
An informational stair climbing intervention with greater effects in overweight pedestrians

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Abstract

Previous interventions have successfully increased levels of stair climbing in public-access settings (e.g. malls). This study used robust methods to establish the magnitude of intervention effects among a specific target group—the overweight. Ascending stair/escalator users ($N = 20\ 807$) were observed in a mall. A 2-week baseline was followed by a 5-week intervention in which message banners, promoting stair climbing, were attached to the stair risers. Standardized silhouettes were used to code individuals as normal/overweight. Logistic regression analyses were conducted with stair/escalator choice as the outcome variable and weight status entered as a moderator alongside condition, gender, ethnicity and ‘pedestrian traffic volume’. Overall, the intervention significantly increased the rate of stair climbing [odds ratio (OR) = 1.28, 95% confidence intervals (CI) = 1.08–1.53], with the effects sustained over 5 weeks. There were differential effects between weight categories, with greater increases in overweight (OR = 1.95, CI = 1.34–2.83) versus normal weight individuals (OR = 1.29, CI = 1.09–1.53). In conclusion, message prompts produced larger effects among overweight individuals, who could benefit most from stair climbing. The public health value of these interventions may, therefore, be greater than realized. The heightened effects among the

overweight were likely due to the salience of the current message, which linked stair climbing with the target of weight control.

Introduction

Climbing the stairs is a widely accessible activity, which expends 9.6 times the energy used at rest [1]. Because it involves raising one’s weight against gravity, greater energy expenditure can be expected in overweight individuals. It is estimated that an 80-kg man, climbing a 3-m flight of stairs 10 times per day, would expend 10 035 kcal over a year [2]. This equates to ~4 days without food. Recent evidence concurs that realistic levels of stair climbing may benefit individuals’ health [3–5]. A cross-sectional study, spanning eight European cities, found that men who resided four floors above ground were an average of 2.7 kg lighter than equivalent ground floor dwellers [4]. Among women, however, no significant association emerged. Meanwhile, in a quasi-experimental trial, individuals were encouraged to use the stairs instead of the elevators at work [5]. At 12-week follow-up, there were significant changes in participants’ weight (–0.7%), fat mass (–1.7%), VO_{2max} (+9.2%), low-density lipoprotein cholesterol (–3.0%) and diastolic blood pressure (–1.8%), after they increased the daily number of flights that they ascended or descended by an average of 16. It

appears, therefore, that in league with other changes to diet and physical activity, stair climbing could be useful in terms of population weight control.

Given the potential benefits, numerous interventions have sought to promote stair choice. Studies usually follow an interrupted time-series design, whereby pedestrian behaviour at a single site is observed during baseline and a subsequent intervention phase. Typically, interventions involve the introduction of poster/banner prompts, extolling the benefits of stair climbing, at the 'point-of-choice' between the stairs and the escalator/elevator. These interventions are easy and inexpensive to execute, such that they could be iterated on a large scale. A critical question, however, is whether they engage overweight individuals.

A worksite intervention examined this issue, using standardized silhouettes to code individuals' weight status [6]. A logistic regression was performed, with stair/elevator choice as the outcome variable and weight status included alongside other potential moderators (e.g. gender, baggage). Such an approach provides an estimated effect size for each moderator, which is corrected for the impact of the other moderators. This is not the case where separate univariate analyses are used to examine the respective influence of each moderator on stair/escalator choice. Overall, normal weight workers in the study of Eves *et al.* [6] were more likely to climb the stairs than the overweight [odds ratio (OR) = 1.83, confidence intervals (CI) = 1.58–2.11]. During the intervention, however, overweight individuals showed a greater increase in the rate of stair climbing than the normal weight (+5.4% versus +2.5%).

The success of this intervention could be attributed to the message used, which detailed specific health benefits of stair climbing and the amount required to obtain these (i.e. '*Doctors have found that 7 minutes of stair climbing a day halves your risk of a heart attack ... Can you spare 7 minutes to live longer ...?*'). According to interview work, such messages are more likely to motivate stair choice than generic entreaties to be active (e.g. '*Regular stair climbing is the easy way to exercise*') [7]. Other worksite interventions have, however,

struggled to change behaviour [8]. Two studies, for example, found that message prompts significantly increased stair descent but did not impact on stair climbing [9]. Elsewhere, the number of pedestrians using the stairs decreased during the intervention [10]. This mixed evidence contrasts with near universal success for interventions hosted in public-access settings (e.g. train stations, malls). To date, 26/29 of these report positive effects on behaviour [2, 11, 12]. Importantly, the effect sizes routinely exceed those achieved in the most successful worksite interventions.

