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## **Background:**

The positive influence of physical activity on physical and mental health is widely accepted (1,2). Regular physical activity has been shown to reduce the prevalence of noncommunicable diseases such as cancers (3), diabetes (4), and cardiovascular disease (5), whilst also improving muscular and cardiorespiratory fitness, and bone health (6). Aside from these physical health benefits, engagement in physical activity also has the potential to improve mental health (2), with previous studies finding alleviation in symptoms of depression (7), anxiety (8) and stress (9). Conversely, lack of physical activity leads to negative health effects, with both sedentary behaviour (sitting, lying or reclining with low energy expenditure) and physical inactivity being linked to increased incidence of noncommunicable diseases including cancers (10), cardiovascular disease (5,11) and all-cause mortality (12,13), as well as leading to a reduction in cardiac output and systemic blood flow (14,15). In the UK, National Health Service costs directly attributed to sedentary behaviour is in the region of £900 million each year (16), an increase of £200 million since 2016/17 (17).

The World Health Organization recommend that those aged 18 to 64 do a minimum of 150 minutes of moderate intensity aerobic physical activity each week (6). However, recent research has found that around 27.5% of adults worldwide are insufficiently active according to these guidelines (18). It has been found that in the UK, adults are sedentary for an average of 60% of their waking hours (19), a figure believed to be around 75% in the US (20) and suggested to be increasing year on year (21). A major factor in this is inactivity at work. Over 80% of US jobs are classed as being predominantly sedentary, with individuals spending an average of 89% of their working hours seated (22). Similar figures are reported in Australia (81.8%)(23) and the UK (84%)(24). In the UK, it is estimated that 1 in

6 deaths are at least partially attributable to physical inactivity (16), which highlights the need for effective programmes to support individuals to increase their physical activity.

One way in which this issue can be addressed is through programmes designed to increase physical activity within the workplace. These programmes take different forms: for example, some employ formal exercise sessions run by professionals, with activities including circuit training (25), strength training (26), football matches (27) and aerobic exercise classes (28). Whilst these have shown positive findings, there are issues with adherence rates with some studies reporting large proportions of participants not completing the full duration of the exercise programmes (29). To make their programmes more accessible and increase participation, other programmes take a different approach and implement a less regimented exercise plan or incorporate lower intensity exercise (30,31). For example, some programmes choose walking as the exercise of choice (30,32), given that the intensity of this can be determined easily through varying pace and distance, and that walking is one of the most accessible forms of physical activity (33).

One such programme is the Step Count Challenge (SCC), run nationally twice a year by Scottish charity Paths for All, whose mission is to increase walking in Scotland. SCC is a unique programme that attracts participants from a wide range of workplaces, with entries open to any large public sector organisations (e.g. hospitals and universities) or small private companies, from both urban and rural environments, anywhere across Scotland. A large programme with over 4000 participants in its latest round, the programme invites teams of five colleagues to complete as many steps as possible within a given timeframe (either four weeks in Autumn or eight weeks in Spring). Whilst the competition is measured in step counts, usually measured by an activity tracker or smartphone, the challenge also allows participants to record other activities (namely running, swimming, cycling and yoga), which are then given a step count equivalent based on the distance/duration, and the metabolic equivalence of these activities. These are self-reported by the participant via their profile on the SCC website, where they can access the leaderboards, team portal, and other features. As a

nationwide competition, the SCC requires participants to be self-motivating, and for their workplaces to encourage the activity behaviours, as no formal sessions, training, or structure is provided, putting the onus and autonomy in the hands of the participants themselves. To aid this, the website features personalised weekly goal-setting, which can be set by the individual or automatically by the site based on the previous week, as well as graphical progress monitoring and multiple leaderboards for social comparison – all of which have been shown to have positive impact on behaviour change(34). Although it is acknowledged that there are multiple influences on physical activity behaviour in the workplace, many of which may not be addressed, the SCC targets some of these possible influences by utilising team support and competition via local and national online leaderboards to increase the physical activity levels and motivation of employees to increase their step counts. Niven et al., analysed the step count data from 8 SCCs across 4 years and found participants increased their daily step counts by nearly 1000 steps in Week 8 compared to Week 1 - equating to an additional 63 minutes of walking each week(33).

