

**Effects of text messaging in addition to emails on physical activity among university and college employees in the UK**

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## **Abstract**

**Objectives:** To test the effects of adding text messages to weekly email communications on recipients' total physical activity (leisure-time; workplace; domestic and garden; and active transportation) in employees of universities and colleges in the UK.

**Methods:** A randomised trial with two study groups (email only or email plus text messaging for 12 weeks) was implemented at five workplaces. Data were collected at baseline, immediately after, and four weeks after the intervention. Intervention effects on physical activity were evaluated using latent growth modelling.

**Results:** Total physical activity decreased over time in both groups but the decrease was non-significant. The only significant difference between groups was found for workplace physical activity, with the group receiving emails and text messages having a linear decrease of 2.81 Metabolic Equivalent h/week ( $\beta = 0.31$ ,  $p = 0.035$ ) compared to the email only group.

**Conclusions:** Sending employees two additional text messages resulted in less physical activity. Further investigation is needed to understand whether text messaging may play a beneficial role in promoting physical activity in workplace settings.

## **Keywords**

e-health, physical activity, worksite health promotion

## **Introduction**

Public health organizations across the globe advocate promoting health and physical activity in the work- place. Information and communication technologies, such as mobile phone, email and the Internet, have been utilised for promoting health in many settings including workplaces, and shown positive results. Email has shown to be feasible to implement and accepted by employees,<sup>1</sup> and has demonstrated improvements in self-efficacy, intentions, and behaviours related to physical activity and nutrition.<sup>2</sup> Mobile phone text messages or short messaging service (SMS) has been associated with positive effects on a variety of health behaviours,<sup>3</sup> improved health care outcomes,<sup>4</sup> disease prevention and management,<sup>5,6</sup> physical activity<sup>7,8</sup> and weight loss.<sup>9,10</sup> A recent meta-analysis of 11 physical activity interventions using mobile devices<sup>11</sup> found that eight used SMS to promote physical activity and five reported physical activity outcomes. One of the studies<sup>12</sup> was conducted with teachers in primary schools in Hong Kong and used pedometers to measure step counts. No other SMS for physical activity studies have been reported in worksite settings.

The purpose of this study was to test the effects of adding weekly SMS communication to weekly email communication on physical activity of employees of academic workplaces in the UK.

## **Methods**

### **Participants and procedures**

Participants were academic staff of five universities and colleges in the UK. The study was approved by the local Medical School Ethics Committee. Workplaces were provided the intervention free of charge and were asked to promote it amongst their staff through email and printed posters provided to them by the researchers. During a series of six recruitment and enrolment periods, between September 2009 and April 2010, interested participants were invited to visit the study website to obtain information about the study, procedures and eligibility requirements. Participants were excluded if they reported physical impairments that prevented them from undertaking physical activity, or required medical supervision. After informed consent was supplied, participants completed a baseline assessment and provided their email address and mobile phone number.

Random assignment to one of two study groups was performed by computer-generated randomisation. Control group members were sent one personalised email per week for 12 consecutive weeks. The intervention group received the same personalised email as the control group, plus two standard SMS reminders per week for 12 consecutive weeks.

Enrolment procedures and participant allocation are shown in Figure 1.<sup>13</sup>

### **Intervention**

Message content was based on the Theory of Planned Behaviour. Formative research conducted with the target population helped to refine the message content and establish message delivery timing. Email content was validated using a web-based Delphi

approach with experts in physical activity and the Theory of Planned Behaviour. Each of the 12 email messages addressed a specific theoretical construct and aimed to motivate participants to engage in regular physical activity. Twenty-four SMS messages were designed to reinforce the email messages (i.e. two SMS for every email message). Personalised emails included a greeting line with the participants' name (e.g. 'Dear John. . .'). Standard SMS reminders included a generic greeting line (e.g. 'Hello!' or 'Hi M8!'). Emails were delivered at 11:00 am on Wednesdays. Text messages were sent at 11:00 am on Fridays and at 14:30 am on Mondays.

## **Measures**

Demographic and background characteristics included age, sex, education, perceived health status, height and weight (used to calculate Body Mass Index).

Physical activity was assessed using the International Physical Activity Questionnaire long-form (IPAQ-L).<sup>14</sup> This collects information about the intensity, frequency and duration of daily physical activities over a seven- day period in four domains: leisure-time physical activity (LTPA), workplace physical activity (WPA), domestic and garden physical activity (DGPA), and active transportation physical activity (ATPA), as well as total physical activity (TPA), which is the sum of the domains.

Outcome physical activity variables for each domain were calculated following established guidelines.<sup>15</sup> Time spent in moderate, vigorous and walking activities in each domain was used to calculate total time per week (min/week) and multiplied by the metabolic equivalent.<sup>16</sup> TPA score was calculated as the sum of all four domains. The

resulting variables were winsorized, with extreme cases identified using the outlier labelling rule.<sup>17</sup> Finally, the physical activity outcome variables were rescaled to Metabolic Equivalent (MET) h/week by dividing the MET-min/week by 60.