Public-access interventions appear, therefore, to have particular promise. The vital question of whether they engage overweight individuals has not been fully resolved, however. Four earlier public-access interventions coded pedestrians' weight status [13–15]. Since their publication, there have been advances in the methods used to examine pedestrian behaviour. The current study adds to the evidence base by implementing principles of best practice. First, the data were analysed using logistic regression. Next, this is the first public-access stair climbing intervention to code pedestrians' weight status using a standardized measure (i.e. silhouettes). Inter-observer reliability ratings were also calculated to add methodological rigour. Finally, this is the first study of weight status in a public-access setting to control for the potential confounding effects of 'pedestrian traffic volume'. This variable describes the total number of people using the stairs and escalator at a given time. As pedestrian traffic volume increases, so too does the proportion of people who climb the stairs. The rational explanation is that during periods of heavy traffic, escalators become congested. To avoid queuing, individuals therefore take to the stairs. These effects are almost ubiquitous in public-access settings, with 16/17 studies reporting a positive association between traffic volume and percentage stair choice [16]. If left uncontrolled, fluctuation in traffic levels between the baseline and intervention phases of a study could, therefore, confound the effects of the intervention.

To summarize, the current study used robust methods to establish the respective effects of

a mall-based stair climbing intervention on the stair/escalator choices of normal weight and overweight individuals.

Methods

The study was conducted in a UK mall. The site was chosen as it featured the prototypical layout found in previous stair climbing interventions—a bank of ascending and descending escalators, flanked on either side by a staircase. The site featured an overhanging ceiling, such that the top of the staircase was not visible from the foot of the stairs. Each staircase contained 38 steps.

On Wednesdays and Thursdays (11.00 a.m. to 2.00 p.m.), an inconspicuous observer recorded the travel mode used by each ascending pedestrian (stairs/escalator). Individuals were counted if they completed an entire ascent using either mode. Additionally, established criteria were used to code the following personal/demographic characteristics, which are known to influence stair/escalator choice: gender, ethnicity (White/non-White) and large baggage (i.e. presence of anything larger than a briefcase/medium-sized bag) [17–23]. Finally, the observer used the same methods as Eves *et al.* [6] to code individual's weight status (normal weight/overweight). The process utilized a standardized scale, comprising nine silhouettes of men and women, respectively [24]. The silhouettes progress from underweight to overweight, via normal weight. The validity of the scale has been tested by asking individuals to choose the silhouette which most closely resembles a known acquaintance. Choice of silhouette was strongly correlated with the acquaintances' objectively measured body mass index, both for men ($r = 0.63$) and women ($r = 0.74$) [24]. Furthermore, good 18-week test–retest reliability has been reported for the scale (men, $r = 0.60$, women, $r = 0.66$) [25]. The fifth figure in the scale was used as the end point for normal weight status and the sixth figure as the starting point for overweight status. Copies of these silhouettes were attached to the current observer's clipboard, such that she coded weight status by

deciding which silhouette a pedestrian more closely resembled.

During the data collection phase, a second observer coded a subsample of pedestrians ($N = 256$) to produce inter-observer reliability ratings. The following kappa (k) ratings were established: mode of ascent ($k = 1.00$), gender ($k = 1.00$), ethnicity ($k = 1.00$), baggage ($k = 0.79$) and weight status ($k = 0.95$). Each day of monitoring consisted of six consecutive 30-min slots. For every individual, a value for pedestrian traffic volume was calculated as the total number of people ascending the stairs and escalators within the relevant 30-min period. In accordance with previous studies, individuals with pushchairs and unsupervised children were excluded from analyses [17–23]. These individuals did, however, count towards the pedestrian traffic volume figures.

