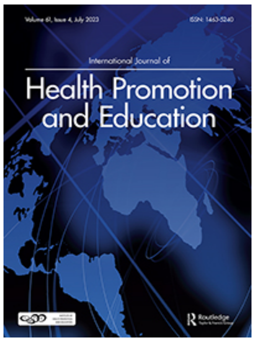

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Promoting physical activity for health benefits via a 10-week mobile-application-based personal training programme

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ABSTRACT
Mobile-application-based interventions promoting engagement in regular physical activity have been shown to afford weight loss, although the wider health benefits remain unknown. This exploratory intervention study quantified the effects of a 10-week mobile-application-based personal training programme combined with nutritional education content, considering physical and psychosocial health-related outcomes. Eleven healthy individuals completed the intervention, comprising physical activity prescription (resistance and high-intensity interval training), nutritional education, a daily step target and online personal trainer support. Outcomes included anthropometrics, circumferential measurements, resting heart rate, blood pressure, aerobic capacity, self-rated health, physical activity enjoyment scale, and the Pittsburgh sleep quality index. Significant improvements in body mass, circumferential measurements and aerobic capacity ($p < 0.05$) were observed amongst participants. Mobile-application-based interventions promoting physical activity may elicit improvements in physical health outcomes. Although healthy individuals were recruited for the purpose of this study, further research is now warranted to explore the potential health-related benefits of such mobile-applications amongst targeted groups such as disengaged, inactive populations, or individuals with long-term health conditions.

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Mobile-application; physical activity; exercise intervention; health promotion; weight loss

Introduction

Thirty-eight percent of adults in England are considered to be overweight and 26% are obese, based on the latest national statistics (NHS Digital, 2021). Yet, when considering the general population, only 61.4% of adults in England participate in the government recommended amount of physical activity per week (Sport England 2022). Frequent participation in physical activity has been related to reduced incidence of many chronic health conditions and, as such, exercise prescription is not uncommon (Pedersen and Saltin 2015). Weight loss is only possible when an energy deficit is consistently maintained, and both nutrition and physical activity levels are key influences (Fonseca et al.

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2018). The most common motivators for participating in physical activity are to facilitate fat loss, stress management, and to prevent future health conditions (Spiteri et al. 2019). Implementation of effective exercise prescription and nutritional education for the general population may help promote physical activity and increase uptake, improving adherence to healthier lifestyles (Spiteri et al. 2019). In turn, the adoption of long-term healthier habits and lifestyle choices may prove beneficial at both an individual and national health service level (Barry et al. 2014; Spiteri et al. 2019). Growing evidence suggests that health problems can be amended regardless of body mass index (BMI) and being active may be more relevant than the actual body mass (Bacon and Aphramor 2011; Barry et al. 2014). Therefore, interventions are evolving from being fixated on mere weight-loss to focusing on holistic health promotion (Bacon and Aphramor 2011).

Many fitness professionals are now promoting engagement in physical activity by offering innovative, remote services that enable access to exercise prescription away from a traditional gym setting, with the intention to reach a larger population (Emberson et al. 2021). Most people use a smartphone routinely in many areas of their personal lives, including mobile-applications related to health, fitness and well-being (Emberson et al. 2021; Pradal-Cano et al. 2020). Such mobile-applications (mHealth) enable fitness professionals to communicate with clients and support the long-term management and reinforcement of health behaviours remotely (Emberson et al. 2021; Mateo et al. 2015). Existing fitness apps facilitate nutrition, weight management and activity tracking, whilst providing health-related education (Emberson et al. 2021; Mateo et al. 2015; Schoeppe et al. 2017; Wang et al. 2016). With the continuing advancement and use of technology in mobile devices, evaluating the effectiveness of mobile applications for improving health outcomes is worthwhile (Emberson et al. 2021). The benefits of app-based delivery approaches include the ability to provide real-time updates anywhere and at any time, making it more accessible, scalable and cost-effective (Direito et al. 2015; Emberson et al. 2021; Schoeppe et al. 2017). It has been suggested that interventions of short durations offer accessibility and flexibility to potential users, thus encouraging increased levels of participation in the future (Pradal-Cano et al. 2020).