Despite the widespread and increasing participation in SCC across Scotland since its inception in 2011, its health and wellbeing related impacts have not been assessed. Here we report a multi-study assessment of the impact of participation in SCC on both the physical fitness and mental wellbeing of participants. The first two studies are repeated-measures online-based nationwide cohort studies of employees and Study 3 is an in-person experimental design with a control group in a bespoke SCC. Study 1 assessed whether participation was associated with any changes in physical fitness or mental wellbeing. Study 2 followed studying the same outcomes during a challenge of differing duration and season. By collecting data from both Spring and Autumn challenges, we were able to begin investigating the possible impact of challenge duration (8 vs. 4 weeks) on fitness and wellbeing in SCC participants. Additionally, the comparison of the Spring and Autumn challenges is important, as not only do they differ in duration, but also in terms of weather conditions and day length given the different times of year. It has been found that physical activity levels vary based on the season, with the highest levels being seen between April and August (for those based in the Northern

Hemisphere) (35,36) and previous studies have reported that many individuals see weather (36) and daylight hours (37) as barriers to exercise. Finally, Study 3 compared the fitness and wellbeing of SCC participants in a bespoke challenge with that of a non-participating control group, across the challenge duration to more formally assess the impact of SCC.

The first of the three studies took place in Spring 2021. Based on previous findings showing increased activity levels<sup>31</sup>, it was hypothesised that participant physical fitness and mental wellbeing would improve across the course of the challenge. Study 2 then replicated Study 1, but during the 4-week Autumn SCC – when Scottish daylight hours are shorter and the weather is typically colder and wetter. This also allowed us the opportunity to assess whether the 4-week duration SCC is associated with improvements in health, given that previous workplace physical activity intervention research suggested that it may require eight weeks for significant health improvements (38,39). It was hypothesised that improved physical fitness and mental wellbeing would also be the case across the Autumn challenge. Study 3 once again sought to investigate the effects of the Step Count Challenge on participant health and wellbeing, but this time compared to a control group. It was hypothesised that those who participated in the Step Count Challenge would experience an increase in both physical fitness and mental wellbeing while non-Step Count Challenge participants would not.

## **Methods:**

### **Study 1 & 2**

Study 1 data collection took place across the duration of the Spring 2021, spanning May & June, whilst Study 2 was conducted during the Autumn SCC spanning October and November 2021. Ethical approval was obtained from the University of St Andrews, School of Psychology and Neuroscience (Approval Code: PS15433). All participants provided their informed consent before participation. Study 2 was additionally preregistered on the AsPredicted repository (#79111).

## Participants

We recruited participants through advertisements on Paths for All's blog and social media channels, as well as a pop-up message upon online registration to the challenge (Study 1,  $n = 475$ ; Study 2,  $n = 336$ ). A summary of the demographic data collected from participants can be seen in Table 1. All participants were of working age and employed in Scotland at the time of the challenge. No further demographic details were collected. Due to the parameters of our Data Sharing Agreement with Paths for All, it is unknown whether any participants from Study 1 also participated in Study 2.

## Design & Setting

The study was repeated measures, with mental wellbeing assessments taken fortnightly and the physical fitness tests every four weeks. This structure was the same for both Studies 1&2, meaning there were five mental wellbeing timepoints and three physical fitness timepoints in Study 1, and three wellbeing and two fitness in Study 2. Data collection for mental wellbeing and fitness took place on the SCC website - the same location that participants would visit to report their daily step counts. Participants could upload their step counts as and when they wished. The platform also allowed for syncing of the activity tracker to automatically upload step counts. Collecting data directly from the website allowed us to advertise to the entire SCC cohort. It also enabled us to collect data at a time where in-person experiments were not possible due to the ongoing COVID-19 pandemic.

## Materials

Mental wellbeing was assessed using the Short Warwick-Edinburgh Mental Wellbeing Scale (SWEMWBS (40)). This scale requires participants to rate seven statements about their thoughts and feelings in the two weeks prior to completion on a five-point Likert scale, where higher scores represent better wellbeing. SWEMWBS was chosen as it has high validity and reliability amongst the UK general population and takes only a few minutes to complete(41).

The two-minute step test (2MST (42)) was used as an indicative measure of cardiovascular and muscular fitness. It has been found to have a high test-retest reliability and a good convergent validity relative to more complex alternatives such as the one-mile walk test (43) and does not require specialist equipment and has been shown to be reliable and accurate in both active and sedentary adults (44). The test requires participants to march on the spot as quickly as possible for 120 seconds, ensuring that their knees reach approximately 60° each step. The test is scored by counting the number of times that the individual's right foot completed a full step, having reached target height. A video showing an example of how to measure performance on the 2MST was included on the SCC portal, enabling participants to learn how to complete the test and the scoring – which was self-reported due to the nationwide dispersion of participants and ongoing Covid-19 restrictions.

## **Procedures**

Upon SCC registration, all new participants were asked to provide their gender (Man, Woman, Non-Binary, Other - via open text entry) and age category (18-24; 25-34; 35-44; 45-54;55-64; 65-74; 75+). On the SCC Web Portal homepage, a pop-up advertising the study appeared, giving the participants the chance to read the information sheet (and subsequently the consent form), or opt not to participate.

To establish baseline levels of mental wellbeing and physical fitness, in the week before the challenge began, participants were asked to complete the first iterations of each measure (2MST and SWEMWBS). Throughout the challenge, participants were asked to complete the mental wellbeing scale fortnightly and physical fitness test every four weeks, and this would appear via a pop-up banner at the top of their portal during the correct research window periods.