Two weeks of baseline monitoring was followed by a 5-week intervention in which banners were installed on the stair risers of both staircases. They carried the message '*Stair climbing burns more calories per minute than jogging. Take the stairs*'. The text was 5-cm high. Owing to limited man power, observations were not taken in Week 5 and the study was terminated after 7 weeks of observation.

Statistical analyses

Chi-square tests were used to compare the distribution of each personal/demographic characteristic between baseline and the intervention. Given that gender and ethnicity are less subjective, one would expect the accuracy of coding for these variables to remain constant over time. As such, the stability of gender and ethnicity distribution between time points provided a benchmark, against which to compare weight status. Relative to gender and ethnicity, greater variation in the distribution of weight status between time points, could indicate drift in the coding accuracy for this more subjective variable.

A logistic regression was performed with stair/escalator choice as the dichotomous outcome variable. Main effects of condition (i.e. baseline versus

intervention), pedestrian traffic volume and the personal/demographic characteristics from above are well-established in literature [26]. Hence, these variables were grouped in a block and simultaneously entered. Note that traffic was entered as a continuous variable. By contrast, there is little theoretical consensus as to how personal/demographic factors and traffic interact with intervention effects. The exploratory nature of our analyses therefore justified the use of stepwise entry. Hence, a second block was created comprising interaction terms between condition and each of the personal/demographic variables, as well as traffic. Variables in this block were added to the model at the same time as the first block, using conditional forward selection. An alpha level of 0.05 was used to assess

statistical significance. All analyses were performed using SPSS (V. 16.0).

Results

Three and a half hours of observations were excluded because the escalator malfunctioned. This left a data set comprising 20 807 pedestrian stair/escalator choices. During baseline 3.9% of individuals took the stairs. Table I shows descriptive characteristics for the sample and the percentage rate of stair climbing in each moderator group during both phases of the study. The average level of pedestrian traffic volume was 339 people per 30 min (range = 252–438).

The chi-square analyses revealed no significant difference in the proportion of men versus women between the baseline and intervention phase ($P = 0.78$). By contrast, there was a significant difference in ethnic distribution, such that during the intervention 2.3% more people were coded as non-White than at baseline ($P < 0.001$). Similarly, the proportion of people coded as overweight significantly differed between baseline and the intervention (33.3% versus 31.7%; $P < 0.05$).

Table II shows the regression results. Largely as expected, the moderators in the first block had significant main effects on stair/escalator choice. Overall, males, Whites, and normal weight individuals were all more likely to climb the stairs than their counterparts. The only exception was baggage,

Table I. Population characteristics and percentage rate of stair climbing, stratified by moderator group and phase ($N = 20\ 807$)

Distribution	Percentage rate of stair climbing			
	Baseline ($n = 5466$)	Intervention ($n = 15\ 341$)	Baseline ($n = 5466$)	Intervention ($n = 15\ 341$)
Moderator group				
Male	46.8%	47.0%	4.8%	6.7%
Female	53.2%	53.0%	3.1%	4.0%
White	85.4%	83.1%	3.9%	5.5%
Non-white	14.6%	16.9%	3.5%	4.1%
Overweight	33.3%	31.7%	1.9%	3.6%
Normal weight	66.7%	68.3%	4.9%	6.1%

Table II. OR and 95% CIs for moderators of stair/escalator choice

Moderator	Full data set ($N = 20\ 807$)		Normal weight individuals. ($n = 14\ 130$)		Overweight individuals ($n = 6677$)	
	OR	95% CIs	OR	95% CIs	OR	95% CIs
Intervention versus baseline	1.28	1.08–1.53	1.29	1.09–1.53	1.95	1.34–2.83
Men versus female	1.70	1.49–1.93	1.64	1.42–1.90	1.93	1.45–2.57
White versus non-White	1.46	1.22–1.77	1.57	1.28–1.93	1.00	0.64–1.56
No baggage versus baggage	0.88	0.76–1.02	0.90	0.76–1.06	0.82	0.59–1.12
Pedestrian traffic volume	1.00	1.00–1.00	1.00	1.00–1.00	1.00	1.00–1.00
Over versus normal weight	0.37	0.25–0.54	—	—	—	—
Intervention \times weight status	1.54	1.02–2.32	—	—	—	—

which was not significantly associated with stair/escalator choice ($P = 0.09$). There was also a significant effect of pedestrian traffic volume, such that stair choice was more common at higher traffic levels. Importantly, the main effect of condition confirmed that the rate of stair climbing was significantly higher in the intervention phase than at baseline. Additional analyses, comparing stair/escalator choice in successive weeks of the intervention, showed no decline in effects over the 5-week lifespan.