Recent systematic review investigations to evaluate the efficacy of mobile fitness applications concluded that these types of interventions may be well accepted by users and may facilitate success by positively influencing eating habits, achieving weight loss and increasing physical activity levels (Emberson et al. 2021; Lahtio et al. 2022; Mateo et al. 2015; Pradal-Cano et al. 2020; Yen, Jin, and Chiu 2023). The use of a mobile phone app to promote weight loss and increase physical activity has been associated with significant reductions in body weight and body mass index specifically (Mateo et al. 2015). However, there is a significant lack of empirical evidence to support the efficacy of app-based interventions when considering a wider range of outcomes related to mental health and general wellbeing (Emberson et al. 2021). Exploring the potential effectiveness of exercise and nutrition app-based interventions for physical/physiological and psycho-social health-related benefits is therefore warranted.

Although exercise interventions delivered via digital means potentially generate barriers to participation for some individuals, the increased accessibility and flexibility offered through the use of mobile-application-based approaches may overcome some of the barriers to face-to-face participation in exercise (Gann 2019; Schoeppe et al. 2017). In turn, this may increase adherence to the recommended levels of physical activity, which on a larger scale, may contribute to health benefits and reducing the risk of non-communicable diseases through enabling long-term adoption of healthy habits (Emberson et al. 2021; Pradal-Cano et al. 2020). This study aimed to quantify the wider health benefits associated with participating in a 10-week mobile-application-based personal training programme. The objectives of this study were to measure changes in; [1] components of body composition; [2] aerobic capacity; [3] measures of self-rated health; [4] attitudes towards physical activity; and [5] subjective sleep quality.

Materials and methods

This quantitative, exploratory study followed a pre-post repeated measures intervention study design and was approved by the University's ethics committee (HEALTH#0028). This is the first study to investigate the potential efficacy of this specific mobile-application for health benefits. Participants were recruited through advertisements and social media. Inclusion criteria included the following: [1] All gender identities [2] 18+ years of age [3] self-reported healthy status, referring to being in a general state of good physical and mental wellbeing; [4] free from injury, referring to any damage to physical condition which causes pain or reduced function, and [5] no health issues which would ordinarily require medical clearance prior to beginning physical activity, assessed using the Physical Activity Readiness Questionnaire (PARQ+) (Warbuton et al. 2018). The exclusion criteria included the following: [1] unsuccessful screening using the PARQ+ (Warbuton et al. 2018) and [2] presence of an injury.

This study was exploratory in nature, so to be consistent with published rules of thumb for pilot studies (Whitehead et al. 2016), a target sample size of between 12 and 20 participants was set. Fifteen participants were initially recruited to the study, however due to the time of data collection (July – August 2021), four participants were withdrawn due to testing positive for COVID-19, resulting in a final sample size of eleven, and a retention rate of 73%. All participants provided electronic informed consent prior to participation and the study conformed to the Declaration of Helsinki and General Data Protection Regulations.

Procedure

All participants attended two data collection sessions at a local, private fitness studio (CB Fitness Studio, Fleetwood, UK). These were scheduled at week 0 (Baseline) and at the end of week 10 (post-intervention). At each data collection session, physical health outcomes and participant reported outcome measures (PROMs) were recorded. Physical health outcomes included: anthropometrics (height, body mass and BMI), circumferential measurements (waist, hip, chest, upper arm and thigh) (Al-Gindan et al. 2014), resting heart rate (RHR), resting blood pressure (BP) and a measure of aerobic fitness, the Cooper's 12-min run (Cooper 1968). Although height measurements were not expected to change over the course of a 10-week intervention, in order to calculate BMI as accurately as possible, up-to-date measures of height and body mass would be considered best practice, and therefore both height and body mass were recorded at each data collection session. PROMs were documented through three validated questionnaires:

- Self-Rated Health (SRH) Questions – a rating of self-perceived overall, physical and mental health status, choosing from 'excellent', 'very good', 'good', 'fair', and 'poor' (Perneger and Lübbeke 2019), which were quantified 1-5. A higher score reflects improvements in self-rated health.
- Physical Activity Enjoyment Scale (PACES) – a measurement of the extent to which participants enjoy participating in physical activity (Kendzierski D, 1991). A higher score reflects a greater level of enjoyment (Kendzierski D, 1991).
- The Pittsburgh Sleep Quality Index (PSQI) – a measurement of sleep quality that distinguishes between 'good' and 'poor' sleepers. A lower score reflects greater sleep quality, with a score of greater than 6 indicating sleep disturbance (Buysse et al. 1989).