## **Statistical Analyses**

Mental wellbeing and physical fitness scores were analysed using repeated measures ANOVAs with timepoint as the within subjects factor. The 2MST and SWEMWBS scores were the dependent variables. However, when using repeated measures ANOVAs, any individual with missing data points will have all their responses excluded from analysis (45) through the process of listwise deletion (46). This reduces sample sizes and subsequent statistical power and means valuable data is not analysed (47). Therefore, in addition to the repeated measures ANOVAs, linear mixed models (LMM) analyses were also utilised, using the process of restricted maximum likelihood estimation to predict missing values based on the information in the dataset. LMMs allow us to use all the data collected, while the repeated measures ANOVA provides a more conservative sample of only those participants that completed all measures of the DVs. Analysis was conducted using IBM SPSS Statistics Software v28.

### **Study 3:**

This study was preregistered with AsPredicted in March 2023 (#125946), before data collection took place between March and June 2023. Full ethical approval was again attained from the University of St Andrews School of Psychology and Neuroscience (Approval Code: PS16827). All participants were fully informed before the study began and had the opportunity to ask questions to the researchers before providing their informed consent. Participants who completed the study were entitled to £20 recompense.

#### **Design & Setting**

Paths for All, the charity who run the programme, also offer bespoke SCCs, where workplaces can tailor their challenge to their needs, setting the length and dates, rather than being limited to the nationwide events. Bespoke challenges run using the same system and interface, and instead of having a 'Nationwide' leaderboard, there is an extra emphasis on the 'Workplace' leaderboard. We ran a bespoke 4-week SCC from March 27<sup>th</sup> to April 23<sup>rd</sup> 2023. Data collection was conducted in-person at the School of Psychology in a lab setting on two occasions. There were a small number of

participants who were unable to attend the final lab session, and so the measures for these participants were taken via a Qualtrics survey.

## **Participants**

Using G\*Power, we conducted A Priori calculations to determine our desired sample size based on the effect sizes found in Study 1, with a desired power of 0.8. Results from this analysis suggested that a total sample size of 34 would give sufficient statistical power. Allowing for potential attrition, recruitment was capped at 50 individuals (Step Count Challenge group,  $n = 25$ ; Control group,  $n = 25$ ). To control for variance, this study was carried out at a single setting (University of St Andrews), recruiting university students. Participants were recruited in a number of ways including posters placed around the University campuses, a blog post attached to the weekly university newsletter, and an advertisement for participation placed a participant pool management system through the School of Psychology. The adverts invited them to sign up to either aspect of the study (Step Count Challenge or control), however the teams of five were required to enter together. Control participants entered individually. Following some participant attrition, final group sizes were 20 in the SCC group, and 18 in the Non-SCC group. A summary of demographic information can be seen in Table 1. In an attempt to ensure we assessed the impact of SCC participation, we recruited participants of similar age and background to each other. While this limits generalisability to general population, it provides experimental control over factors that could affect performance beyond SCC participation.

## **Materials**

Similar to Studies 1 & 2, mental wellbeing was assessed using the Short Warwick-Edinburgh Mental Wellbeing Scale, and physical fitness assessed with the Two-Minute Step Test. All participants were asked to track their daily step counts for the duration of the study (using a fitness tracker or smartphone device), with the SCC group reporting these via the portal at their desired interval frequency, and Control group reporting all daily totals upon final visit to the lab.

## **Procedure**

Participants were emailed the information sheet upon their sign-up to the study and asked to return an electronically signed copy of the consent form. The first data collection timepoint for the SCC group occurred in the week prior to the challenge beginning. Those in the control group were given the option as to whether they visited the lab during that same week, or during the first week of the challenge.

At each data collection point participants completed the physical fitness and mental wellbeing tests. The order of tests was counterbalanced across participants and sessions. The tests were conducted as in Study 1, although during the 2MST the researcher set the target height and timed the participant. Performance on the 2MST was videoed and scored by the experimenter watching the video at 0.5x speed, ensuring knees met the target height. Footage was permanently deleted in sight of the participant, in line with our approved ethics protocol.

The second data collection point happened at the end of the challenge where participants carried out the same tests. Participants from the control group were additionally asked to provide their step counts from the 28 days between visits.

## **Statistical Analyses**

Mental wellbeing and physical fitness scores across the challenge were analysed using 2x2 repeated measures ANOVAs, where the within subjects factor was timepoint and Step Count Challenge participation status (Group) was the between-subjects factor. Participant scores on the 2MST and SWEMWBS were the dependent variables. Additionally, two regression analyses were conducted. These examined the relationships between either participant's total step counts over the four-week period or the difference score between timepoints (Timepoint 2 Score – Timepoint 1 Score) and their scores for each test at Timepoint 2.