Of the interaction terms entered in the second block, there was no significant interaction between condition and either gender ($P = 0.59$), ethnicity ($P = 0.46$), baggage ($P = 0.23$) or traffic ($P = 0.14$). There was, however, a significant interaction between condition and weight status, suggesting greater responses to the intervention among overweight individuals. Consequently, separate regressions were conducted for each weight category (see Table II). In both cases, the same approach as before was taken but with 'weight status' and the 'condition \times weight status' interaction term removed.

The normal weight analysis showed a significantly increased likelihood of pedestrians taking the stairs during the intervention (OR = 1.29, CI = 1.09–1.53). The pattern of effects for gender, ethnicity and traffic was similar to the full analysis. Again, there was neither a main effect of baggage nor any significant interactions between condition and any of the personal/demographic variables or traffic. Meanwhile, the overweight analysis indicated much larger intervention effects (OR = 1.95, CI = 1.34–2.83) and a main effect of gender. Main effects did not emerge, however, for ethnicity, pedestrian traffic volume or baggage. Once more, there were no interactions between condition and the personal/demographic variables or traffic.

Figure 1 shows raw percentage rates of stair climbing during the study, stratified by condition and weight status. In accordance with the regression results, the increase in stair climbing among the overweight during the intervention phase is clearly greater than observed for normal weight individuals.

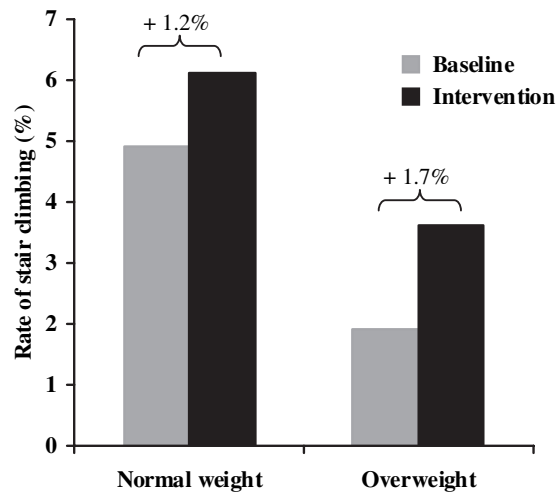


Fig. 1. Raw percentage rates of stair climbing in baseline and intervention conditions, stratified by weight status.

Discussion

The current results indicate that the impact of a public-access stair climbing intervention differs between weight categories. Overall, overweight pedestrians were less likely to take the stairs than the normal weight. This likely reflects the heightened physical demands of stair climbing for these individuals. Despite starting from a lower baseline, however, the overweight increased their rate of stair climbing more during the intervention than their normal weight counterparts. This finding replicates the evidence of heightened responsivity among overweight individuals previously observed in a workplace intervention [6]. Consistent with earlier studies, there were additional main effects, such that stair climbing was more common among men, Whites and at higher levels of pedestrian traffic volume [17–23, 27].

It is important to compare the current findings with previous public-access studies which considered weight status. The main effect of lower stair choice among the overweight/obese is consistent across studies [13–15, 28]. By contrast, the pattern of intervention effects between weight categories differs. In one study, the rate of stair climbing

among obese individuals decreased during the intervention phase (−1.6%), compared with a significant increase in the non-obese (+7.0%) [15]. A possible explanation is that the intervention period fell in the summer months (May to August), when high humidity could exacerbate the physical demands of stair climbing for obese individuals [2, 29]. In two other studies, there were analogous intervention effects between normal weight individuals and the overweight/obese (normal weight +5.7% versus overweight +5.1% [14]; non-obese +8.2% versus obese +6.3% [15]). This is itself encouraging, given that the overweight/obese started from lower baseline rates of stair climbing. Meanwhile, the final study by Andersen *et al.* [13] consisted of two intervention phases, whereby an initial poster with a heart-health theme was replaced by a poster with a weight-related theme. Relative to baseline rates, the heart-health prompt produced similar effects among normal weight (+1.8%) and overweight individuals (+2.5%). By contrast, the weight-related prompt was associated with a greater increase in stair climbing among overweight individuals (+3.9%) than their normal weight counterparts (+1.5%).