The intervention

Within 24 hours of completing their baseline data collection session, participants logged into the mobile-application (CB Fitness 'PT in Your Pocket', UK) and started the 10-week physical intervention (SS19 Transformation). The intervention combined physical activity prescription and nutritional education, aiming to achieve an energy deficit. The physical activity component comprised 3 × 45-minute resistance training sessions per week and 3 × High-Intensity Interval Training (HIIT) sessions per week. A daily step target was also set, starting at 12,000 for the initial 4 weeks, and increasing by 500 steps each consecutive week until 15,000 steps per day was achieved at week 10. Participants had access to nutritional educational content, including suggested recipes and online support from a qualified personal trainer.

Data processing and statistical analysis

Quantitative data was processed in Microsoft Excel (Microsoft Corporation, Redmond, WA) and analysed in SPSS statistical software (2020. IBM SPSS statistics for Windows, version 27.0). Paired sample T-Tests (parametric) or Wilcoxon tests (non-parametric) was used to compare within group changes, with statistical significance level set at $p < 0.05$.

Results

Participant ($n = 11$) demographics, anthropometrics, physical health outcomes and PROMs are listed in Table 1. There were significant reductions in body mass (−1.6 kg, −2.0%; $p = 0.032$) and BMI measurements (−0.5 kg/m2, −1.9%; $p = 0.037$). Chest (−2.2 cm, −2.3%), waist (−4.4 cm, −5%), left arm (−1.5 cm, −5.0%) and right arm (−1.4 cm, −4.7%) circumferential measurements also significantly reduced post-intervention ($p < 0.024$). Participants covered a significantly greater distance during the Cooper's 12-minute run

Table 1. Demographic data, physical health outcomes and participant reported outcomes expressed as mean (SD) at baseline and post-intervention of the participants ($n = 11$), and change (%) compared to baseline. *Denotes significance.

	Baseline	Post- Intervention	Change (%)	p-value	Effect Size (Cohen's d)
Demographics					
Age (years)	39 (7)				
Gender	8 Females, 3 Males				
Height (m)	1.76 (0.1)	1.76 (0.1)			
Anthropometrics					
Body mass (kg)	78.61 (17.9)	77.03 (16.8)	−1.6 (−2.0%)	0.032*	0.75
BMI (kg/m^2)	26.02 (2.6)	25.52 (2.3)	−0.5 (−1.9%)	0.037*	0.73
Chest circ. (cm)	96.73 (7.8)	94.50 (6.9)	−2.2 (−2.3%)	0.024*	0.80
Waist circ. (cm)	88.00 (11.1)	83.61 (8.7)	−4.4 (−5.0%)	0.024*	0.80
Hip circ. (cm)	101.27 (7.2)	99.91 (7.5)	−1.4 (−1.4%)	0.262	0.36
Left arm circ. (cm)	30.09 (3.2)	28.59 (2.3)	−1.5 (−5.0%)	0.008*	1.00
Right arm circ. (cm)	30.0 (3.7)	28.59 (2.6)	−1.4 (−4.7%)	0.015*	0.88
Left thigh circ. (cm)	55.86 (4.0)	54.45 (3.6)	−1.4 (−2.5%)	0.137	0.49
Right thigh circ. (cm)	56.14 (4.3)	55.25 (3.1)	−0.9 (−1.6%)	0.349	0.30
Physical Health Outcomes					
RHR (bpm)	71 (10.3)	73.2 (10.1)	+2.27 (+3.2%)	0.582	−0.17
Systolic BP (mmHg)	131 (15.1)	124.0 (15.4)	−7.2 (−5.5%)	0.086	0.57
Diastolic BP (mmHg)	85 (7.1)	83.1 (9.0)	−1.7 (−2.0 %)	0.442	0.24
Cooper's Run (m)	1655.45 (194.7)	1869.6 (176.5)	+214.1 (+12.9%)	<0.001*	−1.71
PROMs					
PACES	43.73 (16.2)	41.27 (20.81)	−2.45 (−5.6%)	0.425	0.25
PSQI	5.82 (2.4)	5.55 (2.2)	−0.27 (−4.7%)	0.720	2.45

