



Opinion paper

Integrating smartphone technology, social support and the outdoor built environment to promote community-based aerobic and resistance-based physical activity: Rationale and study protocol for the ‘*ecofit*’ randomized controlled trial

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ABSTRACT

Introduction: Regular physical activity can significantly reduce the risk of numerous chronic diseases, and improve bone density and mental health. Yet, only 50% of Australian adults meet the aerobic physical activity guidelines and 9–19% meet the resistance-based physical activity guidelines. The aim of this study is to enhance community-based aerobic and resistance-based physical activity through the use of publicly available outdoor exercise equipment, social support and smartphone technology.

Research design and methods: The *ecofit* intervention will be evaluated using a two-arm randomized controlled trial. A total of 240 adults (aged 18–80) will be recruited and randomly allocated to either the *ecofit* intervention or a ‘wait-list’ control group. Both groups will have access to the two types of outdoor park exercise equipment, but the intervention group will be given access to the purpose-built *ecofit* app and a 90-min introductory group training session. To promote social support, participants can enrol in a group of up to four individuals and access the *ecofit* Facebook group. The *ecofit* app include workout plans that can be tailored to different locations, difficulty levels and workout-types (i.e., resistance-only or combined resistance and aerobic workouts). Outcome assessments will be conducted at baseline, 3- (primary-end point) and 9-months follow-up. The primary outcomes are upper and lower body muscular fitness. The secondary outcomes include physical activity, body composition, aerobic fitness, body mass index, self-report resistance-based physical activity, and mental health outcomes. The cost-effectiveness of the study will also be evaluated.

Discussion: *ecofit* is an innovative, multi-component physical activity intervention that integrates smartphone technology, social support and the outdoor built environment to promote community-based aerobic and resistance-based physical. The findings will be used to guide future interventions and to support councils to promote community-based physical activity through the use of local outdoor exercise equipment.

Trial registration: ACTRN12619000868189.

1. Introduction

Physical inactivity is a major risk factor for non-communicable disease, only half of Australian adults meet the recommended guidelines for aerobic physical activity [1] and only 9–19% meet the recommendations for resistance-based physical activity [2].

A substantial number of community-based interventions have attempted to address physical inactivity, while few have been successfully scaled-up and sustained in the real world [3]. Interventions to-date which have demonstrated partial effects on physical activity behavior change include, built environment [4,5], social support [6], technological approaches [6,7] and social marketing [8]. However, changing

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population-based physical activity behavior is a complex task that is influenced by multiple factors (i.e., individual, social, environmental and policy) [9,10], thus, multi-component approaches may be more effective than single-component interventions [11]. The majority of such interventions have focused on aerobic physical activity, and few have integrated both aerobic and resistance-based physical activity. Resistance-based physical activity provides additional benefits that are separate of aerobic exercise, which include lower risk of developing metabolic syndrome [12], increased muscular fitness [13], improved cardiovascular disease risk profile [14], increased lean body mass and reductions in body fat [15], as well as improved fall risk factors such as balance, postural control, mobility and leg strength in the elderly [16]. Therefore, there is a need for scalable community-based interventions which promote physical activity behavior change at multiple-levels to explicitly target sustainable change in aerobic and resistance-based physical activity.

Both aerobic and resistance-based physical activity requires specific skill sets (i.e., knowledge of types and correct techniques, and knowledge regarding duration, frequency, intensity and availability of equipment). However, resistance-based activities may require additional knowledge and instructions to ensure safe and effective techniques compared to aerobic activity [17]. There are also a number of financial barriers to resistance-based physical activity, i.e., gym memberships, exercise classes or personal training sessions. Thus, new and innovative initiatives that increase community-based aerobic and resistance-based physical activity are important in order to remove barriers relating to participation, and reduce the many financial, social and health consequences of physical inactivity.

The context in which physical activity is undertaken may also provide benefits additional to those of physical activity alone. Exercising outdoor in a natural environment may have additional health benefits compared to engaging in physical activity indoors [18-20], including immediate improvements in positive affect [21], and self-reported mental health [20], improvements in numerous cognitive outcomes [22], and improvements in immune functioning [23] and physiological biomarkers of stress [24]. One way to engage in aerobic and resistance-based activities outdoors is through the use of parks and outdoor gyms. Outdoor gym (i.e., outdoor exercise equipment) installations have become increasingly popular among local government agencies in Australia [25,26] and globally [27]. These facilities are often installed in park areas, and commonly consists of all-weather exercise apparatus that requires no electricity, often low cost and suitable for most age groups and fitness levels [28]. For example, local government agencies in Victoria, Australia have reported over 90 current outdoor gym installations with intentions for more [29], and Brisbane city council have fitted outdoor gym equipment in 150 of the city's parks [30]. A few small-scaled exercise interventions [31-32], which have included outdoor gym equipment, have shown promising results and larger scale studies are beginning to emerge [33]. However, general utilisation of the equipment appears low [28,34] and no large scale RCT's to date have attempted to increase the community-based usage of the equipment [35]. Thus, there is a need for researchers to partner with local councils that are in charge of outdoor gym installations to collaboratively work to increase community-based usage.

Technology-based interventions (i.e., websites and apps) have the potential to influence physical activity behaviour through their ability to reach people on large scales, disseminate education material to participants, foster social support, and allow self-monitoring and feedback on behaviour [36,37]. A recent meta-analysis found technology-based interventions were 25% more effective than usual care in physical activity promotion among patients, and increased physical activity by 12% in non-patient populations compared to similar or minimal interventions without the use of technology [38]. Successful technological-based interventions that promote physical activity include the use of mobile phones (including apps) [36], computer-based (online) information sources [36,39], and fitness tracking devices [40]. Given the

technological adoption, its use and availability, even amongst older adults [41], technology-based platforms to promote physical activity is a promising avenue [42].