The pattern of results across studies may reflect the content of the messages that were used. The interventions which did not report heightened effects among the overweight/obese made more generic entreaties for pedestrians to use the stairs (*'No time for exercise, use the stairs'* [14]; *'Your heart needs exercise, use the stairs'* [13]; *'Your heart needs exercise ... here's your chance'* [15]). By contrast, the current message and the weight-related message used by Andersen *et al.* [13] (i.e. *'Improve your waistline, use the stairs'*) did not simply indicate that stair climbing was good for you. Rather, they stated specific health-related outcomes, which could arise from stair climbing (i.e. calorific expenditure and reduced waist size). As mentioned, research suggests that detailing specific benefits of stair climbing is likely to be more motivating [7]. Furthermore, the outcome to which these two messages allude—weight loss—is likely to be salient among the overweight. Evidence suggests that many overweight individuals are aware of their

condition and keen to take action to control their weight. For example, a cross-sectional survey from the United States found that 61% of respondents with a body mass index > 25 had engaged in some form of weight control practice within the previous 12 months [30]. These two messages may have been effective among overweight individuals because they communicated the hitherto unrealized potential of stair climbing, as a means for achieving weight control.

Generally speaking, the results of public-access stair climbing interventions among the overweight are encouraging. A further study suggests that interventions can engage target groups. Kerr *et al.* [31] interviewed a subsample of stair climbers about their global activity levels. Those questioned during the intervention phase reported significantly lower activity levels than those approached at baseline, indicating that the intervention had recruited proportionately more sedentary individuals onto the stairs. Physical activity initiatives which achieve heightened effects in the overweight are not commonplace. One reason may be that they often revolve around sports or structured exercise. Overweight individuals could be reluctant to engage owing to concerns over their appearance and ability [32, 33]. The peculiarity of stair climbing is that it allows individuals to discretely accrue exercise, without any financial outlay or the need for special clothing, equipment or instruction. Thus, typical barriers to participation do not apply.

Although the current findings are promising, it should be acknowledged that the overall intervention effects were small relative to other examples. For instance, a previous mall-based intervention, which also featured the current message, saw the rate of stair climbing increase from 5.3% at baseline to 14.6% during the intervention [22]. One explanation for this disparity is that at 38 steps, the current staircases were substantially longer than those in other mall-based studies (range = 15–30 steps) [17–23, 27]. Relatively speaking, climbing the current staircases would, therefore, be more physically demanding. Indeed, the baseline rate of stair climbing in the current study (3.9%) is lower than in other mall interventions (mean = 5.5%), indicating that

individuals were less willing to climb the stairs in the first place [26]. Interview data from a worksite intervention indicates that individuals can only be persuaded to climb a finite number of steps [9]. Similarly, pedestrians in public-access settings may be less responsive to interventions where an extreme ascent is involved. Furthermore, because the top of the staircase was not visible from the foot of the stairs, first time visitors to the venue would have no idea of the scale of the stair ascent in prospect, which could further reduce their receptivity to the intervention. There is a clear case for replicating the current study in a venue with a less imposing staircase, where greater overall effects could be anticipated.

Some caution is required when interpreting the current findings. As outlined in the introduction, there is clearly a theoretical case for the role of stair climbing in weight control. It is worth remembering, however, that the level of physical activity participation required for weight management is much greater than that needed for protecting general health (i.e. 30 min of moderate-intensity activity, 5 days per week). The latest guidelines suggest that 60 min of moderate- to vigorous-intensity activity on most days of the week is needed to entirely avert weight gain [34]. Meanwhile, up to 90 min of daily moderate-intensity activity may be needed to achieve weight loss. These recommendations also require calorific intake to be tightly regulated. Thus, it appears that while stair climbing is highly accessible and interventions are successful, in isolation this form of behaviour modification is unlikely to facilitate widespread weight loss among the population.