## **Results:**

## Study 1:

We first examined changes in mental wellbeing across the Spring SCC. Mean SWEMWBS scores increased consistently across the 8 weeks of the Spring challenge (Figure 1a). This was confirmed using repeated measures ANOVA which examined data from participants who provided all five mental wellbeing responses, showing a statistically significant change in SWEMWBS scores across the SCC ( $F_{(4,248)} = 9.29, p < .001, \eta^2 = .13$ ). The ANOVA provides a conservative analysis of only participants who provided all SWEMWBS measures but disregards data from those who missed one or more measures. To examine the complete dataset, we used a linear mixed model analysis, which included estimation of missing data. This confirmed the results of the ANOVA showing there to be a significant change in mental wellbeing across the challenge ( $F_{(4,416.10)} = 5.98, p < .001$ ). To examine these effects in more detail, we used pairwise comparisons which showed significant increases in SWEMWBS scores from weeks 0-2 and 6-8 ( $p = .012, d = .33$  and  $p = .014, d = .32$  respectively). There was no significant change in scores for 2-4 week ( $p = .292$ ) and 4-6 week ( $p = .594$ ) periods demonstrating that wellbeing was most affected at the beginning and end of the challenge.

Next, we examined physical fitness across the Spring SCC. The average two-minute step test score increased consistently across the challenge (Figure 1b). Repeated measures ANOVA confirmed that this increase was significant ( $F_{(2,184)} = 20.85, p < .001, \eta^2 = .185$ ). This finding was also supported by the supplementary linear mixed models analysis, which also showed there to be a significant main effect ( $F_{(2,264.43)} = 9.50, p < .001$ ). When examining the pairwise comparisons for this effect, significant increases were found for both the Week 0 to Week 4 interval, and also Week 4 to Week 8 ( $p < 0.001, d = .34$  and  $p = .026, d = .24$  respectively) demonstrating that fitness improved across the whole SCC.

## Study 2:

Across the four weeks of the Autumn Step Count Challenge 2021 there was an increase in the average SWEMWBS score (Figure 2a). A repeated measures ANOVA was conducted to evaluate the

effect of time on participant mental wellbeing, which found the increase to be statistically significant ( $F_{(2,182)} = 5.09, p = .007, \eta^2 = .053$ ). Again, this result was supported by a linear mixed models analysis, which also showed there to be a significant increase over time ( $F_{(2,201.47)} = 6.63, p = .002$ ). When analysing the pairwise comparisons resulting from the ANOVA, a significant effect was found for the first fortnightly interval ( $p = .023, d = .23$ ), but not for the second ( $p = .09$ ).

When evaluating the effect of time on physical fitness during this challenge, again there was an increase in average scores seen over the duration of the challenge (Figure 2b). A repeated measures ANOVA found the effect to be statistically significant, such that participant fitness improved after the four week challenge ( $F_{(1,45)} = 6.58, p = .014, \eta^2 = .128$ ). This was supported by the finding of the linear mixed models of the whole sample ( $F_{(1,69.34)} = 11.82, p < .001$ ).

### **Study 3:**

Four participants (3 SCC, 1 Control) had injuries or illness which prevented them completing the physical fitness test at Timepoint 2. Analysis of the physical fitness test results found that there was no significant main effect of timepoint on Two-Minute Step Test scores, ( $F_{(1,30)} = 0.173, p = .680$ ), and there was also no main effect of group effect -  $F_{(1,30)} = 0.047, p = .831$ . However, there was a significant Timepoint\*Group interaction,  $F_{(1,30)} = 6.226, p = .018, \eta^2 = .172$ . Post-hoc pairwise comparison tests showed there to be a significant improvement in the Two-Minute Step Test scores of Step Count Challenge participants across the four-weeks ( $p = .042, \eta^2 = .131$ ) - the decrease seen by the Non-SCC participants was not significant ( $p = .164$ ).

This shows that those participating in the Step Count Challenge significantly increased their physical fitness over the course of the challenge, relative to those who did not participate (Figure 3).

Interestingly, when assessing the relationship between participant 2MST scores and their step counts over four weeks, regression analyses showed there to be no significant relationships for either their Timepoint 2 score ( $R^2 = .005, F_{(1,30)} = 0.159, p = .693$ ) or their difference scores ( $R^2 = .014, F_{(1,30)} = 0.419, p = .522$ ).

Next, we examined the impact of participation on mental wellbeing. Wellbeing scores for both groups increased over the 4 weeks (SCC: +1.047,  $p = .166$ ; Control: +0.136,  $p = .863$ ) but the results of the 2x2 repeated measures ANOVA found no significant main effect of timepoint ( $p = .280$ ), or group ( $p = .849$ ) and no significant timepoint x group interaction ( $p = .404$ ). Similarly, the results of the regressions once again showed no significant relationships between participant step counts and their mental wellbeing scores at Timepoint 2 ( $R^2 = .005$ ,  $F_{(1,32)} = 0.151$ ,  $p = .700$ ) or when examining difference scores ( $R^2 = .026$ ,  $F_{(1,32)} = 0.812$ ,  $p = .374$ ).