Body Mass Index (BMI), Circumference (Circ.), Resting Heart Rate (RHR), Blood Pressure (BP), Physical Activity Enjoyment Scale (PACES), Pittsburgh Sleep Quality Index (PSQI). *Statistical significance set at $p < 0.05$.

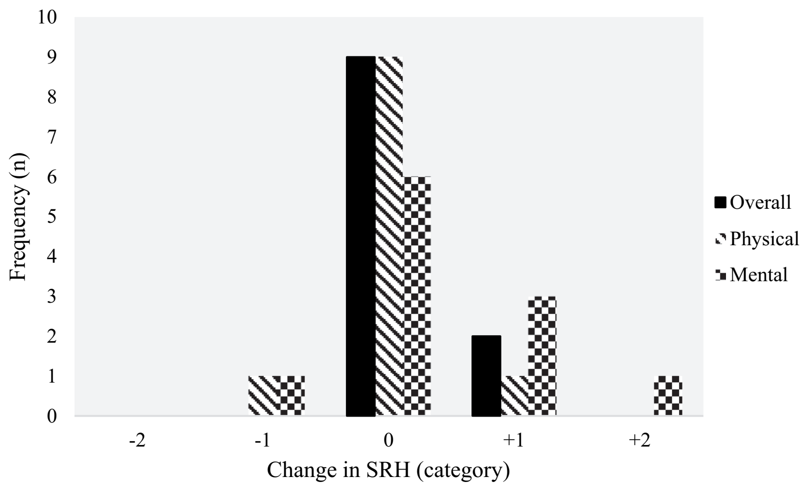

Figure 1. Distribution of change in self-rated health (SRH) on a 5-category scale (excellent, very good, good, fair, poor), expressed in number of categories, between baseline and post-intervention. A positive change indicates a perceived improvement in health, a negative change indicates a perceived deterioration in health. Zero indicates no perceived change.

after the 10-week intervention period, with a mean increase of 12.9% (214.1 metres) compared to baseline ($p < 0.001$), indicating a significant improvement in aerobic fitness.

No significant changes were observed in SRH (Figure 1), PACES and PSQI ($p > 0.05$), indicating a level of steadiness in participants' perceived health, attitudes towards physical activity and sleep quality, respectively.

Discussion

This study aimed to quantify the wider health benefits associated with participating in a 10-week mobile-app-based personal training programme. The findings of this study suggest that this method of training may elicit improvements in physical health outcomes (Figure 2), although the wider health benefits were not so clear and may require longer term intervention/follow up.

In agreement with previous research investigating the effectiveness of mobile applications on weight and waist circumference, significant reductions in body mass, BMI and anthropometric circumferences were also observed in this study, confirming the app's effectiveness in supporting users to achieve weight loss (Flores Emberson et al. 2021; Lahtio et al. 2022; Mateo et al. 2015; Yen, Jin, and Chiu 2023). Additionally, wider benefits were also observed, such as improvement in body composition, and improvement in aerobic fitness. These positive results may be attributable to the intervention design, which combined HIIT training, resistance work and a daily step target. The UK Chief Medical Officers' Guidelines recommend a combination of moderate or vigorous intensity exercise, such as HIIT, for cardiovascular health, and strength-based training,