### **Data analysis**

Intervention effects were measured by comparing data collected at three time-points: baseline (Time 0), immediate post-intervention (i.e. 12 weeks post-baseline) (Time 1) and one month post-intervention (i.e. 16 weeks after baseline) (Time 2).

Intervention effects were measured using latent growth modelling (LGM) with Mplus v6.12. Unlike ANOVA, MANOVA or ANCOVA for repeated measures, LGM can test for inter-individual differences in various developmental trajectories of variables over time.<sup>18</sup> LGM has been used in studies using physical activity longitudinal data<sup>19,20</sup> and is a powerful approach for detecting changes over time and between groups even with small samples (i.e. <100).<sup>21</sup>

LGM models were estimated using full-information maximum likelihood in combination with a maximum likelihood estimator with robust standard errors to accommodate missing data in Time 1 and Time 2 surveys. LGM can handle large amounts of missing data through full-information maximum likelihood as efficiently as multiple imputation.<sup>22</sup> To improve the estimation process, relevant ‘auxiliary variables’ that were correlated with missingness were added to the model.<sup>23</sup> The procedure is described below.

LGM in a structural equation modelling framework represents each measurement as observed variable in function of two latent factors (intercept and slope).

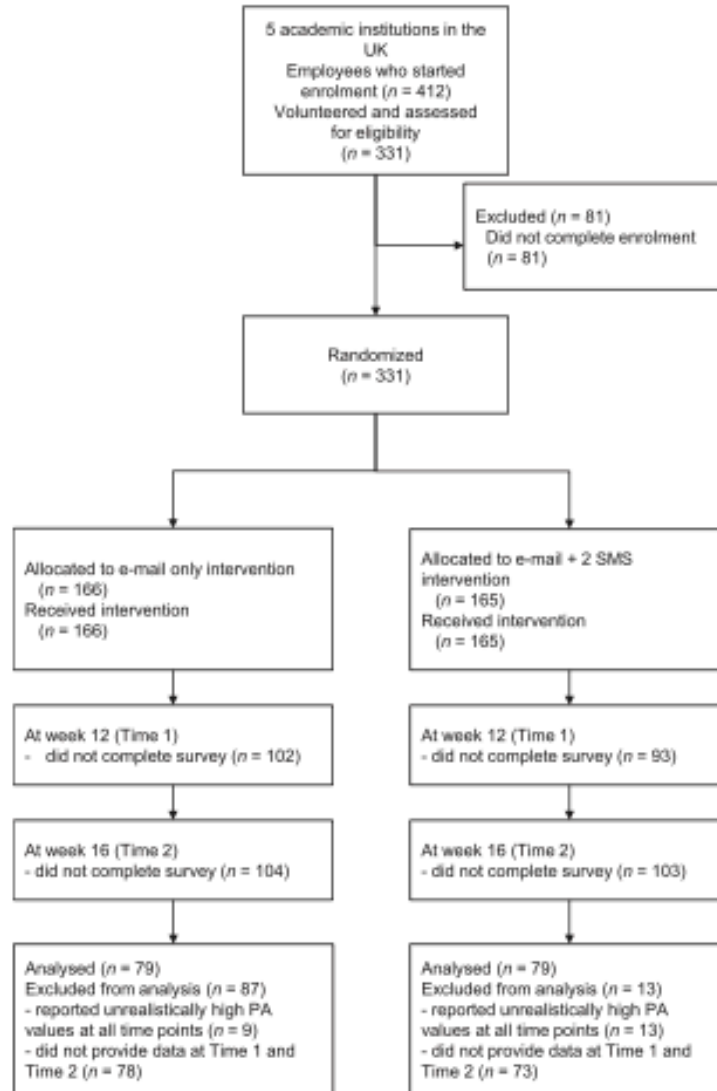


Figure 1. CONSORT diagram of participation flow through the MoveMB trial. PA: physical activity.