Finally, we examined whether there was a difference in total step counts between the groups. Results of this between-subjects one-way ANOVA showed a significant difference between the groups, such that on average those in the Step Count Challenge group achieved significantly more steps over the four weeks -  $F_{(1,32)} = 4.221$ ,  $p = .048$ ,  $\eta^2 = .117$ .

## **Discussion:**

Here we report three studies designed to explore the influence of participation in the SCC on physical fitness and mental wellbeing. This series of longitudinal repeated-measures studies also sought to explore the potential impact of challenge duration and season, as well as importantly comparing against a non-participating control group. We report that in the two iterations of SCC during 2021 (Studies 1 & 2), both mental wellbeing and physical fitness significantly improved by the end of the challenges in large samples of participants. Study 3 also demonstrated improved fitness in SCC participants but importantly this time this was relative to a control group who did not take part in SCC.

The findings of Studies 1&2 demonstrated that, as hypothesised, both mental wellbeing and physical fitness improved by the end of the challenge in a large sample of participants. These significant increases in both elements of health and wellbeing, across both studies, suggest that it is possible to improve fitness and mental wellbeing through both 4- and 8- weeks of unstructured physical activity as part of a workplace physical activity challenge. Additionally, Study 2's results enable us to

examine how season and challenge duration may have affected the potential health impacts of SCC. We report that SCC participants show improved fitness and wellbeing irrespective of the season or duration of the challenge. The Autumn challenge finishes in late November (when daily daylight hours were nearly three times lower than in June 2021 in the UK (48)), yet the mental wellbeing and physical fitness of the participants were still significantly higher than at the start of the challenge. However, given that both duration and season were changed in Study 2, it is not possible to comment on either factor individually. Additionally, while these studies report findings from large, diverse pools of participants, the lack of control group limits our ability to make conclusions about the impact of SCC on fitness and wellbeing.

To address this Study 3 examined two groups of participants; one taking part in SCC and a control group. The results of Study 3 again showed improvement in the physical fitness for SCC participants. Importantly, the inclusion of a control group in which no improvement in fitness scores was found strengthens our interpretation that SCC participation is associated with improved physical fitness. The significant improvement of fitness in SCC participants in Study 3 had a moderate effect size ( $\eta^2 = .131$ ) which compares well to Delestrat et al.<sup>44</sup> who used an 8-week Zumba intervention and found an associated cardiovascular endurance improvement also with moderate effect size. Chovanec & Gropel (38) used an 8-week intervention comparing endurance training, resistance training and a control group and found that both exercise groups significantly increased, and the effect size of the interaction was very large ( $\eta^2 = .50$ ). This shows that fitness improvements in SCC are broadly similar to those from other programmes. It is interesting that in both Studies 2 and 3, we were able to find significant improvements of moderate effect sizes in just 4 weeks, half the time of the two studies mentioned above. This is particularly promising given that SCC is unstructured program where the participant had complete choice and flexibility, rather than adhering to instructed sessions at set times, durations, and intensities each week.

When combined with the findings of Niven et al.,<sup>31</sup> who found that participation in the SCC increased individuals' activity levels, the findings of our first two studies demonstrate that participation is associated with not only an increase in physical activity, but also an improvement in fitness and mental wellbeing of participants. With the further consideration of Study 3's significant physical fitness result, we were able to determine that active participation in the SCC is beneficial for participation health. Critically we observed that whilst physical fitness significantly improved in SCC participants, this was not the case in the control group. This increases confidence that the SCC participation was the cause, rather than any potential alternative explanations for improved fitness in Studies 1 & 2, such as participants trying to beat their score from the previous testing session.

Studies 1 & 2 reported that Step Count Challenge participants had significantly improved mental wellbeing scores across the duration of both the Spring and Autumn challenges of 2021. However, contrary to the hypothesised differences, when assessing this against a control group in Study 3, we found no significant improvement. One potential explanation for this lack of significance is that these findings may reflect the timing of the study, which took place in the final weeks of the academic year, and therefore some participants would have had exams during this window. While it has been previously reported that students show increased sedentary behaviour around exam times which would be a good model of workplace behaviour in a standard SCC (49), it is possible that this also likely impacted their mental wellbeing (50). Therefore, this study should be replicated outside of the exam period or with a working adult sample to further examine the effect of SCC participation on mental wellbeing.