Social support has been found to be significantly correlated with physical activity across different populations [11,43], and therefore found to be an effective approach in promoting behaviour change in physical activity interventions [6,44]. The importance of social support has been highlighted in both independent and programmed outdoor gym use [45,46]. A recent review demonstrated that app-based physical activity interventions that incorporated an existing Web-based social networking platform achieved increased and sustained intervention engagement [42].

The present study is built upon Plotnikoff and colleagues' (2016) 'ecofit' efficacy trial [47]. The aim of *ecofit* was to improve aerobic and muscular fitness in individuals (aged 18-80) at risk of, or diagnosed with Type II diabetes. The community-based multicomponent physical activity intervention involved the outdoor built environment (i.e., park benches, bike rack and trees at 12 exercise locations) smartphone technology (i.e., an app) and social support (i.e., face-to-face group sessions). Study results at the 10-week primary-end point indicated significant improvements for the primary outcomes of aerobic fitness and lower body muscular fitness. Significant improvements were also found for a host of physical and clinical secondary outcomes, including upper body muscular fitness. As the efficacy trial was conducted in a disease specific population, the current study has extended its functionality to be more suited to the general population through, improved app-based technology, relevance of resources and updated workouts. Additionally, the current study will utilize outdoor gym equipment in addition to some facilities that were used in the efficacy trial e.g., park benches.

Therefore, the purpose of this paper is to provide a rationale and study description for the *ecofit* effectiveness study, which is an innovative community-based multi-component physical activity intervention that promotes aerobic and resistance-based physical activity through smartphone technology, social support and the use of outdoor exercise equipment.

2. Material and methods

2.1. Objectives

The specific study objectives are (1) to examine the impact of *ecofit* on the two primary outcomes of upper and lower body muscular fitness, and on secondary outcomes including physical activity (accelerometry and self-report), body composition, aerobic fitness, body mass index, self-reported resistance-based physical activity and mental health outcomes (i.e., self-reported happiness, depression, anxiety and stress); and (2) conduct a cost-effectiveness of the intervention.

2.2. Study design

The *ecofit* intervention will be evaluated using a two-arm RCT with assessments at baseline, three-month (primary-end point) and nine-month follow-up. The intervention targets adults (18-80 years of age) who do not meet current Australian aerobic and/or resistance-based PA guidelines [48] in the Lake Macquarie, Newcastle and Maitland Local Government Areas of New South Wales (NSW), Australia. The present study include 12 parks in the aforementioned regions. See Table 1 for characteristics of each park location including the Index of Relative Socio-economic Advantage and Disadvantage (IRSAD) deciles [49], population size within the postcode of each parks, and number and type of outdoor gym equipment. The design and conduct will be reported according to the Consolidated Standards of Reporting Trials (CONSORT) guidelines [50]. Approval for the present study has been obtained from the Human Research Ethics Committee of the University of Newcastle, Australia. The trial is registered with the Australian and New Zealand

Table 1
Characteristic of each workout location.

Parks	Installation year	Suburb/Local Government Area	Population size based on post code	IRSAD ^a	Type of gyms	Number of pieces of equipment	Type of equipment
Cameron Park	2018	Cameron Park/ Lake Macquarie City Council	27,815	6	Pod	19	Dexterity builder; sit-up bench; parallel bars; gorilla bars; pull-up bars; multi bench; shoulder mobility wheel; chest press; pull downs; body twist; leg raises; leg press; step-up; aerobic cycle; elliptical trainer; stretch station; body pulls; push ups; box jumps (Benches, bike racks and grassy areas)
Dixon Park	N/A	Merewether/ Newcastle City Council	13,413	9	Trail	0	
Fernleigh Track	2018	Adamstown/ Newcastle City Council	18,825	8	Trail	3x pieces across 2 stations	Pull-up bars; step-up; parallel bars
Islington Park	2018	Tighes Hill/ Newcastle City Council	1,620	4	Trail	7x pieces across 2 stations	Half ring bars; pull up bars; chest press; stretching station; push up bar; parallel bars; step up
Lambton Park	2018	Lambton/ Newcastle City Council	10,686	4	Trail	8 x pieces across 5 stations	Sit-up bench; squat-up bench; pull-up bars; parallel bars; push-up bars
Maitland Park	2016	Maitland/ Maitland City Council	34,556	5	Pod	12	Balance beam; dip bars; sit-up bench, leg raise; parallel bars; pull-up bars; roman rings; step up; stretching station
Speers Point Park	2018	Warners Bay/ Lake Macquarie City Council	10,450	3	Trail	10x pieces across 6 stations	Multi-bench; sit-up bench; multi-use arch; monkey bars; pull-up bars; roman rings; leg raises; tricep dips; pull-ups; plyo boxes
Speers Point Park	2018	Warners Bay/ Lake Macquarie City Council	10,450	3	Pod	8	Monkey bars; pull-up bars; step-up bench; parallel bars; ladder; balance beam; balance poles
Stockton	2019	Stockton/ Newcastle City Council	5,818	3	Trail	15x pieces across 6 stations	Bench press; push up bars; shoulder press; chin up bars; stretch station; sit up boards; aerobic walker; cycle seat; parallel bars; pull up bar; leg lift; dip bar; quad extensions; plyo box
University of Newcastle	2018	Shortland	3,708	3	Trail	8	Stretching stations; chest press, dip bar, leg press, pull downs, pull up bar; sit up bench
Wangi Wangi Foreshore	2018	Wangi Wangi/ Lake Macquarie City Council	2,673	5	Trail	10x pieces across 5 stations	Bench dip; log hop; step-up; body curl; sit-up; push-up; vault bar; achilles stretch; sit and reach; leg stretch;
Warabrook Wetlands	2018	Warabrook/ Newcastle City Council	14,987	3	Pod	7 pieces in total (3x pieces at one pod and 4x pieces at the second pod)	Sit ups; step-up; plyo box jump; chin-ups; parallel bars
Warners Bay Foreshore	2018	Warners Bay/ Lake Macquarie City Council	14,451	8	Trail	7x pieces across 4 stations	Multi bench, sit-up bench; step-up; leg raises; pull up bar; body dips; roman rings

^a The Index of Relative Socio-economic Advantage and Disadvantage (IRSAD). A low score indicates relatively greater disadvantage and a general lack of advantage, whereas a high score indicates a comparable lack of disadvantage and a general greater advantage [49].