**Table 1.** Sample descriptive statistics.

| Variable   | Email only (n = 79) |             | Email plus SMS (n = 79) |             |
|--|---------------------|-------------|-------------------------|-------------|
|  | n (%)               | M (SD)      | n (%)                   | M (SD)      |
| Gender   |                     |             |                         |             |
| Female   | 130 (82.8)          |             | 125 (82.2)              |             |
| Male   | 27 (17.2)           |             | 27 (17.8)               |             |
| Age (y)  |                     | 39.2 (11.5) |                         | 39.8 (12.1) |
| Education  |                     |             |                         |             |
| Higher degree/degree level qualification           | 121 (77.1)          |             | 108 (71.1)              |             |
| A-level or equivalent                              | 16 (1.2)            |             | 19 (12.5)               |             |
| O-Level passes/GCSE or equivalent                  | 9 (5.7)             |             | 9 (5.9)                 |             |
| Other professional qualification                   | 7 (4.5)             |             | 8 (5.3)                 |             |
| Other/no qualifications                            | 4 (2.5)             |             | 8 (5.3)                 |             |
| Workplace type (cluster)                           |                     |             |                         |             |
| Universities                                       | 142 (9.4)           |             | 137 (9.1)               |             |
| Colleges   | 15 (9.6)            |             | 15 (9.9)                |             |
| Perceived health status                            |                     |             |                         |             |
| Excellent/very good                                | 54 (34.4)           |             | 68 (44.7)               |             |
| Good   | 78 (49.7)           |             | 65 (42.8)               |             |
| Fair/poor  | 25 (15.9)           |             | 19 (12.5)               |             |
| Body mass index (kg/m <sup>2</sup> )               |                     | 26.1 (5.6)  |                         | 25.9 (5.2)  |
| Underweight  | 3 (1.9)             |             | 4 (2.6)                 |             |
| Normal range                                       | 74 (47.1)           |             | 75 (49.3)               |             |
| Overweight   | 49 (31.2)           |             | 44 (28.9)               |             |
| Obese  | 31 (19.7)           |             | 29 (19.1)               |             |
| Baseline physical activity categories <sup>a</sup> |                     |             |                         |             |
| Low (insufficiently active)                        | 6 (3.8)             |             | 12 (7.9)                |             |
| Moderately active                                  | 77 (49.0)           |             | 50 (32.9)               |             |
| Highly active                                      | 74 (47.1)           |             | 90 (59.2)               |             |

Notes: <sup>a</sup>Physical activity (PA) categories are based on total PA estimates and defined by the 'Guidelines for Data Processing and Analysis of the International Physical Activity Questionnaire (IPAQ) – Short and Long Forms' (IPAQ Research Committee, 2005): Low = does not meet the recommended levels or is not included in the other two categories; Moderate = at least five days of moderate PA for 30 min/day, or at least five days of walking for 30 min/day, or three days of vigorous PA for at least 20 min/day, or five days of a combination of activities for a minimum of 600 METs; High = at least three days of vigorous for a minimum of 1500 METs, or seven days of a combination of activities for a minimum of 3000 METs.<sup>15</sup> MET: Metabolic Equivalent.

**Table 2.** Descriptive statistics for PA variables (MET-h/week) across time and linear change factor (slope).

|      | Full sample (n = 158) |                |                |      | Email only (n = 79) |                |                |      | Email plus SMS (n = 79) |                |                |      | Slope difference between groups |
|------|-----------------------|----------------|----------------|------|---------------------|----------------|----------------|------|-------------------------|----------------|----------------|------|---------------------------------|
|      | Baseline, M (SD)      | Time 1, M (SD) | Time 2, M (SD) | d    | Baseline, M (SD)    | Time 1, M (SD) | Time 2, M (SD) | d    | Baseline, M (SD)        | Time 1, M (SD) | Time 2, M (SD) | d    |                                 |
| TPA  | 56.5 (35.1)           | 5.5 (37.1)     | 48.1 (31)      | 0.25 | 53.4 (33.7)         | 5.8 (33.9)     | 48.1 (28.7)    | 0.25 | 59.5 (36.1)             | 49.5 (39.6)    | 48.8 (33.1)    | 0.17 | -4.6                            |
| WPA  | 6.7 (1.7)             | 5.7 (9.3)      | 5.7 (8.1)      | 0.13 | 5.4 (9.4)           | 6.5 (10)       | 6.3 (8.7)      | 0.11 | 8 (11.7)                | 4.9 (8.5)      | 5.0 (7.1)      | 0.10 | -2.8 <sup>a</sup>               |
| LTPA | 17 (17.1)             | 17.6 (19.3)    | 18.5 (19)      | 0.09 | 17.9 (18.1)         | 17.4 (19)      | 19.8 (19.2)    | 0.09 | 16.1 (15.9)             | 17.9 (19.7)    | 17.5 (18.7)    | 0.10 | 0.6                             |
| DGPA | 19.7 (22.8)           | 15.3 (17.8)    | 13.9 (16.4)    | 0.28 | 17.4 (19.5)         | 15.5 (17.5)    | 12.2 (14.7)    | 0.28 | 22.1 (25.5)             | 14.8 (17.6)    | 15.6 (18.3)    | 0.28 | -1.4                            |
| ATPA | 13.1 (12.2)           | 11.9 (12.3)    | 9.9 (11.1)     | 0.31 | 12.8 (12.2)         | 11.9 (11.2)    | 9.7 (11.8)     | 0.29 | 13.3 (12.2)             | 11.9 (13.4)    | 1.5 (9.4)      | 0.30 | 0.02                            |

Notes: TPA: Total physical activity; WPA: workplace physical activity; LTPA: leisure-time physical activity; DGPA: domestic and garden physical activity; ATPA: active transportation physical activity; MET: Metabolic Equivalent.

d = Cohen's d, calculated as the difference in means between the first and the last assessment, divided by the pooled standard deviation.<sup>25</sup> All measures are expressed in MET-h/week.

