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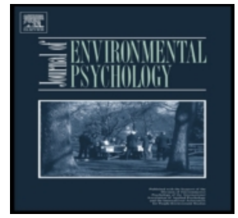

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Increasing stair climbing in a train station; effects of contextual variables and visibility

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Abstract

Accumulation of physical activity during daily living is a current public health target that is influenced by the layout of the built environment. This study reports how the layout of the environment may influence responsiveness to an intervention. Pedestrian choices (n = 41 717) between stairs and the adjacent escalators were monitored for seven weeks in a train station (Birmingham, UK). After a 3.5 week baseline period, a stair riser banner intervention to increase stair climbing was installed on two staircases adjacent to escalators and monitoring continued for a further 3.5 weeks. Logistic regression analyses revealed that the visibility of the intervention, defined as the area of visibility in the horizontal plane opposite to the direction of travel (termed the isovist) had a major effect on success of the intervention. Only the largest isovist produced an increase in stair climbing (isovist=77.6 m^2, OR = 1.10, CIs 1.02-1.19; isovist=40.7 m^2, OR = 0.98, CIs 0.91-1.06; isovist=53.2 m^2, OR = 1.00, CIs 0.95-1.06). Additionally, stair climbing was more common during the morning rush hour (OR = 1.56, CIs 1.80-2.59) and at higher levels of pedestrian traffic volume (OR = 1.92, CIs 1.68-2.21). The layout of the intervention site can influence responsiveness to point-of-choice interventions. Changes to the design of train stations may maximize the choice of the stairs at the expense of the escalator by pedestrians leaving the station.

Key words: Stair climbing, Interventions, Visibility, Isovist, Lifestyle physical activity

1 Introduction

Inadequate levels of physical activity are one of the major causes of weight gain and premature death (Department of Health, 2004; Fleagal, Graubard, Williamson et al., 2005; U.S. Department of Health and Human Services, 2000). To combat this, current recommendations are for the accumulation of at least 30 minutes of moderate intensity physical activity on five or more days of the week; ten minute bouts of brisk walking during the day would achieve this aim (Department of Health, 2005; U.S. Department of Health and Human Services, 2000). Further, from an energy expenditure perspective, walking does not need to be accumulated in ten minute bouts; all physical activity expends energy. Indeed, it has been estimated that accumulation of one extra mile or twenty minutes of walking during the day would have counteracted 90% of the growth in obesity in the US over an eight year period (Hill, Wyatt, Reed et al., 2003). Concurrent with these recommendations for the accumulation of physical activity as part of a healthy lifestyle is a growing realisation that the design of the built environment influences physical activity levels (Frank, Sallis, Conway et al, 2006; Nicoll, 2007, Sallis, Bauman & Pratt, 1998). This suggests that modifications to the built environment may encourage the incorporation of physical activity into daily living.

Like walking, stair climbing is freely available to most of the population, with ample opportunities for its accumulation throughout the day. Unlike walking, however, stair climbing requires vigorous physical activity, using more energy per minute than jogging. It has been estimated in the field that stair climbing expends 9.6 METs, i.e. 9.6 times the energy expenditure of rest (McCardle, Katch & Katch, 2007; Teh & Aziz, 2002). With obesity prevention as a major aim of physical activity promotion, the high energy requirements of stair climbing can help improve the balance between energy intake and expenditure in the population. For example, an

80 kg man climbing a typical three metre flight of stairs in his home 10 times a day would expend approximately 27.5 Kcals a day, more than a quarter of the additional daily expenditure estimated by Hill and co-workers (2003) to counteract the growth in obesity. Importantly, interventions to increase stair climbing on public access staircases are consistently successful; 24/26 studies that have employed public access staircases have significantly increased stair climbing (see Eves & Webb, 2006; Eves, Masters, McManus et al., 2008). In the early research, a poster was placed at the point-of-choice between stairs and the escalator, encouraging pedestrians to take the stairs for their health (e.g. Blamey, Mutrie & Aitchison, 1995; Brownell, Stunkard & Albaum, 1980; Kerr, Eves & Carroll, 2001a). More recently, health promotion messages have been placed on banners affixed to the stair risers in shopping malls, resulting in a doubling of the effectiveness of the intervention (e.g. Kerr, Eves & Carroll, 2001b; Webb & Eves, 2005). This improvement resulted from the enhanced visibility of stair riser banners as a point-of-choice prompt relative to posters (Webb & Eves, 2005). Despite the success of point-of-choice prompts, they are not a panacea. A recent series of studies in Hong Kong that failed to impact stair climbing suggested that the environmental context, e.g. climate and terrain, may be barriers to successful intervention (Eves & Masters, 2006; Eves, et al., 2008). Here we report a second potential contextual barrier, namely the layout of the environment in which the intervention is installed.