Clinical Trial Registry (ANZCTR): ACTRN12619000868189.

sample size of 240 (120 per study group).

2.3. Sample size calculation

Power calculations (two-tailed) were conducted to determine the sample size required to detect changes in the two primary outcomes (i.e., lower and upper body muscular fitness) at the primary end-point of three months. The effect sizes for upper body are much larger than lower body in such trials [47], so the sample size is conservatively based on the effect size for lower body muscular fitness. Power calculations were based upon the *ecofit* efficacy study [47] conservatively using 2.4 as the standard deviation for the chair-stand test (lower body muscular fitness), as measured by the number of repetitions in 30 s, with the alpha set at 0.025 (adjusting for two primary outcomes), and power = 80%. To detect an effect of half a standard deviation (i.e., effect of 1.2 in intervention vs control), 77 participants are required in each arm. Allowing for approximately 25% attrition (based on the *ecofit* efficacy trial [17]), 200 individuals (100 per arm) are required. Given participants are able to enrol in clusters of up to 4 people, we assume an average cluster size of 2–3, with an ICC = 0.1, giving us an estimated design effect of up to 1.2. The design effect is given by $1 + (m-1)p$ where m is the average number per cluster and p is the ICC. We therefore calculate a total

2.4. Participants: Eligibility, recruitment and screening

The study will recruit adults from the Newcastle City, Lake Macquarie and Maitland Local Government Agencies of NSW. Participants will be recruited through radio, TV, newspaper advertisements, social media, school newsletters, flyers distributed to letter boxes of residents living in the geographical suburbs of each of the 12 locations in which Local Councils have installed outdoor fitness equipment. Interested individuals will be asked to email an expression of interest to the researchers. The research team will contact interested individuals and provide them with an information statement outlining the requirements of participation and a link to complete the eligibility questionnaire online. Participants aged 18–80, having access to a smartphone, not meeting current aerobic and/or resistance-based physical activity guidelines and identified as low risk, or have medical approval if necessary, on the Adult Pre-Exercise Screening Tool [51] will be eligible. The Adult Pre-Exercise Screening Tool is designed to identify individuals with known disease, signs or symptoms, or who may be at higher risk of an adverse event with exercise. Participants who identify as having any medical issues from the screening tool will be required to obtain

clearance from their GP prior to participating in the study. This process has been included to minimise the risk of potential harms. Participants will be excluded if they report participating in other physical activity interventions at the time of enrolment.

All participants will be contacted regarding their eligibility. Those deemed eligible will be sent a consent form and instructions on how to register for their baseline assessment via an online booking portal. Individuals can enrol alone, but will be encouraged to enrol in pairs or small groups (of up to four individuals) to promote social support. All participants will be required to provide written informed consent upon study participation. This recruitment process will occur on a rolling basis until an adequate number of participants have been recruited to ensure sufficient statistical power to the study. Recruitment will commence in September 2019 and we are expecting to have collected all baseline data by April 2020.

2.5. Blinding and randomisation

Recruitment and baseline assessments will be conducted prior to randomisation. For the purpose of the randomisation, clusters of up to four participants will be used to allow for group participation. A researcher not involved in the *ecofit* study will randomly allocate each cluster to either the intervention or 'wait-list' group, using a computer-based random number producing algorithm. This method will ensure that individual participants and clusters have an equal chance of allocation to either condition, and that individuals enrolling as part of a cluster are allocated to the same group. Participants will remain in their allocated treatment group (i.e., intervention or 'wait-list' group) for the duration of the study. Those who are waitlisted will be given access to the app and the introductory session at the end of the study period.

Clustering was included in the randomization process to account for participants signing up as a group. This was to promote social support and to decrease the likelihood of having two participants who are planning to work-out together to be in opposite groups. Of note, individuals are not prescribed to work-out in groups; they have the choice to work-out on their own or with their training partner(s). There are no specific requirements regarding having to work out with whom one is enrolled with. Further, participants are not required to have the same physical activity level or share similar socio-demographics.

2.6. Intervention overview and delivery

The multi-component *ecofit* intervention will be evaluated over a nine month study period. The intervention will incorporate (i) smartphone technology (i.e., app) (ii) social support (i.e., enrolling as groups of up to four and the *ecofit* Facebook group), and (iii) the outdoor built environment (i.e., the recently installed outdoor fitness equipment). The *ecofit* smartphone app is based upon the existing *ecofit* app, which has been described in detail elsewhere [17]. Participants will be encouraged to complete two *ecofit* workouts per week, to meet the resistance-based physical activity guidelines. The updated version of the app is tailored to each of the 12 park locations and has been modified to extend the functionality to be more suited for the general population. The app is

comprised of multiple functions, including:

2.6.1. Standardised workouts

Each workout in each park location is composed of eight resistance-based exercises (i.e., two core, two upper body, two lower body, one chest and one back) that targets major muscle groups, as per recommendations from the resistance-based physical activity guidelines [48]. There is an animated video and an explanatory text for each type of exercises. (See Fig. 1 for an example from the *ecofit* app). Participants can choose between two types of workouts (see 2.5.2. 'Workout locations' below). Once the workout type has been chosen, participants will select between three types of training categories; 'resistance only', 'resistance and aerobic' or integrated resistance and aerobic' (see 2.5.3. *Workout categories*). To allow for participant progress and targeting users of different fitness levels, the app has built in three different difficulty levels (i.e., beginner, intermediate, and experienced). For example, a beginner-level push-up is completed on the knees whereas an experience-level push-up is completed on the toes. (See Fig. 2 for a visual representation of the steps of choosing a workout).

