)	10	0.3 (-0.4, 0.9)	-0.5 (-1.1, 0.2)	-0.72 (-1.63, 0.17)	0.107	-0.42
	20	0.3 (-0.6,0.7)	-0.5 (-1.1, 0.1)	-0.54 (-1.46, 0.37)	0.280	-0.34
Systolic blood pressure (mmHg)	10	-1.4 (-7.2, 4.4)	-11.8 (-17.7, -6.0)	-10.42 (-18.68, -2.16)	0.013*	-0.70
	20	-2.4 (-8.8, 4.0)	-13.7 (-20.5, -6.8)	-11.25 (-20.60, -1.90)	0.021*	-0.67
Diastolic blood pressure (mmHg)	10	-6.6 (-13.3, 0.2)	-8.0 (-14.7, -1.3)	-1.44 (-10.98, 8.09)	0.777	-0.38
	20	-2.6 (-7.8, 2.6)	-9.7 (-15.1, -4.1)	-7.04 (-14.59, 0.51)	0.097	-0.73

Note: * indicates statistical significance ($p<0.05$)
[a] Time differences were calculated as 10-weeks minus baseline and 20-weeks minus baseline. [b] Differences between groups in changes from baseline to 10 and 20 weeks (intervention minus control); the intervention was conducted in 2015 at the University of Newcastle, NSW, Australia

Table 4

Post-program process evaluation data results for cognitive mentoring sessions, group outdoor training and the *eCoFit* app (n=30); the interventi was conducted in 2015 at the University of Newcastle, NSW, Australia.

Process evaluation items *Cognitive Mentoring Sessions*	Mean (SD)	Process evaluation items *Group Outdoor Training*	Mean (SD)
Overall Evaluation		Overall Evaluation	
"Overall I would rate the cognitive mentoring sessions"	4.7 (0.5)	"Overall I would rate the personal training sessions"	4.9 (0.3)
"Overall I would rate my instructor`s delivery of the cognitive mentoring sessions"	4.8 (0.6)	"Overall I would rate my instructor`s delivery of the personal training sessions"	4.9 (0.3)
Utility Evaluation		Utility Evaluation	
"The cognitive mentoring sessions helped me to understand my thoughts related to physical activity"	4.6 (0.6)	"The personal training sessions provided me with the skills and confidence to complete the individual *eCoFit* Challenge"	4.8 (0.4)
"The cognitive mentoring sessions provided me with useful strategies to increase my motivation for physical activity"	4.6 (0.6)	"The personal training sessions helped me to improve my resistance training technique"	4.6 (0.6)
""The cognitive mentoring sessions provided me with useful strategies to overcome barriers of physical activity"	4.7 (0.6)	"The personal training sessions helped me to improve my aerobic fitness"	4.2 (0.7)
"I found the cognitive sessions enjoyable"	4.7 (0.6)	"The personal training sessions helped me to improve my muscular fitness"	4.4 (0.7)
Instructor Evaluation		Instructor Evaluation	
"I found the instructor easy to relate to"	4.7 (0.5)	"I found the instructor easy to relate to"	4.9 (0.3)
"I found the instructor knowledgeable about cognitive mentoring (e.g. motivation, overcoming barriers)"	4.9 (0.4)	"I found the instructor knowledgeable about health and fitness"	4.9 (0.3)
"I liked the instructor that delivered the cognitive mentoring sessions"	4.9 (0.4)	"I liked the instructor that delivered the personal training sessions"	4.9 (0.3)
"I feel that instructor gave me adequate support to overcome barriers and increase motivation to be physical active"	4.6 (0.6)	" I feel the instructor gave me adequate support to improve my training technique"	4.9 (0.4)

Process evaluation items *eCoFit* app	Mean (SD)
Overall Evaluation	
The Fit Mind Challenges were useful" (cognitive tasks)	4.0 (0.8)
The App increased my knowledge of how to use the outdoor physical environment (e.g., parks) to be more physically active	4.0 (1.0)
I enjoyed the *eCoFit* Challenges	4.3 (0.6)
The App helped me to set goals and plan my physical activity	3.8 (1.0)
The app helped me to monitor my physical activity progress	3.7 (1.0)