A recent report on stair use in buildings has outlined how the theoretical framework of space syntax may help to explain the choice of stairs within the built environment (Nicoll, 2007). Space syntax refers to the way the arrangement of spaces forming an environmental system influences the patterns of movement within that system (Penn, 2003). Hence, space syntax techniques provide an excellent means to investigate pedestrian movement patterns in a train station where transit is the primary goal of its users. Two aspects appear directly relevant to stair climbing interventions. First, pedestrians minimise horizontal deviation from their path where possible, preferring to follow lines-of-sight that run through the space (see Penn, 2003). As a consequence, the proximity of stairs to the platform on which a train stops will be important; stair use is more likely when the stairs are proximal to the direction of travel (Kerr, Eves & Carroll, 2003). Second, pedestrians are more likely to use stairs that are more visible along their path on travel. Space syntax techniques provide a metric to quantify visibility. Space syntax defines a variable called an isovist as the area of a polygon projected on a building plan or map that represents the boundaries of visibility of a specific object. Concerning a train traveller negotiating their way from the platform to the exit, the line-of-sight may provide direction but it is the isovist taken from the point of reference of the exit that may specify the visibility of the way out for the traveller. In buildings larger isovists, i.e. increased visibility, have been associated with greater use of the stairs (Nicoll, 2007). This paper reports how the isovist of an intervention for stair climbing installed on the way out of the station influenced the response to the intervention. It was expected that larger isovists, i.e. greater visibility, would result in a greater response to the intervention.

2 Methods

2.1 The Intervention Site

The setting for this study was a train station with three platforms (Birmingham, UK). All trains stopped opposite the station buildings requiring travellers to walk down the platform to leave the station. Figure 1 depicts a schematic of the layout of the station with the isovists of the intervention for each platform superimposed on the figure. As they moved towards the exit, travellers were faced with a 39-step staircase (0.165 m riser height) and an adjacent escalator on each side of the station. Whereas Platform Three had sole access to the stair and escalator complex, Platforms One and Two shared the same egress. For Platform One, the stairs were nearer the platform than the escalator (c.f. Kerr et al., 2003).

2.2 Procedure

Four observers (inter-observer agreement kappa range .85-.94) recorded stair or escalator choices of ascending commuters (n= 41 717), between 8.15 and 9.45 am, two days a week (Tuesday, Thursday) for seven weeks in 2006. Three and a half weeks of baseline was followed by 3.5 weeks of a stair riser banner intervention. The text in 6-8 cm high black letters on four successive stair risers was superimposed on a yellow background such that the total intervention measured 1.76m wide by 0.99m high and was centred 3.14 m above the ground to make it clearly visible above the head of an approaching pedestrian. The content and layout of the text was, line 1, “Take the stairs.”; line 2, “Stair climbing burns more”; line 3, “calories per minute than jogging.”, line 4, “Burn some today”, a message used successfully in a previous study in a shopping mall (Webb & Eves, 2007). The study was approved by the Ethics Subcommittee of the School of Sport and Exercise Sciences.