<sup>a</sup>Significant difference between groups,  $p < 0.05$ .



**Table 3.** Selected parameter estimates for the MIMIC model testing intervention effects, and predicting intercept and slope factors with covariates.

|                         | TPA                |       |          | WPA     |       |                    | LTPA     |         |       | DGPA  |                     |         | ATPA   |       |          |                    |       |        |       |       |                    |      |        |       |       |
|-------------------------|--------------------|-------|----------|---------|-------|--------------------|----------|---------|-------|-------|---------------------|---------|--------|-------|----------|--------------------|-------|--------|-------|-------|--------------------|------|--------|-------|-------|
|                         | B                  | SE    | B 95% CI | $\beta$ | B     | SE                 | B 95% CI | $\beta$ | B     | SE    | B 95% CI            | $\beta$ | B      | SE    | B 95% CI | $\beta$            |       |        |       |       |                    |      |        |       |       |
| <b>Model A</b>          |                    |       |          |         |       |                    |          |         |       |       |                     |         |        |       |          |                    |       |        |       |       |                    |      |        |       |       |
| Path coefficients       |                    |       |          |         |       |                    |          |         |       |       |                     |         |        |       |          |                    |       |        |       |       |                    |      |        |       |       |
| Intercept-group         | 5.84               | 5.55  | -5.03    | 16.72   | 0.09  | 2.23               | 1.71     | -1.12   | 5.58  | 0.15  | -1.62               | 2.69    | -6.89  | 3.65  | -0.06    | 3.61               | 3.48  | -3.21  | 1.43  | 0.14  | 0.50               | 1.92 | -3.27  | 4.27  | 0.03  |
| Slope-group             | -4.57              | 4.10  | -12.61   | 3.48    | -0.10 | -2.81 <sup>a</sup> | 1.33     | -5.42   | -0.20 | -0.31 | 0.56                | 1.91    | -3.18  | 4.30  | 1.00     | -1.38              | 2.60  | -6.48  | 3.72  | -1.00 | 0.02               | 1.61 | -3.13  | 3.18  | 0.00  |
| Means (intercepts)      |                    |       |          |         |       |                    |          |         |       |       |                     |         |        |       |          |                    |       |        |       |       |                    |      |        |       |       |
| Intercept               | 53.53 <sup>b</sup> | 3.82  | 46.05    | 61.02   | 1.67  | 12.63 <sup>b</sup> | 6.04     | 3.42    | 7.64  | 0.74  | 17.73 <sup>b</sup>  | 2.02    | 13.77  | 21.68 | 1.23     | 17.90 <sup>b</sup> | 2.25  | 13.49  | 22.32 | 1.35  | 12.95 <sup>b</sup> | 1.37 | 1.26   | 15.64 | 1.32  |
| Slope                   | -3.76              | 3.02  | -9.66    | 2.15    | -0.17 | -5.89              | 4.51     | -0.84   | 2.19  | 0.15  | 0.91                | 1.33    | -1.70  | 3.52  | 3.28     | -3.68 <sup>a</sup> | 1.78  | -7.15  | -0.20 | -5.34 | -2.37 <sup>a</sup> | 1.18 | -4.69  | -0.05 | -0.30 |
| <b>Model B</b>          |                    |       |          |         |       |                    |          |         |       |       |                     |         |        |       |          |                    |       |        |       |       |                    |      |        |       |       |
| Path coefficients       |                    |       |          |         |       |                    |          |         |       |       |                     |         |        |       |          |                    |       |        |       |       |                    |      |        |       |       |
| Intercept-group         | 5.71               | 5.68  | -5.43    | 16.85   | 0.09  | 3.09               | 1.74     | -0.33   | 6.50  | 0.18  | -0.94               | 2.51    | -5.85  | 3.98  | -0.03    | 1.94               | 3.35  | -4.62  | 8.51  | 0.07  | 0.57               | 1.99 | -3.34  | 4.47  | 0.03  |