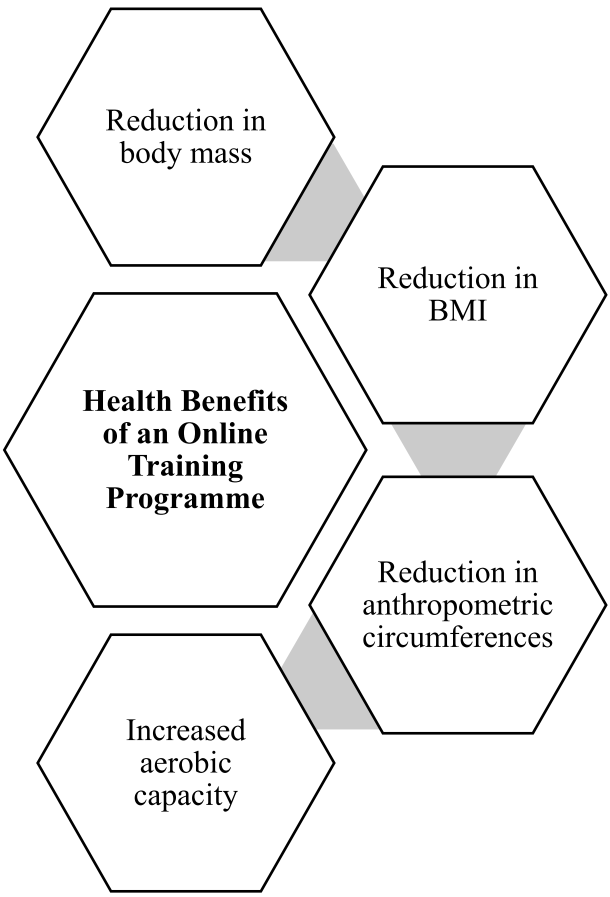

Figure 2. The evidenced health benefits of participating in a 10-week personal training intervention.

such as resistance training, to maintain or develop muscle, bone and joint strength (Sport England 2022). HIIT is an enhanced form of interval training that alternates periods of short, intense anaerobic exercise with less-intense recovery periods, eliciting approximately 85–95% of maximal heart rate and maximal oxygen consumption (VO2max) during a typical training session (Gaesser and Angadi 2011).

Similar to the present study's findings, improvements in aerobic capacity and body composition have previously been reported after a 12-week intervention period, using HIIT training amongst recreationally active runners (Hottenrott, Ludyga, and Schulze 2012). HIIT has been demonstrated to be a more time-efficient and more effective approach than traditional endurance training in improving aerobic capacity, reducing whole-body fat mass and waist circumference measurement (Gaesser and Angadi 2011; Wewege et al. 2017). The wider benefits of improving VO_2max and aerobic capacity, aside from improved sports performance, include increasing expected lifespan, improved quality of life, reduced risk of stroke, heart disease, cancers, and diabetes, improved mood, and improved sleep quality (Gaesser and Angadi 2011; Kurl et al. 2005; Signe and Nielsen 2013). A 13-week aerobic exercise intervention demonstrated improvements in sleep quality amongst sedentary, moderately overweight men (Signe and Nielsen 2013), even though they were reported to be efficient sleepers. This intervention was 3 weeks longer that the intervention used in the current study, suggesting that longer intervention or follow-up periods may have been required to record wider significant changes.

The second component of the intervention was resistance training, which includes any activity that stimulates a muscle contraction against an external force (Fisher et al. 2011). Aside from the primary benefits of resistance training, which include muscular adaptations in strength, size, power and endurance, wider health benefits include increased resting metabolic rate which is beneficial for weight loss, reduced resting BP, improved maximal aerobic capacity, increased bone mineral density, enhanced flexibility, and reduced risk of injury (Fisher et al. 2011). Accordingly, within the present study, significant improvements in aerobic capacity, body mass, and BMI and non-significant improvements in resting BP were shown. RHR did not change significantly, consistent with results reported in a previous study (Miyachi et al. 2004).