With respect to the representativeness of the samples in Studies 1&2, our samples were gender-skewed with over 70% were women in both studies. However, these were representative of their respective SCC populations where participation was also skewed towards women (as can be seen in Table 1 and Supplementary File 1). Similarly, the age category dispersions in both studies were very similar to that of their SCC counterparts. Given the populations from which the samples were

collected their skewed nature is potentially positive as it allows generalisability to that main population. Further research might aim to examine why the SCC population in general is skewed.

Given the accessibility of walking as a form of physical activity, it has been labelled as 'a best buy for public health' (33,51). Here we show that a walking-based workplace activity challenge produces meaningful outcomes similar to those with a more structured approach. This has significant potential to inform policy regarding advice for physical activity levels in the workplace as SCC has been demonstrated to be easily scalable to reach large populations of people in a diverse range of workplaces at a national level.

The findings from the current studies are potentially very powerful and suggest that targeting activity in the workplace is an important and fruitful avenue that could provide a low-cost way of improving health across workplaces. As previously mentioned, SCC participation has been shown to be associated with an average increase of 63 minutes activity per week (33). Given that WHO guidelines recommend adults should take 150 minutes of moderate-intensity physical activity per week, the 63 minute per week increase seen in SCC is significant (42% of the WHO guidelines). Seeing this increase in a workplace-based challenge highlights the importance of this setting, where we spend a lot of our time and often sedentarily. This is why some researchers, stress that physical activity and sedentary behaviour should be tackled as one energy expenditure spectrum(52). This approach acknowledges the health benefits of increased physical activity, but also suggests that we strive to remain in a state of light-intensity activity over longer time periods to limit the amount of time we spend sedentarily (52).

In addition to the reported strengths, it is also recognised that the research is not free from limitations. Namely, the design of Studies 1&2 are limited by the lack of control group. This was addressed in part by the inclusion of a control group in Study 3, which sought to allow comparison of those participating in SCC with those simply being measured across multiple time points. This allowed us to examine whether repeated testing of fitness or wellbeing results in improvements

without SCC participation. It is also true that the demographic characteristics of participants for Study 3 are different to the other 2 studies. While this may limit generalisability, it does allow us much tighter experimental control over these variables, such that we can say that even in samples who are very closely matched on age and background we still see a significant impact of SCC participation. Furthermore there is potential for selection bias in Study 3, due to the non-randomisation of assignment to condition. Teams were recruited as groups of five, rather than assigning five individuals to teams randomly, as this models the recruitment of SCC. This allowed us to mimic the team camaraderie element of the SCC. However, this non-random assignment may have also affected results. It would be interesting to investigate in future studies if the positive impacts of SCC participation are also seen in randomly assigned groups.

More generally, the restricted demographic information collected limits generalisability for the representativeness of these samples in comparison to the entire SCC sample or Scotland as a whole. For instance, although the age category and gender dispersions of the samples in Studies 1&2 were representative of their respective SCC, it is unknown whether they were representative on a geographical, or baseline physical activity level. In terms of the measures used, the physical fitness measure used (2MST) may also have limitation, as there is a paucity of literature where this is self-assessed. However, steps were taken to address this, such that participants were given clear instructions (text and audiovisual options), in which they were asked to either film themselves and measure from the recording or ask someone else to score for them, though in general, the 2MST has been seen to have highly acceptable reliability and validity (42,44,53). Finally, it would have been beneficial to have follow-up data to enable long-term outcomes to be assessed, however this was not possible in Studies 1 or 2, due to the nature of the SCC and the data-sharing agreement, whereby no contact details were shared with researchers, and all data was pseudonymised before receipt by the researchers. We need longer follow-up data to answer questions about lasting impact of participation in workplace physical activity programmes.

## **Conclusions:**

Our findings show that the physical fitness of SCC participants improved after completing the Step Count Challenge. This was the case regardless of season, and irrespective of whether participating in the 8-week or 4-week iteration of the challenge. **These findings significantly contribute to the workplace physical activity literature, providing evidence that an unstructured, flexible steps-based programme is associated with improved participant physical fitness.** By adopting a mixed-methods, multi-study approach, we have been able to replicate the study and findings in a real world setting across challenges of different lengths at different times of year, while also demonstrating that changes in physical fitness can be seen in a small, well-controlled experimental setting compared to a control group.

The findings for mental wellbeing were also very positive with significant increases reported in both Studies 1 & 2. However, mental wellbeing did not significantly improve, relative to a control group in Study 3. Further research will be needed to see if this is an artifact of the specific environment used in the study (e.g., stress from exams in a university setting) or a meaningful effect.

In the wider context of what our research contributes, we have provided evidence from across Scotland at a nationwide-level as to how workplaces, education providers and public health officials, may be able to utilise the principles of competition and teamwork to help individuals increase their physical activity and have meaningful impact on physical and psychological health, following a small change in a typically sedentary contextual environment (workplace). The findings from our 3 studies provide unique and rigorous examples of the way that social influences can be harnessed to achieve behaviour change.