| Intercept-age           | 0.08               | 0.25  | -0.04    | 0.56    | 0.03  | -0.13              | 0.08     | -0.29   | 0.03  | -0.18 | -0.259 <sup>a</sup> | 0.12    | -0.50  | -0.02 | -0.21    | 0.53 <sup>b</sup>  | 0.14  | 0.26   | 0.80  | 0.44  | -0.03              | 0.08 | -0.19  | 0.13  | -0.04 |
| Intercept-gender        | -5.42              | 7.20  | -19.53   | 8.69    | -0.06 | -3.64              | 2.42     | -8.39   | 1.11  | -0.16 | -5.59               | 4.43    | -14.29 | 3.10  | -0.14    | 7.48 <sup>a</sup>  | 3.36  | 0.88   | 14.07 | 0.19  | -3.37              | 2.93 | -9.12  | 2.37  | -0.13 |
| Intercept-BMI           | -0.28              | 0.65  | -1.54    | 0.99    | -0.04 | 0.04               | 0.20     | -0.36   | 0.43  | 0.02  | -0.06               | 0.27    | -0.59  | 0.46  | -0.02    | -0.35              | 0.40  | -1.14  | 0.43  | -0.12 | 0.18               | 0.20 | -0.21  | 0.56  | 0.09  |
| Intercept-health status | -4.61              | 3.60  | -11.67   | 2.45    | -0.11 | 0.53               | 1.14     | -1.70   | 2.77  | 0.05  | -2.75               | 1.81    | -6.30  | 0.80  | -0.14    | 0.29               | 2.03  | -3.70  | 4.28  | 0.02  | -2.55 <sup>a</sup> | 1.23 | -4.96  | -0.14 | -0.20 |
| Intercept-education     | -2.05              | 2.25  | -6.45    | 2.35    | -0.07 | -0.43              | 0.57     | -1.55   | 0.69  | -0.06 | -1.01               | 0.85    | -2.68  | 0.65  | -0.08    | -0.02              | 1.42  | -2.80  | 2.76  | 0.00  | -0.30              | 0.75 | -1.78  | 1.17  | -0.04 |
| Slope-group             | -3.12              | 4.08  | -11.12   | 4.88    | -0.07 | -3.02 <sup>a</sup> | 1.38     | -5.73   | -0.31 | -0.27 | 0.76                | 1.94    | -3.04  | 4.57  | 0.26     | -0.33              | 2.50  | -5.23  | 4.57  | -0.04 | 0.32               | 1.59 | -2.80  | 3.45  | 0.02  |
| Slope-age               | -0.06              | 0.19  | -0.44    | 0.32    | -0.03 | 0.04               | 0.06     | -0.07   | 0.15  | 0.08  | -0.03               | 0.09    | -0.21  | 0.15  | -0.23    | -0.18              | 0.12  | -0.42  | 0.06  | -0.53 | 0.12               | 0.08 | -0.03  | 0.26  | 0.18  |
| Slope-gender            | -7.97              | 5.49  | -18.72   | 2.79    | -0.13 | 1.78               | 2.12     | -2.38   | 5.93  | 0.11  | -3.85               | 2.61    | -8.96  | 1.26  | -0.94    | -6.58 <sup>a</sup> | 3.05  | -12.55 | -0.60 | -0.60 | 1.11               | 2.05 | -2.91  | 5.13  | 0.05  |
| Slope-BMI               | 0.01               | 0.51  | -1.00    | 1.02    | 0.00  | 0.02               | 0.12     | -0.22   | 0.25  | 0.01  | -0.08               | 0.21    | -0.48  | 0.33  | -0.24    | 0.36               | 0.35  | -0.32  | 1.04  | 0.43  | -0.25              | 0.15 | -0.55  | 0.04  | -0.16 |
| Slope-health status     | 5.67 <sup>a</sup>  | 2.61  | 0.56     | 1.77    | 0.20  | 0.85               | 0.96     | -1.04   | 2.74  | 0.11  | 0.01                | 1.36    | -2.66  | 2.68  | 0.01     | 1.74               | 1.60  | -1.38  | 4.87  | 0.33  | 3.08               | 1.17 | 0.78   | 5.38  | 0.30  |
| Slope-education         | 1.45               | 1.71  | -1.91    | 4.80    | 0.08  | 0.18               | 0.45     | -0.70   | 1.06  | 0.04  | 0.55                | 0.67    | -0.76  | 1.85  | 0.44     | 1.32               | 1.24  | -1.12  | 3.75  | 0.39  | -0.84              | 0.57 | -1.96  | 0.28  | -0.13 |
| Means (intercepts)      |                    |       |          |         |       |                    |          |         |       |       |                     |         |        |       |          |                    |       |        |       |       |                    |      |        |       |       |
| Intercept               | 77.19 <sup>b</sup> | 21.46 | 33.13    | 119.24  | 2.39  | 11.84 <sup>a</sup> | 5.99     | 0.10    | 23.58 | 1.41  | 42.72 <sup>b</sup>  | 1.38    | 22.37  | 63.08 | 2.98     | -0.37              | 11.65 | -23.19 | 22.46 | -0.03 | 19.77 <sup>a</sup> | 6.32 | 7.38   | 32.17 | 2.06  |
| Slope                   | -12.70             | 13.23 | -38.63   | 13.23   | -0.59 | -5.13              | 4.42     | -13.79  | 3.53  | -0.91 | 6.22                | 6.04    | -5.62  | 18.07 | 4.22     | -7.13              | 8.18  | -23.17 | 8.91  | -1.81 | -8.30              | 4.84 | -17.78 | 1.18  | -1.08 |