2.3 Data Reduction and Analysis

As pedestrians were obliged to walk down the platform to approach the stairs and escalators, the isovist for visibility of the intervention was operationalised as the polygon of visibility of the intervention projected onto the horizontal plane towards the oncoming travellers at each platform. All three isovists were essentially triangles interrupted by the pillars supporting the concourse overhead (see figure 1). The area of the isovists was measured by superimposing the station plan onto squared paper (scale 1 mm^2=10 cm^2) and summing the completed squares. Platforms One, Two and Three had isovists of 40.7 m^2, 77.6 m^2 and 53.2 m^2 respectively. To allow comparison of the effects of this continuous variable with dichotomous variables scored 0 or 1 in logistic regression, the isovist was rescaled to a maximum of 1 by dividing by the largest isovist, i.e 77.6 m^2. Pedestrian traffic volume was operationalised as the number of passengers from each train using the stairs and escalator. Preliminary inspection revealed greater traffic volume for travellers in the commuting period before 9.00 am than in the succeeding hour (8.15-9.00 am, mean = 191.6 ± 64.1; 9.00-9.45 am, mean = 76.0 ± 40.1: t_{299}=18.41 p<.001). To allow assessment of the effects of the commuting period unconfounded by these differences in pedestrian traffic volume, the traffic data were rescaled to the range 1-0 for each time period and then mean centred to remove any differences between the time periods in average traffic volume.

Logistic regression analyses were conducted with escalator/stair use as the dependent variable and gender, stairs proximity, commuting period and intervention as dichotomous predictor variables. The rescaled values for the isovists and pedestrian traffic volume were entered as continuous variables.

3 Results

As the isovist of the intervention would only be relevant when the intervention was present on the stair risers, the effects of isovists, i.e. visibility, were modelled as an interaction between the intervention and the isovist. Table 1 summarises the results of logistic regression analyses. As can be seen from the table, the predicted interaction between the isovist and the intervention was found (Odds Ratio (OR) = 1.30, 95% Confidence Intervals (CIs) 1.09-1.56 p=.004). Follow-up analyses for each platform separately revealed an effect of the intervention for the platform with the largest isovist (Platform 2, isovist=77.6 m^2; baseline = 39.7%, intervention = 40.8%: OR = 1.10, CIs 1.02-1.19 p=.02). In contrast, for platforms with smaller isovists, there were no effects of the intervention (Platform 1, isovist=40.7 m^2; baseline = 41.7%, intervention = 40.5%: OR = 0.98, CIs 0.91-1.06 p=.62: Platform 3, isovist=53.2 m^2; baseline = 40.6%, intervention = 41.0%: OR = 1.00, CIs 0.95-1.06 p=.95). There were no interactions of the isovist or the intervention with gender, time of day or pedestrian traffic volume.

Further inspection of Table 1 reveals additional effects of contextual variables on the choice between stairs and the escalator. At least two effects with appreciable ORs relate to the fact that travellers may be trying to leave the station by the quicker or shorter route (Gärling & Gärling, 1988; Penn, 2003). Thus, increases in pedestrian traffic volume were associated with greater stair climbing. In addition, travellers were more likely to choose the stairs during the commuting period. Indeed the greater stair use on stairs proximal to the platform may also reflect a choice of the shorter, i.e. quicker route. Finally, men chose the stairs more than women, a consistent finding in previous research on public access staircases (Blamey et al., 1995; Brownell et al., 1980; Kerr et al, 2001a, 2001b; Webb & Eves, 2005, 2007).

4 Discussion

In summary, this study demonstrated clear effects of the visibility of a point-of-choice intervention defined as the isovist of the intervention opposite to the direction of travel for pedestrians leaving the station. Only the largest isovist was associated with any increase in stair climbing. In addition, increased pedestrian traffic volume, stairs proximal to the platform and the morning commuting period were associated with increased choice of the stairs at the expense of the escalator.