The third and final component of the intervention was step counting, which is a form of behavioural target against sedentary behaviour, supporting motivation and adherence towards physical activity (Kraus et al. 2019). Pedometer-based programs have previously resulted in modest weight loss (Richardson et al. 2008), which was also observed amongst participants in the current study. Increasing daily step counts have previously been correlated with a decrease in all-cause mortality, cardiovascular events, and type 2 diabetes incidence (Kraus et al. 2019).

Some of the measures included within the study did not change in response to the intervention, such as the PSQI. However, published cut-off scores state that scores of below 6 indicate that there is no sleep disturbance present (Buysse et al. 1989). In this study, at baseline and post-intervention, mean scores were 5.82 (2.4) and 5.55 (2.2), respectively. Amongst a group of individuals where poor sleep is not present to begin with, the likelihood of improvement may be limited. To investigate this further, future studies could specifically recruit 'poor sleepers' to explore to what extent the intervention affects sleep quality. Whilst there were no significant changes in SRH, when considering the measure descriptively, two (18%) participants felt their overall health improved, one

(9%) felt their physical health improved and four (36%) felt their mental health improved at the end of the 10-week intervention. Although these reports are representative of a small proportion from a small sample, it indicates that there may be potential for this type of intervention to have an effect on measures such as SRH, particularly mental health, and had the sample size been larger significant findings may have been found.

This exploratory study is not without its limitations. Although initially the target sample size was achieved for this study, due to the COVID-19 pandemic, four participants were lost at follow-up which meant that the sample size dropped below the minimum required. This may suggest a lack of relevancy for the results, however, based upon published guidance (Whitehead et al. 2016) it is suggested that sample sizes of 15 and 10 are recommended when effect sizes are medium (0.5) or large (0.8), respectively. Within the results of this study, for all significant findings, the smallest observed effect size was 0.73. Therefore, even with a final sample size of 11, whilst smaller than desired, the results could still be considered interesting, novel and relevant.

Upon reflection, another potential downfall of the study is the lack of a longitudinal follow-up period to ascertain whether the health-related gains that were observed immediately post-intervention were maintained in the long term (Emberson et al. 2021). Given the nature of the intervention included within this study (unsupervised physical activity), it was essential to screen participants to ensure their safety throughout. The PARQ+ (Warbuton et al. 2018) excluded individuals if they answered 'yes' to any of the following:

(1) Has your doctor ever said that you have a heart condition/high blood pressure?
(2) Do you feel pain in your chest at rest, during your daily activities of living/when you do physical activity?
(3) Do you lose balance because of dizziness/have you lost consciousness in the last 12 months?
(4) Have you ever been diagnosed with another chronic medical condition?
(5) Are you currently taking prescribed medications for a chronic medical condition?
(6) Do you have a bone or joint problem that could be made worse by becoming more physically active?
(7) Has your doctor ever said that you should only do medically supervised physical activity?

Participants were eligible to take part if they passed the PARQ+ and perceived themselves to be of a healthy status defined as being in a general state of good physical and mental wellbeing. Reflecting on the baseline BMI score range amongst participants, (20.7 – 31.6kg/m^2), a combination of healthy, overweight and obese individuals participated in the study. Had the group been heavily weighted to obese individuals, greater improvements in health may have been observed. However, individuals within the obese category based on BMI are more likely to answer 'yes' to the included screening questions due to obesity being a modifiable risk factor for many conditions. The benefit now is that there is initial evidence to support the feasibility and acceptability of this intervention's protocol amongst generally healthy individuals. Future work should recruit specific target groups (e.g. chronic health conditions, overweight, mental illness, etc.) who may benefit from participating in this type of intervention, especially when in-person, face-to-face activities may present as a barrier to participation. Findings from these types of studies may elicit greater improvement in health-related factors given there is a wider scope for improvement to begin with.

Conclusion

To conclude, this initial exploratory study utilising a quantitative methodology outlines a robust and feasible research protocol and study design to demonstrate that a mobile-based application intervention may have the potential to promote engagement in physical activity to elicit a wide range of health benefits. Further research is now warranted to support this small-scale study, investigating its effectiveness amongst targeted participant groups such as disengaged, inactive populations, or individuals with chronic long-term health conditions, where greater health benefits may be expected.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

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