Notes: a =  $p < 0.05$ ; b =  $p < 0.001$ . Model A = MIMIC LGM with intervention as covariate predicting intercept and slope factors; Model B = MIMIC LGM with intervention and background factors as covariates predicting intercept and slope factors. TPA = Total physical activity; WPA: workplace physical activity; LTPA: leisure-time physical activity; DGPA: domestic and garden physical activity; ATPA: active transportation physical activity. B: unstandardized coefficient; SE: standard error of the unstandardized coefficient; B 95% CI: 95% confidence interval for the unstandardized coefficient;  $\beta$ : standardized coefficient, BMI: body mass index.

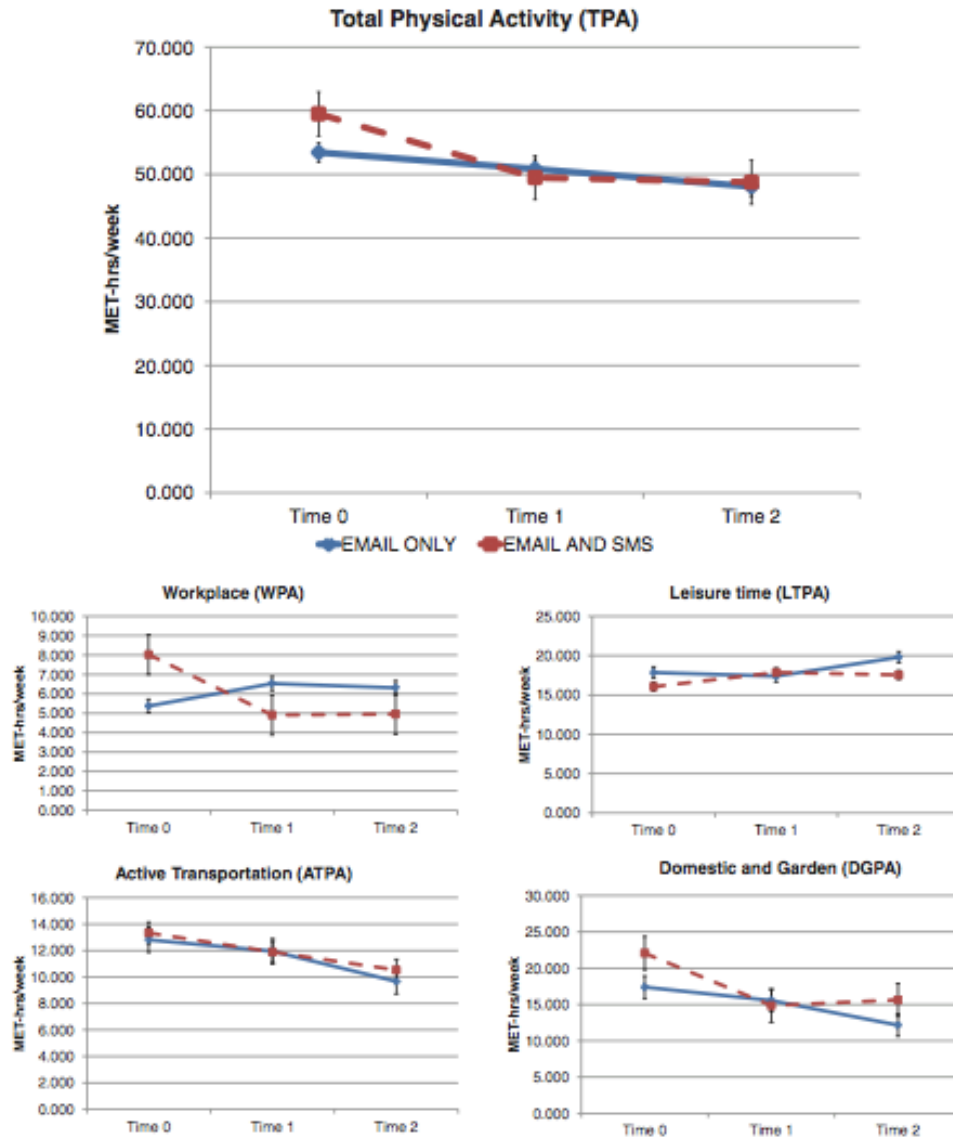


Figure 2. Total, workplace, leisure-time, domestic and garden and active transportation physical activities measured by the IPAQ-L (means  $\pm$  SE) in intervention and control groups. MET: Metabolic Equivalent.

The intercept represents the initial status (intra-individual mean values at baseline), and the slope represents the linear change over time (intra-individual difference over time). LGM accounts for measurement error in each time point and on latent factors, and produces statistical indexes of model fit,<sup>24</sup> which indicate the extent to which the data fit linear change functions in initial status and change. Statistical significance is tested with critical ratios (i.e. z-scores of parameter estimates divided by their standard errors).