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## Tables

Table 1 - Demographic information collected from each of the three studies, with Studies 1&2 also demonstrating the comparative figures for the entire SCC sample. Study 3 shows the demographic comparison between the SCC Group and Control Group.

	Study 1 – Spring 2021 (n=475)		Study 2 – Autumn 2021 (n=336)		Study 3 – Bespoke Challenge (n=38)	
Age Category (Years)	Sample Frequency (%)	SCC Frequency (%)	Sample Frequency (%)	SCC Frequency (%)	SCC Group Frequency (%)	Non-SCC Group Frequency (%)
18 to 24	15 (3.16)	204 (4.95)	14 (4.17)	103 (4.62)	14 (70)	4 (22.22)
25 to 34	101 (21.26)	883 (21.41)	62 (18.45)	461 (20.68)	6 (30)	14 (77.78)
35 to 44	134 (28.21)	1090 (26.42)	97 (28.87)	615 (27.59)	0 (0)	0 (0)
45 to 54	122 (25.68)	1033 (25.04)	98 (29.17)	558 (25.03)	0 (0)	0 (0)
55 to 64	64 (13.47)	495 (12.00)	32 (9.52)	252 (11.31)	0 (0)	0 (0)
65 to 74	6 (1.26)	37 (0.89)	5 (1.49)	25 (1.12)	0 (0)	0 (0)
Not Specified	33 (6.95)	383 (9.29)	28 (8.33)	215 (9.65)	0 (0)	0 (0)
<b>Gender</b>						
Woman	360 (75.79)	2715 (65.82)	240 (71.43)	1536 (68.91)	8 (40)	13 (72.22)
Man	84 (17.68)	1001 (24.26)	72 (21.43)	512 (22.97)	12 (60)	5 (27.78)
Non-Binary	1 (0.21)	6 (0.15)	0 (0.00)	5 (0.22)	0 (0)	0 (0)
Not Specified	30 (6.32)	403 (9.78)	24 (7.14)	176 (7.90)	0 (0)	0 (0)
<b>Pre-Challenge Activity Level</b>						
Low (<5000 steps)					1 (5)	2 (11.11)
Medium (5000-9999)					15 (75)	10 (55.56)
High (10000+)					4 (20)	3 (16.67)

Figures

Figure 1:

Mental wellbeing (1a) and physical fitness (1b) scores of participants throughout the Spring 2021 Step Count Challenge.

Note. Error bars represent  $\pm 1$  SEM. Significance: \* =  $p < .05$ , \*\* =  $p < .001$ .

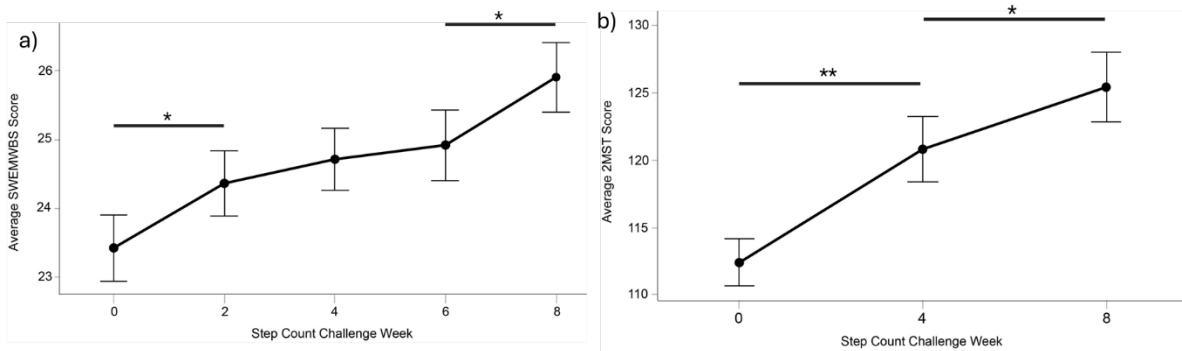
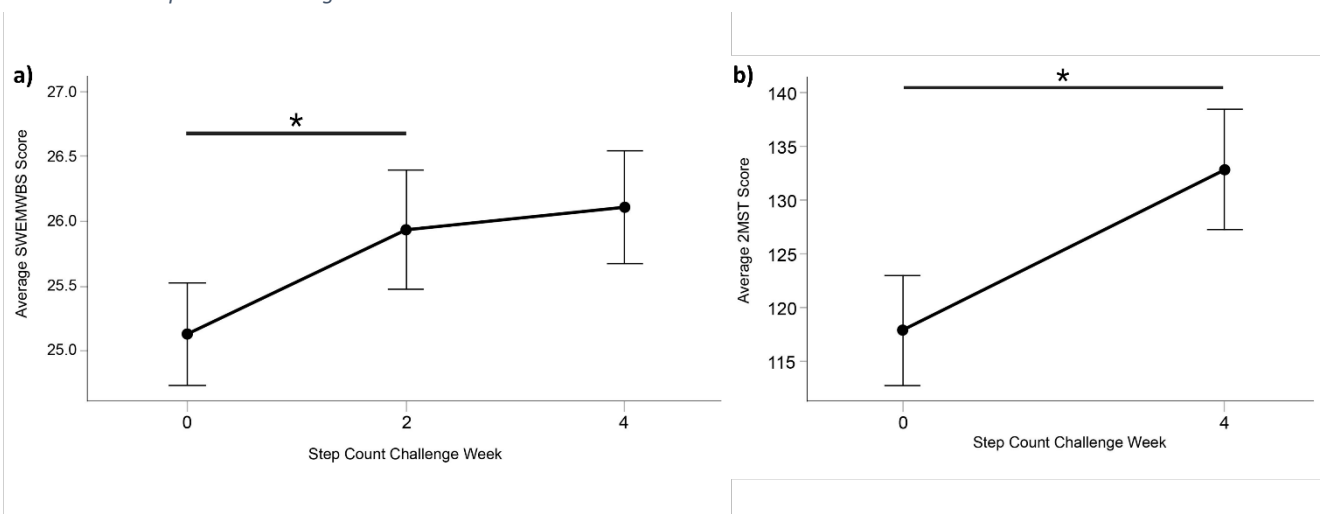