2.6.2. Workout locations

At the 'Fixed' locations the equipment is clustered in one spot (See Fig. 3 for an example of a 'Fixed' equipment location). 'Fixed' locations allow for all three training categories (i.e., 'resistance only', 'resistance and aerobic' or integrated resistance and aerobic'). At the 'Trail-based' exercise location, the outdoor exercise equipment is located along a trail which is approximately 3-km in total. (See Fig. 4 for an example of a 'Trail-based' fitness location). When completing a 'Trail-based' workout, participants exercise at each fitness location and run or walk to the next, until a total of a 20 min of walking/running has been completed along with all resistance-based exercises. The 'Trail-based' locations only allows for the 'integrated resistance and aerobic' option. The app currently includes eight locations with 'Trail-based' equipment, one with 'Fixed' equipment and two locations that include both. (See Fig. 5 for an example from the *ecofit* app).

2.6.3. Workout categories

The resistance only option consist of eight resistance-based exercises. While all exercises will cover the same body parts (i.e., two core, two upper body, two lower body, one chest and one back), the types of exercises may vary slightly between parks depending on the availability of equipment. The 'resistance and aerobic' option consists of an added aerobic workout (i.e., run, jog or brisk walk) for 20 min upon completion of all the resistance-based exercises. The 'integrated resistance and aerobic' option alternates one resistance-based exercise with a short bout of aerobic activity (i.e., 60-s run).

2.6.4. Self-monitoring function

The app includes a number of self-monitoring functions. These include, to set weekly workout goals, track workout history, track past work out goals and monitor progress. (See Fig. 6 for an example from the *ecofit* app). The *ecofit* self-assessment is a brief tool based on measures which allows participants to monitor their physical progress and

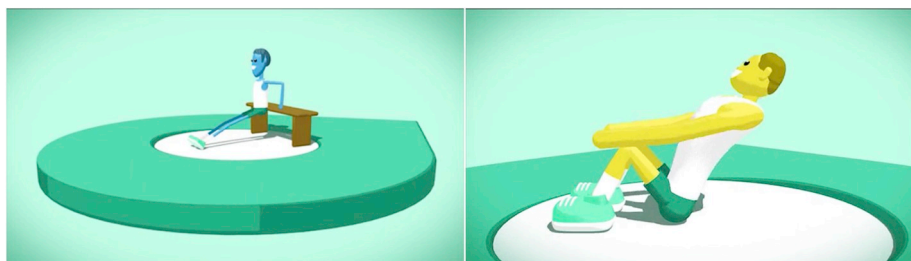


Fig. 1. Example of animated workouts.

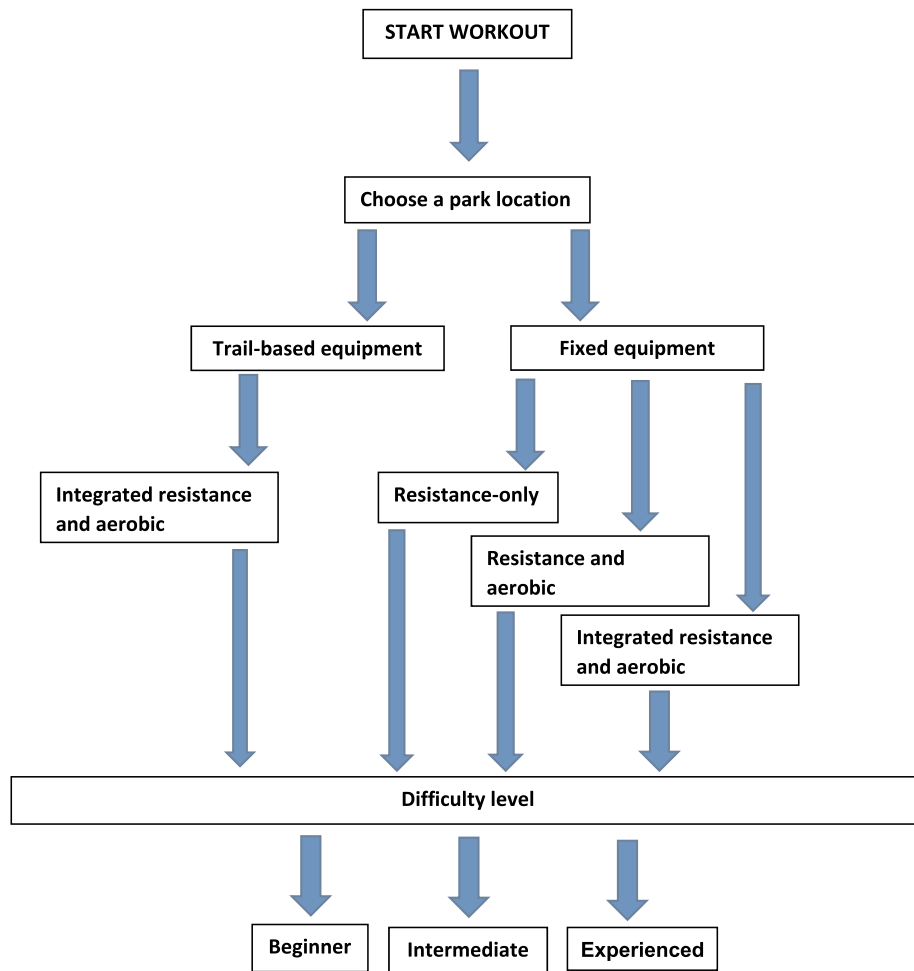


Fig. 2. Flow diagram of the process of choosing an ecofit workout.



Fig. 3. Example of a ‘Fixed’ equipment location.



Fig. 4. Example of a ‘Trail-based’ equipment location.

happiness throughout the intervention period. The self-assessment tool incorporates a 1-item happiness question [52], 12-min walk/run [53, 54], sit-to-stand test [55,56] and the push-up test [57].

2.6.5. Exercise library

In the exercise library, participants can access a complete list of all included resistance-based exercises, read the instructions and watch the animated instructional videos.

2.6.6. Resources

The resource folder include information regarding the physical, psychological and clinical benefits of aerobic and resistance-based

physical activity and the current physical activity guidelines. There are also action and coping planning strategies, based on the Health Action Process Approach [58,59] and Cognitive Behavioral Therapy strategies such as mindfulness, goal setting and cognitive distortions [60].