The LGM models tested linear change functions in TPA and in the physical activity domains across three time points. Factor loadings of slope were fixed at Time 0 (0), Time 1 (1) and Time 2 (1.33), to reflect non-equidistant assessments. First, a preliminary test of baseline unconditional models (i.e. with only the outcome variables under study) was conducted with the full sample in order to determine model fit and to estimate the trajectories of growth for each variable. Then, to explore whether the intervention had an effect on change trajectories of the studied variables, a Multiple Indicators and Multiple Causes (MIMIC) LGM model was estimated.<sup>21</sup> Group membership was coded email only = 0; email plus SMS = 1. Group differences in intercept and slope result in significant path coefficients between the dummy intervention variable and the intercept and slope factors. This approach is appropriate when the sample size is small and one wants to test intervention effects while controlling for other background factors or covariates.<sup>21,25</sup> Background factors including sex, age, body mass index (BMI), perceived health status and education were specified in a final conditional model in addition to the intervention.

Model fit was assessed with goodness-of-fit indices<sup>26</sup> including the chi-square measure of absolute fit, which should be non-significant, the Comparative Fit Index, which should range from 0.90 to 0.95, respectively, indicating acceptable and good fit, and the standardised root mean residual, with values below 0.05 indicating close fit.<sup>26</sup> The sample size provided adequate statistical power for detecting significant changes in all unconditional LGM models.<sup>21</sup>

## Results

Initially, 331 people enrolled in the programme and were randomized to the study conditions. A total of 195 did not return Time 1 questionnaires (58.9%), 207 did not complete Time 2 questionnaires (62.5%), and 151 did not complete both Time 1 and Time 2 questionnaires (45.6%). Cases were included if they completed the baseline and at least one of the two follow-up questionnaires. A further 22 cases were excluded because of unrealistically high values for daily physical activities (i.e. more than 16 h/day). This resulted in 158 cases in the study.

### Sample characteristics

Sample characteristics are summarised in Table 1. No significant differences were found in intervention and control groups regarding background characteristics and baseline physical activity. At baseline, 50.6% of the sample was highly active, 44.3% moderately active and 5.1% insufficiently active. Of the 158 participants, 87 had complete data on all three surveys (55%), 41 had completed baseline and Time 1 (26%), and the remainder completed baseline and Time 2 (19%). The overall proportion of incomplete data over three variables was below 14%, and the overall proportion of coverage in the covariance matrix was above 55%. No significant differences were detected between those who responded to all surveys and those who did not, except for education level,  $\chi^2(5)=10.424$ ,  $p=0.048$ ,  $\phi=0.18$ . Higher chances of non-response to both follow-up surveys were significantly associated with having an A-level or equivalent (odds ratio (OR) =3.14, 95% confidence interval (CI) =1.07–9.24) and with having ‘other professional qualification’ (OR = 0.35, 95% CI = 0.12–1.02). Dichotomous variables representing

education levels for A-level and for ‘other professional qualification’ were included in the model as auxiliary variables. Intra-class correlations indicated no statistically significant clustering effects among participants from the five different educational organisations.

### **Unconditional growth models**

Unconditional LGM models were tested first for each variable separately, in order to examine whether the trajectories of change varied between cases across the whole sample. All models exhibited good fit with the data ( $CFI \geq 0.960$ ,  $SRMR \leq 0.043$ ). The unconditional LGM models for DGPA and LTPA achieved acceptable fit with the data but had a negative residual variance associated with the slope latent factor. The parameter was fixed to zero, and the models re-estimated.<sup>27</sup> Table 2 shows the estimated mean scores and standard deviations for the full sample and both intervention groups over three time points. The estimated means and standard deviations are derived from the models adjusted for age, sex, BMI, health status and education.

### **Intervention effects on physical activity**

The MIMIC models with the intervention predicting the intercept and slope factors of the physical activity outcome variables achieved acceptable fit with the data ( $CFI \geq 0.957$ ,  $SRMR \leq 0.032$ ). Table 3 contains the estimated parameters for MIMIC models testing intervention effects and for the MIMIC models adjusted for age, sex, BMI, health status and education as covariates, with effect sizes (Cohen’s *d*), calculated as the difference in means from the first and the last assessment, divided by the pooled standard deviation.<sup>25</sup>

Figure 2 shows the estimated means for each PA variable in intervention and control groups. TPA decreased (i.e. negative linear slope) in both groups, but the decrease was non-significant ( $B_{\text{Slope}} = -3.76$  MET-h/week,  $\beta = -0.27$ ,  $p = 0.213$ ) and it was not associated with significant intervention effects (i.e. intercept-SMS group coefficient for slope:  $B_{\text{Slope-group}} = -4.57$  MET-h/week,  $\beta = -0.10$ ,  $p = 0.266$ ). Significant decreases over time were observed in DGPA ( $B_{\text{Slope}} = -3.68$  MET-h/week,  $\beta = -0.34$ ,  $p = 0.038$ ) and in ATPA ( $B_{\text{Slope}} = -2.37$  MET-h/week,  $\beta = -0.30$ ,  $p = 0.046$ ), with an overall small effect size. Significant difference between groups was found in the WPA domain, where the intervention group (email plus SMS) experienced a linear decrease of 2.81 MET-h/week ( $\beta = -0.31$ ,  $p = 0.035$ ) compared to the email group.