In terms of strengths and limitations, this was the first stair climbing intervention in a public-access setting to measure the weight status of pedestrians with standardized measures. The use of silhouettes could explain the high inter-observer agreement ratings observed for weight status ($k = 0.95$). Furthermore, among studies which have considered weight status, ours is unique in having controlled for the critical moderator of pedestrian traffic volume. The current results suggest that even modest fluctuation in the number of individuals passing through the site could have an appreciable effect on the rate

of stair climbing. The failure to control for traffic volume in previous interventions is clearly problematic. This study, therefore, represents an exacting investigation of correlates of stair climbing. Nevertheless, previous research has identified additional moderators of pedestrian behaviour. For example, the presence of accompanying children negatively predicts stair choice [26]. Given the burden already placed on the observer, this variable was not recorded. As adults with accompanying children only account for $\sim 1.7\%$ of all pedestrians, this omission is, however, unlikely to have compromised the main findings [26]. Meanwhile, age has been consistently shown to influence stair/escalator choice, with older individuals typically less likely to use the stairs overall. While previous studies have reported inter-observer reliability ratings for age, the coding criteria used was relatively crude (i.e. grey hair and/or appearance >60 years old) [17–23]. Furthermore, the validity of age coding has not been established by approaching individuals to verify their age, nor has a scientific rationale been offered for the specific thresholds that are typically chosen (e.g. ± 60 years old). Given that this study sought to use the most robust methods possible, age was omitted from our analyses. In future, it would, however, be desirable to incorporate age alongside weight status and all other relevant moderators. There is clearly a challenge for investigators to develop more sophisticated means of assessing this variable.

The current study features no follow-up period. Previous research suggests a slight decline in the overall efficacy of stair climbing interventions over a 3-month term [26]. It is uncertain if the heightened responsiveness among overweight individuals also changes over time. There may be several methods for arresting the decline in intervention effects, such as refreshing/rotating the messages prompts. Such experimentation is clearly essential and should incorporate measures of weight status.

The separate analyses for normal and overweight individuals showed some inconsistencies. Whereas main effects of ethnicity emerged in the normal weight analysis, they were absent in the overweight analysis. This disparity can be

explained by differences in sample size. Across the whole sample, relatively few individuals were coded as non-White. Where population characteristics are unevenly distributed, evidence suggests that sizeable samples are needed to identify any association between the demographic variable and stair/escalator behaviour [26]. As the 'overweight' analysis contained fewer cases ($n = 6677$), it had less power to detect significant effects of ethnicity. Power issues are also likely to explain why the main effect of pedestrian traffic volume did not emerge in the overweight analyses. Reassuringly, the direction of effects for all moderators is consistent across all three analyses. It must also be acknowledged that the current results only apply to mall settings. Weight effects should be examined in other types of public-access venue (e.g. train stations), using robust methods.

Using standardized silhouettes should be more accurate than previous coding methods. Like any form of manual observation, however, the coder's consistency may have deteriorated over time. Given that ethnicity is a more objective variable, it is likely that the observer's coding for this variable would remain consistent. There was a significant difference in the proportion of people coded as White between the intervention and baseline (2.3%), suggesting that genuine variation in the demographics of the population pool can occur between time points. Thus, the small difference in distribution of weight status between time points (1.6%) could be genuine and does not necessarily reflect any deterioration in the consistency of coding. Indeed, only one scenario exists whereby the heightened intervention effects observed for the overweight could be an artefact of coding inconsistency. Normal weight individuals are, overall, more likely to take the stairs. Should the observer have started to code individuals as overweight, where once she had coded them as normal weight, a false impression of increased stair climbing among the overweight would emerge. Under this scenario, there would be a greater proportion of people coded as overweight in the intervention phase. In the current data, however, the opposite pattern of effects was observed—fewer people were coded as overweight

during the intervention. Therefore, the differential intervention effects observed between weight categories cannot be attributed to coding inconsistency.

In conclusion, stair climbing interventions hosted in public-access settings are almost universally successful. Using robust methods, this study confirms that effects are more pronounced within the target group of the overweight. The potential of these simple and inexpensive interventions for realising public health goals may, therefore, be greater than previously realized. The specific content of the message used appears central to the efficacy of interventions among overweight individuals.

Conflict of interest statement

None declared.

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