2.7. Intervention group

The intervention group will have access to the ‘Fixed’ and or ‘Trail-based’ outdoor fitness equipment which will be installed in the park locations and detailed in the *ecofit* app.

In addition to the app, each participant in the intervention group will

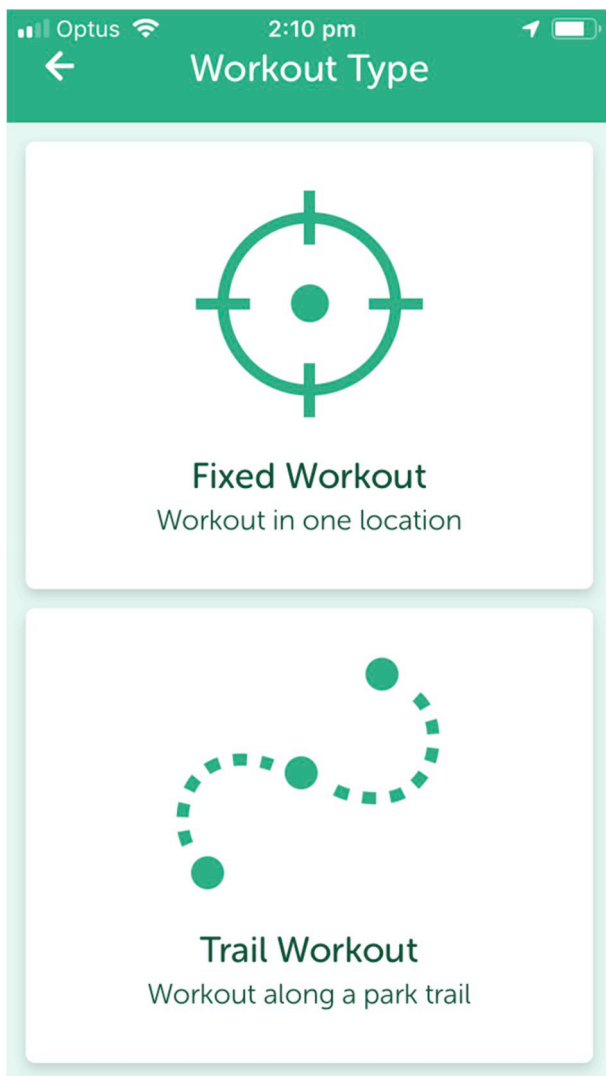


Fig. 5. Choosing a workout type.

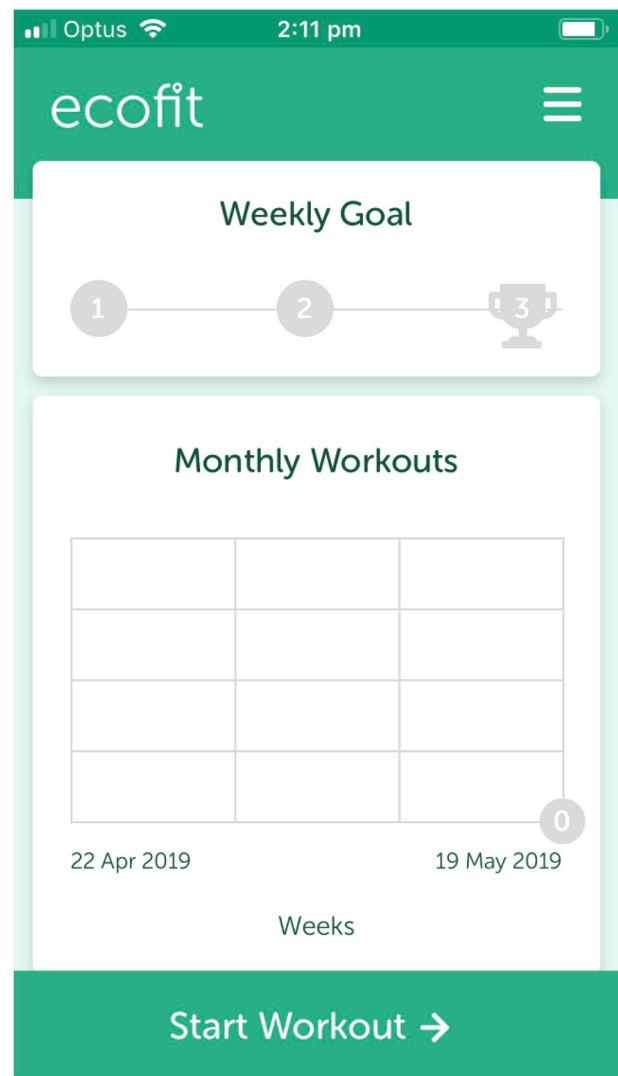


Fig. 6. Example of a self-monitoring function from the app.

be offered one introductory group session (90 min) with a qualified exercise specialist. The group session consists of two parts, a guided exercise component and an app instruction component. The exercise component will educate the participants on how to perform the exercises using correct technique, through theory, demonstration and a guided exercise session. Participants will also receive an app manual (hard copy) which includes a step-by-step presentation of how to use the *ecofit* app. Upon attending the 90-min introductory group session, participants will receive a 'physical activity starter pack' (i.e., *ecofit* workout t-shirt, waist belt for their smartphone and water bottle) valued \$50. In addition, a \$20 store voucher will be offered at the completion of their three- and nine-month assessment time-points.

2.8. 'Wait-list' (control) group

The 'wait-list' (control) group will have access to the 'Fixed' and 'Trail-based' outdoor fitness equipment, but no access to the *ecofit* app for the duration of the study or the introductory group session. The 'wait-list' control will receive exactly the same assessment protocol as the intervention group and will also be offered a \$20 store voucher upon completion of their three- and nine-month assessments. At the nine-month study end-point, participants in the 'wait-list' group will be provided with the 'physical activity starter pack', as well as having access to the *ecofit* app and offered the introductory group session.