Figure 2

Line graphs displaying the mental wellbeing (2a) and physical fitness (2b) scores of participants throughout the Autumn 2021 Step Count Challenge



Note. Error bars represent  $\pm 1$  SEM. Significance: \* =  $p < .05$

Figure 3

Line graph displaying the mean physical fitness scores of participants in both the Step Count Challenge and the Control Group across the four week Bespoke SCC in Spring 2023

Note. Error bars represent  $\pm 1$  SEM. Significance: \* =  $p < .05$

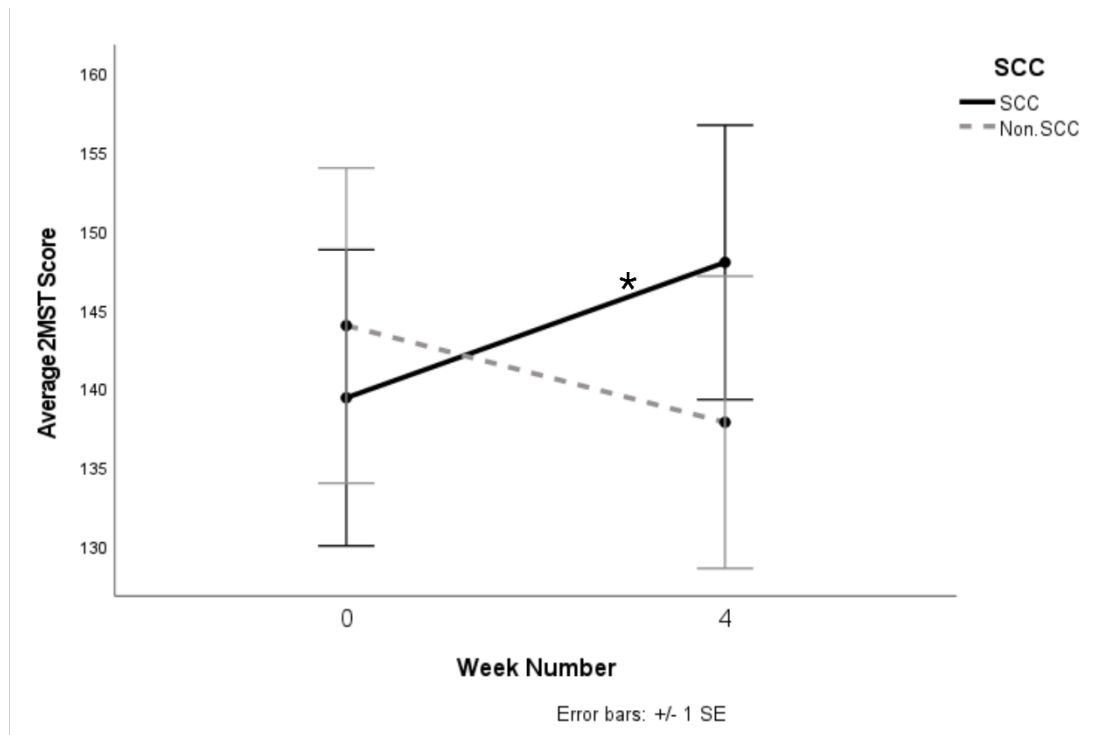


Figure 4

Line graph displaying the mean mental wellbeing scores of participants in both the Step Count Challenge and the Control Group across the four week Bespoke SCC in Spring 2023. Error bars represent  $\pm 1$  SEM.