The MIMIC intervention effect models controlling for background factors showed small significant direct effects of background factors on initial levels and change in the physical activity outcome variables. Differences in initial status and change between the email and email plus SMS groups became non-significant in TPA and all the physical activity domains except for WPA. When confounders were added to the model, the change over time in WPA remained significant, with intervention group (email plus SMS) showing a significant decrease over time by 3.02 MET-h/week ( $\beta = -0.27$ ,  $p = 0.029$ ). No other significant differences between groups were found. There were no significant effects of background factors on initial levels of total PA, whereas change in TPA was positively associated with health status ( $B_{\text{Slope-health status}} = 5.67$ ,  $\beta = -0.20$ ,  $p = 0.029$ ): Among the PA domains, the initial levels of PA were lower in LTPA ( $B_{\text{Intercept-age}} = -0.26$ ,  $\beta = -0.21$ ,  $p = 0.033$ ) and higher in DGPA ( $B_{\text{Intercept-age}} = 0.53$ ,  $\beta = -0.44$ ,  $p < 0.001$ ) among

older participants, were higher in DGPA for females ( $B_{\text{Intercept-gender}} = 7.48, \beta = -0.19, p = 0.026$ ), and were lower in ATPA for employees with higher health status ( $B_{\text{Intercept-health status}} = -2.55, \beta = -0.20, p = 0.038$ ). Finally, change over time in DGPA was significantly lower in males compared to females ( $B_{\text{Slope-gender}} = -6.58, \beta = -0.60, p = 0.031$ ). The effect sizes of the differences between the first and last assessment were overall small ( $d \leq 0.30$ ) and similar for both groups (Table 2).

## **Discussion**

### **Main findings**

The purpose of this study was to examine the effects of adding weekly SMS communication to weekly email communication on the physical activity in a sample of employees at academic workplaces in the UK. Unlike in Plotnikoff et al.'s study,<sup>2</sup> the intervention did not translate into significant increases in physical activity. Employees who participated and received email plus SMS, decreased their TPA, though the decrease was non-significant. While significant decreases over time in physical activity in domestic and garden and active transportation domains and a non-significant decrease in workplace physical activity were found, leisure time activity balanced the decrease with a small non-significant increase.

It should be noted that both the intervention and control groups showed high levels of physical activity at baseline (according to IPAQ guidelines), hence the intervention might have been successful in maintaining, rather than increasing, physical activity among an already active population. While the decrease in workplace physical activity for the email

plus SMS group was significant, it was associated with small effects. The differences between groups in all physical activity variables were small, which is consistent with the workplace physical activity literature.<sup>28</sup>

Employees receiving emails only showed smaller linear decreases in TPA compared to the intervention group. This resulted from the summative effect of small linear increases in WPA and LTPA, and slight linear decreases in ATPA and DGPA. An overall increase in WPA for the email only group is consistent with Plotnikoff et al.<sup>2</sup> in which workplace activity increased from Time 1 to Time 2 in an email group. The negative results for WPA in the SMS group were the direct opposite of our expectations. More research is needed to understand why the additional SMS was associated with a reduction of PA levels and in particular in the workplace domain. Too frequent SMS contact, or too many messages per week, could have been perceived negatively by some recipients. Was it because of the content or the medium? Was it because employees received the messages on their personal mobile phones? Was it because SMS were perceived as too intrusive?

### **Limitations**

One limitation of this study was the recruitment and number of participants, which was compounded by attrition and non-response. Low participation is commonplace in workplace physical activity interventions,<sup>29</sup> and in some technology and web-based physical activity intervention studies.<sup>30</sup> Attrition reduced the power of the study. In addition, the participants already had moderate to high levels of physical activity. Future studies should try to attract those who are least active and may benefit the most from



increased physical activity. Finally, the study did not include a true control group, although previous research has already demonstrated that email intervention is more effective than no intervention.<sup>1,2</sup>

### **Implications**

There is support for using email in worksite physical activity interventions. However, it would be pre-mature to conclude that SMS should be avoided. Further investigation is needed to understand if text messaging may play a beneficial role in promoting physical activity in workplace settings.

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### **Conflict of interest**

All authors declare that they have no competing interests.

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