2.9. Theoretical basis of *ecofit*

The *ecofit* intervention was developed using Social Cognitive Theory (SCT), Cognitive Behavioral Therapy (CBT) strategies, and the Health Action Process Approach (HAPA) model. The intervention is also built upon Ecological models which recognizes multiple levels of influence on health behaviors, such as the individual, social and outdoor built environment [9]. Self-efficacy is one of the core constructs in SCT, and a principal determinant of consistent, health promoting levels of physical activity [61]. Self-efficacy beliefs are important because holding the belief that one can exercise even in situations when obstacles and impediments arise (i.e., feeling tired, stressed or busy), is associated with a greater likelihood of engaging in regular physical activity [62]. Hosting an introductory session with the aim of expanding participants' knowledge of resistance-based exercises, may increase confidence performing such activities, and navigating the *ecofit* app. The *ecofit* app also includes content which may foster self-efficacy, such as goal setting, and the ability to self-monitor and view progress towards workout goals. In addition, social support is another component of SCT that has been found to influence behavior change in physical activity interventions [6, 44]. Social support will be encouraged through signing up to the study in groups of up to four, training with friends or family, and to join the *ecofit* Facebook group. The *ecofit* Facebook group is a closed group, not administered by the researchers, that simply works as a forum where

participants can independently arrange exercise sessions and socialise. However, the researchers will monitor the Facebook group to ensure positive online behavior.

The *ecofit* intervention utilises strategies from CBT to promote the development of cognitive and behavioral functioning. CBT is one of the most researched forms of psychotherapy with a strong evidence-base for treatment of a vast number of mental disorders and health conditions [63]. The *ecofit* app includes CBT-related resources which aim to provide participants with skills and knowledge relating to goal setting, mindfulness strategies, identifying cognitive distortions, problem solving and initiating/maintaining behavior change. These resources may assist participants with skills relating to detection, change and control of unhelpful thoughts, behaviours and attitudes when facing new challenges.

The HAPA model is based on the assumption that engaging in healthy behaviors occurs in two phases: motivation phase and volition phase [64]. The motivation phase starts with the formation of an intended behavioral action, to either change an undesirable health-risk behavior or adopt a health protective behavior, while the volition phase refers to the stages of planning to act and action. Action and coping planning are important components from of the volition phase, and serve as operational mediators between an individual's intentions to perform a behavior and their actioned behavior [59]. More specifically, action planning refers to the "when-where-how" of executing the intended behavior i.e., specifying the time, place and cues that serve to trigger the behavioral action. Inevitable situations or events that may prevent the individuals from reaching their intended goal i.e., bad weather, physical discomfort, visiting friends, commonly arise. Coping plans are formed to serve a compensatory function and account for such barriers [58]. These plans allow individuals to forecast possible scenarios and consequently prepare them for difficult situations, to help individuals' attain their goals. The app includes features which allow individuals to plan the number of intended exercise sessions to perform each week, and resources related to action planning, recognising barriers and goal setting.

2.10. Outcomes

A protocol manual with detailed instructions regarding each assessment will be used by the study's trained research assistants at baseline, 3- and 9-month post baseline to ensure consistency in all assessments. Participants will complete all their assessments at the University of Newcastle. Questionnaires will be completed by participants prior to completing their physical assessments. The following demographic information will be collected at baseline only; age, gender, marital status, ethnic origin, country of birth, number of years in Australia (if not born in Australian), number of people, children and dogs in the household, level of education, gross annual family income, and employment status. Additional self-report information that will be collected during baseline include health and medical background, past behavior related to physical activity and resistance training, smoking habits, and confidence using the internet and/or apps for general purposes. The physical assessments will be completed in a private and discrete setting at baseline, 3-month and 9-months. Note, body composition will only be measured at baseline and primary-end point (3-months).

2.10.1. Primary outcomes

The two primary outcomes are upper and lower body muscular fitness.

2.10.1.1. Upper body muscular fitness. Upper body muscular endurance will be measured using the validated 90° push-up test [65]. Participants will be instructed to keep their body in a straight line from the toes to hips, and to the shoulders [65]. One push-up repetition consists of lowering the body until the elbows bend 90° and the upper arms are

parallel to the floor, followed by pushing back up to the start position. The push-ups are done in time with a metronome, which is set at 40 beats per minute (20 push-ups per minute). The test assesses the maximum number of repetitions that can be performed correctly in rhythm without breaking form for more than two consecutive or non-consecutive push-ups.

2.10.1.2. Lower body muscular fitness. Lower body muscular fitness will be measured using the validated sit-to-stand test which has recent norms for adults aged 18–80 [55]. The sit-to-stand test measures lower body muscular strength and endurance by the number of times the person can stand up and sit down on a regular chair in 1 min [56].

2.10.2. Secondary outcomes

The secondary outcomes include physical activity (accelerometry and self-report), body composition, aerobic fitness, body mass index, self-report resistance-based physical activity, self-reported happiness and mental health outcomes.

2.10.2.1. Physical activity. Physical activity will be objectively measured using water proof Actigraph GT9× Link wrist-worn accelerometers. The Actigraph has shown acceptable validity and reliability compared to other commercially available activity monitors [66–68]. The sum of daily minutes spent in moderate to vigorous physical activity will be monitored by the Actigraph and used to determine participants current physical activity levels [69]. Each participant will be instructed about correct wear and fitting of the ActiGraph activity monitor during the baseline assessment and asked to wear the monitor on their non-dominant wrist for seven consecutive days (24 h/day). Participants will provided a log book to record resistance-based physical activity activities, bed and wake times, and record times when the monitor was removed and physical activity undertaken.

2.10.2.2. Body composition. Body composition will be measured using the validated dual-energy x-ray absorptiometry (DXA) [70]. The GE Lunar Prodigy Scanner (Model part: Spellman, Lunar 8743) will be used to conduct the scans. Participants will lie on a scanner bed while scanning arms pass over their body measuring muscle and fat composition. The scan takes approximately 6 min to complete.