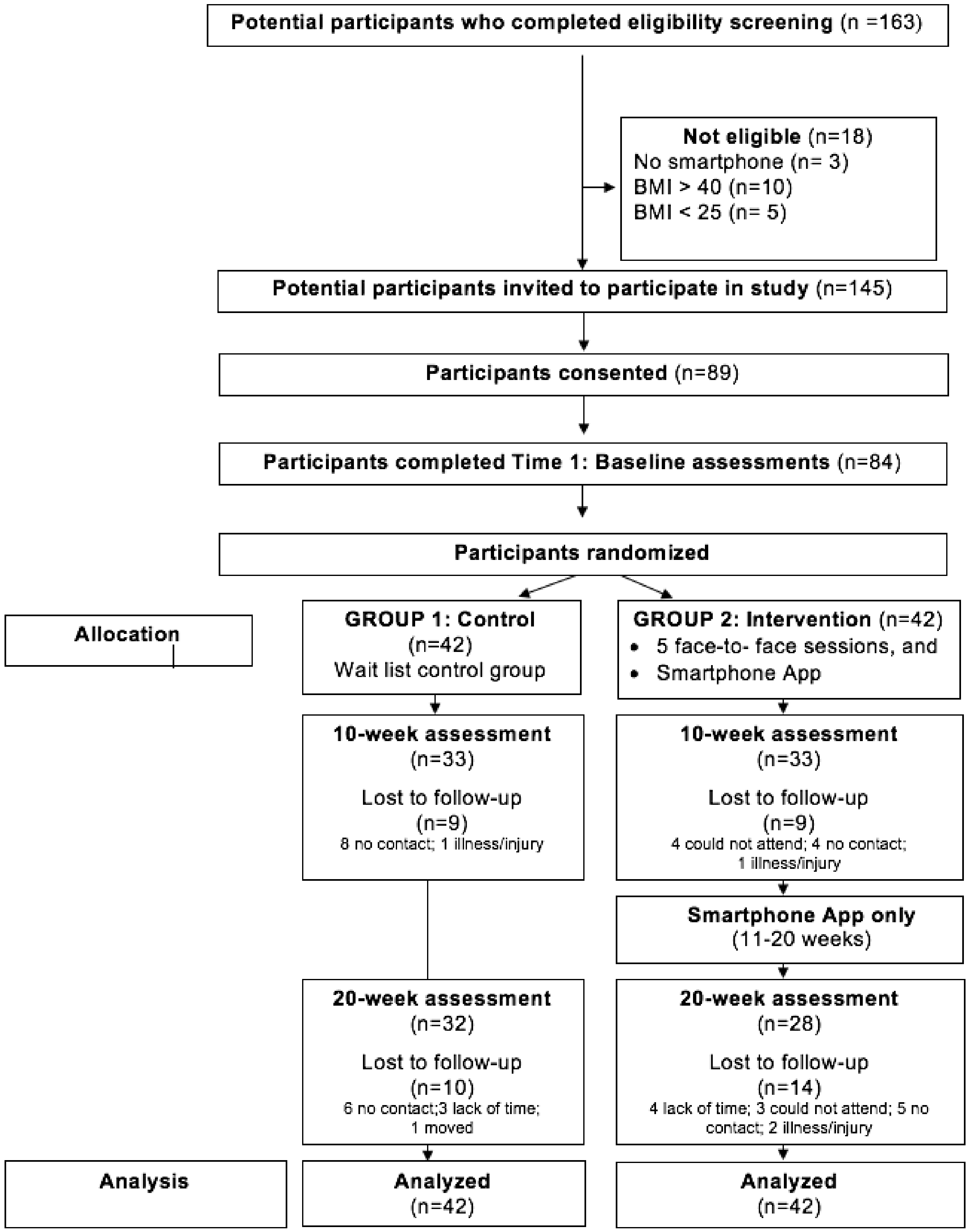

Figure 1. Flow diagram of the *eCoFit* study; the intervention was conducted in 2015 at the University of Newcastle, NSW, Australia

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Highlights

- eCoFit components were effective for improving aerobic and muscular fitness
- eCoFit had an effect on other health-related outcomes
- eCoFit could facilitate a more active lifestyle by using outdoor public spaces
- eCoFit can be standardised to most geographic community outdoor settings
- eCoFit may be scalable for larger community settings and varied populations