2.10.2.3. Aerobic fitness. Aerobic fitness will be measured using the validated YMCA step test [71,72]. The step test measures cardiorespiratory fitness by step up and down a platform at the rate of 24 step-ups/minute for three consecutive minutes. Upon completion of the test, participants are to sit quietly for 1-min. Participants performance level is determined by the recovery heart rate at the 1-min mark post completion.

2.10.2.4. Body mass index. Body mass index (BMI) will be calculated using the standard equation (weight [kg]/height [m]²) based on measured weight and height. Weight will be measured to the nearest 0.1 kg without shoes and in light clothing using a portable digital scale. Height will be measured to the nearest 0.1 cm using a stadiometer. Individuals are classified as being within the healthy weight range if they have a BMI 18.5–24.9. BMI scores of less than 18.5 is classified as underweight, BMI scores of 25–29.9 is regarded as overweight and a BMI of 30 and over is categorised as obese [73].

2.10.2.5. Self-report aerobic and resistance-based physical activity. Self-reported aerobic and resistance-based physical activity will be measured using a modified version [74–76] of the validated Godin Leisure-Time questionnaire [77,78]. The modification includes the average number of minutes per session [74–76], as well as adding an additional question regarding resistance training i.e., average times per week participating in resistance training [47].

2.10.2.6. Active travel. Active travel will be measured using three active travel items from the Global Physical Activity Questionnaire (GPAQ) [79]. Items include, “Do you walk or use a bicycle at least 10 min continuously to get to and from places, other than work?”; “In a typical week, on how many days do you walk or bicycle for at least 10 min continuously to get to and from places, other than work?”; and “How much time in minutes and hours do you spend walking or cycling for travel on a typical day?”.

2.10.2.7. Self-report happiness. Self-reported happiness will be measured by one question, “In the past month, have you felt happy” [52]. Participants can choose from six response options ranging from “never” (1) to “all the time” (6).

2.10.2.8. Mental health outcomes. Mental health outcomes will be measured using a validated self-assessment, the Depression, Anxiety and Stress Scale (DASS-21) [80]. DASS-21 is a 21-item self-report instrument designated to measure the severity of symptoms relating to depression, anxiety and stress [81]. Each item is scored using a 4-point Likert-type scale, ranging from 0 (item did not apply to them at all) to 3 (item applied to them very much, or most of the time), to rate the extent to which participants experienced each state over the past week. For example, over the last week, “I have found it hard to wind down” (0 = not at all, 1 = some of the time, 2 = a good part of the time, 3 = most of the time). Scores are determined by calculating the sum of scores of the relevant items within each of the three scales.

2.10.3. Potential mediators of physical activity

The following social-cognitive measures will be assessed to analyse potential mediators of physical activity behavior change.

2.10.3.1. Physical activity self-efficacy. Self-efficacy will be assessed using 10-items from a 13-item scale for physical activity [75]. For instance, “I am confident that I can participate in regular physical activity when I am a little tired”. Participants respond on a 5-point Likert-type scale ranging from (1) “not at all confident” to (5) “extremely confident”.

2.10.3.2. Resistance training self-efficacy. Resistance training self-efficacy will be measured using the 4-item resistance training self-efficacy scale [82]. Questions query participants about their confidence in engaging in muscle strengthening activities for example, “If I don’t have access to a gym I can still do resistance training activities”. Each item is scored on a 5-point Likert-type scale, ranging from (1) “strongly disagree” to (5) “strongly agree”.

2.10.3.3. Implementation intention for resistance training. Implementation intention for resistance training will be assessed by adopting Gollwitzer’s principle of implementation intentions for physical activity behavior [83]. The questions have been altered to assess ‘resistance training’ as opposed to ‘physical activity’. Four items of the 7-item scale will be scored on a 5-point Likert-type scale, ranging from 1 (not at all) to 5 (completely).

2.10.3.4. Park use. Usual and past week park use will be assessed using the 6-item Brief Questionnaire on Park Use, which has demonstrated moderate to substantial criterion validity and substantial to almost perfect test-retest reliability [84]. Items include “Over the past 7 days, how many times did you visit this park”. Participants respond either by providing a short answer or a number, or choosing between response options.

2.10.3.5. Perceived environment. A 7-item scale will be used to assess the perceived environment in relation to physical activity [85]. Participants are asked to read statements about physical activity and indicate

how much they agree or disagree with each statement, for instance, “there are walking paths on most of the streets in my local area”. Each item is scored on a 4-point Likert-type scale, ranging from (1) “strongly disagree” to (4) “strongly agree”.

2.10.3.6. Social support. Social support will be assessed using 2-items; “People in my social network are likely to help me participate in regular physical activity”; “I feel that someone in my social network will provide the support I need in order to get regular physical activity” [86]. The items will be scored on a 7-point Likert-type scale, ranging from 1 (strongly agree) to 7 (strongly disagree).

2.10.4. Process measures

A range of process measures will be collected to complement the outcome data. We will measure participants’ park use (i.e., duration, type, frequency and location of workouts) and participants’ goals and progress (this will assist in determining intervention compliance). Evaluation of questionnaires will also be used to assess (1): participant satisfaction and feedback with the *ecofit* application and with the outdoor fitness facilities (2); the 90-min personal training session (3); the standardised ‘Fixed’ and ‘Trail-based’ workouts (4); the overall program (5); participants’ involvement in other physical activity activities after the *ecofit* program; and (6) participant feedback in regards to the intervention strengths, barriers, and potential improvements.

2.10.5. Objective audit of parks

The 49-item Quality of Public Open Space Audit Tool (POST) will be used to complete an objective audit of each of the 11 workout locations [87]. The instrument allows the collection of data in a number of domains, including, activities, environmental quality, amenities and safety.

2.11. Statistical methods

Statistical analyses of the primary and secondary outcomes will be conducted with hierarchical mixed models (adjusted for group size) using IBM SPSS Statistics for Windows computers. The mixed models will follow the intention-to-treat principle; mixed models can handle missing data and generate unbiased model parameters estimates that correspond to a missing at random assumption. Potential socio-cognitive mediators of physical activity behavior change will be assessed using the Preacher and Hayes INDIRECT macro. Difference between completers and those who dropped out of the study will be examined using Chi-square and independent samples *t*-test. Descriptive statistics will be used to examine the feasibility components of the study. Additional moderators of intervention effect (i.e., sex, age group, weight status) will be explored using linear mixed models with interaction terms. We will explore positive or negative social support on outcomes through sensitivity analyses by adding a parameter for group size to the models.

Residual distributions will be assessed for evidence of non-normality using QQ-plots and histograms. If normality appears to be an implausible assumption then either a transformation will be applied to the outcome or a generalised linear mixed model with an appropriate distribution family or link function will be used.

2.11.1. Cost effectiveness

A trial-based cost effectiveness analysis will be performed from the societal perspective. The costs and effects of the multi-component intervention will be compared to the control over the nine-month study period. The measurement of costs in the intervention and control groups will be based on project records. The effects will be measured by the differences between the intervention and the control groups on the primary and secondary outcomes (e.g., physical activity behavior, quality of life). The reportable economic outcomes will be average cost-effectiveness and incremental cost-effectiveness ratio for the primary

and secondary efficacy variables.

3. Discussion

The *ecofit* intervention has been designed to influence participants' attitudes and behavior, and increase their knowledge, motivation and skill towards using the outdoor physical environment to engage in more aerobic and resistance-based physical activity. The functionality of the current effectiveness trial is based upon the *ecofit* efficacy trial, with improvements in app-based technology, extended workout routines and in-app resources tailored towards the broader population.

The physical, psychological and clinical benefits of engaging in adequate amounts of physical activity are well established [88,89]. Resistance-based physical activity also provides important additional health benefits [12–14]. Despite this, the prevalence of meeting both the aerobic and resistance-based physical activity guidelines are low [90], and few community-based physical activity interventions to date have included both aerobic and resistance-based workout programs. Another limitation of physical activity interventions to present is that many lack scalability [3], an essential component in order to reach and influence larger proportions of the population [91]. Utilizing the built environment together with smartphone technology offers a unique approach to increase community-based physical activity levels, by following physical activity workouts tailored to different locations and difficulty levels on the smartphone. Local government agencies around Australia are planning future installations of outdoor gym equipment, for example, The City of Sydney are planning to install facilities within 800 m of each household over the next few years [25]. Therefore, there is a need for researchers to partner with local councils that are in charge of outdoor gym installations to collaboratively work to increase community-based usage.

The current study has a number of strengths. First, the intervention targets both aerobic and resistance-based physical activity through a multi-component approach, which integrates the outdoor physical environment, community-based setting, social support, and smartphone technology. Under-utilisation of resistance training is often associated with a lack of access to facilities, cost, knowledge and confidence to participate/perform movements. Thus, the inclusion of resistance training and targeting these barriers are part of the novelty of this program. The development of an innovating strategy that is of low/no-cost for participants, which increases individuals' knowledge, through education and training, is essential to change the perception of resistance training. Community members will be offered this intervention program free of charge. Other study strengths include using an RCT design with a control group, randomized procedures, assessor blinding, objective physical activity measures, and an intention-to-treat statistical plan. Upper and lower body muscular fitness are measured as the primary outcomes to give an indication of changes in muscular fitness. To capture the broader physiological, behavioral and psychological impacts of the program, physical activity (accelerometry and self-report), body composition, aerobic fitness, body mass index, self-report resistance-based physical activity and mental health outcomes are measured as secondary outcomes. Another strength is the inclusion of a cost-effectiveness analysis. Limitations with the current study include the inability to isolate the effect of each component of the intervention, and not targeting individuals under 18 years of age or participants aged 81 and above. Another limitation may be that the intervention is targeting a technologically-competent sample. However, it has been estimated that 88% of Australians aged 18–75 own or have access to a smart phone [90]. In addition, participants will be provided an app manual (hard copy) and an introductory session of how to use the app.

Challenges that may arise during the study include recruitment and retention of participants. Recruiting a sufficient number of participants is a challenge for all large-scale studies, as is the retention of participants in the 'wait-list' control group. We have included a number of recruitment strategies (e.g., radio, TV, newspaper advertisements, social

media, school newsletters and letter drops), which will be implemented on an ongoing basis. To decrease the likelihood of drop outs, we are offering all participants a \$20 gift voucher at the three- and nine-month assessment points. Given the nature of being an outdoor intervention, it is possible that wet weather may influence weekly physical activity and usage of the app. To address this possibility, the *ecofit* app includes an 'indoor' workout option that participants may use when weather impedes outdoor activities.

If found effective, the study results will have implications for increasing resistance and aerobic physical activity in the general population. The *ecofit* intervention may also increase usage of outdoor fitness equipment. Additionally, positive outcomes from the program may also impact on reducing the economic, skill and knowledge-based barriers of performing resistance-based physical activity. Thus, this free gym alternative has the potential to be very beneficial for the community.

At the completion of this effectiveness study, the aim is to conduct a dissemination study of the program. The outcome, process and economic evaluation results from the present study are expected to guide the *ecofit* Dissemination Study. The *ecofit* intervention also has the potential to be adapted to a younger population by modifying the program using the child and adolescent physical activity guidelines, and tailoring smartphone app and the exercises to be more suited for that subpopulation. In addition, the program may also be modified to target those in disease-specific subpopulations, such as those with cardiovascular disease.

4. Conclusion

This paper has outlined the rationale and study protocol for the *ecofit* intervention for adults not meeting current aerobic and/or resistance-based PA guidelines. *Ecofit* is an innovative, community-based program which integrates smartphone technology, social support, and the outdoor environment to improve aerobic and muscular fitness. The intervention has a strong theoretical foundation and incorporates a number of novel strategies to increase aerobic and resistance-based physical activity that have been shown to be effective in a smaller subpopulation.

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