While the majority of previous interventions for stair climbing have been conducted on public access staircases in shopping malls, a considerable number with health promotion messages have been tested successfully in train stations (aggregate n=110,015; Andersen, Franckowiak, Zuzak et al., 2006; Blamey et al., 1995; Brownell et al., 1980; Iversen, Händel, Jensen et al., 2007; Kerr et al., 2001a). At baseline and following the intervention, the sample size weighted averages for stair climbing are 19.2% and 25.8% respectively, representing an average intervention effect of +6.6%. Here, the increase on Platform Two, while significant, was a modest 1.1%. This weak intervention effect probably reflects the layout of the station coupled with high levels of pedestrian traffic volume. Trains always stopped opposite the station buildings and the line-of-sight for the exit was hidden for most of the distance travellers walked along the platform. Consequently, travellers from the carriages proximal to the exit would reach the stairs and escalators before those behind had reached a point on the platform from which the exit and hence the intervention was visible. As a result, the initial wave of pedestrians using the stairs obscured the view of those following behind. Where the isovist was sufficiently large, i.e. Platform Two, a sufficient number of the flow leaving the station were exposed to the intervention before it was obscured from view to allow a modest increase in stair climbing as a result of the point-of-choice prompt. With the smaller isovists of the remaining platforms, insufficient numbers of travellers were exposed to the intervention before it was obscured. Two points are clear from this result. First, use of stair riser banners to promote stair climbing may not be the optimal tool for interventions where levels of pedestrian traffic are high or the immediate line-of-sight does not include the intervention. This caveat particularly applies to train stations where dense waves of pedestrian traffic result from travellers leaving a train at similar times. Second, the effects here underscore the maxim that one size does not fit all. The layout of the environment in which a point-of-choice intervention is installed can have major effects on its success. It seems likely that point-of-choice prompts need to be visible *at the time the choice is made* for optimal results when travellers may be preoccupied with other concerns such as arriving at work and the forthcoming tasks of the day.

Despite these caveats, there is one encouraging aspect about the data in train stations for promotion of lifestyle physical activity. As summarised above, baseline rates of stair climbing in this context at 19.2% are considerably higher than the average rate of 5.5% found in shopping malls (see Eves & Webb, 2006). Hence it appears that pedestrians are more willing to use the stairs in a travel context, possibly prompted by a desire to save time (Kerr et al., 2001a; Adams, Hovell, Irvin et al., 2007). Such an effect accords with enhanced stair use in the commuting period. Changes to the built environment can capitalise on this effect. Thus a wider staircase would allow more pedestrians to use the stairs to leave the station with clear implications for future design of stations; wider stairs have been associated with greater use in the workplace (Nicoll, 2007). Ensuring that the stairs are closer to the platform than the escalator would also be beneficial; greater stair use occurred here when the stairs were proximal to the platform. In the immediate term, slowing the rate of escalator ascent may represent a more achievable goal where changes to the infrastructure of the station are precluded. Where time pressure is prominent, a slower rate of ascent for the escalator would result in greater use of the stairs. Additionally, this study used an intervention message based on calorific expenditure. Previous research, however, suggests that saving time can have additional effects to a message based on health and greater overall effects in a travel context than a shopping one (see Kerr et al., 2001a). It possible that a combination of escalator slowing and a point-of-choice prompt based on time saving may be an effective strategy in a travel context such as stations.

While a single ascent of a set of stairs may appear trivial in public health terms, the height of the stairs in the station here was 6.44m. An 80 kg man climbing these stairs would expend approximately 5.9 kcals in one ascent. If one assumes a five day week and six weeks a year on which the average commuter would not go to work, then commuters leave this station on 230 days each year. If stair use was repeated every workday then this hypothetical pedestrian would accumulate 1,357 kcals of energy expenditure, i.e. equivalent to about a third of a pound of fat (based on McCardle et al., 2007; Teh & Aziz, 2002). Just as obesity develops through the slow accretion of weight gain, so efforts to reverse this trend should target accumulation of energy expenditure wherever possible. The travel context of stations may be promising avenue for further exploitation. As a way of leaving the station, physical activity would be the natural choice when the stairs were the more available option.

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Figure legend

Figure 1: Schematic of the station floor plan with the isovists of the intervention positioned on the stairs for each platform. Trains stopped opposite the station buildings at the bottom of the figure, obliging passengers to walk down the platform to reach the stair (■ ■ ■ ■) and escalator (● ● ● ●) complexes depicted at the top of the figure. Train tracks are positioned between platforms 2 and 3 (thick dashed line) and hence representation of distances between these two platforms are not accurate.

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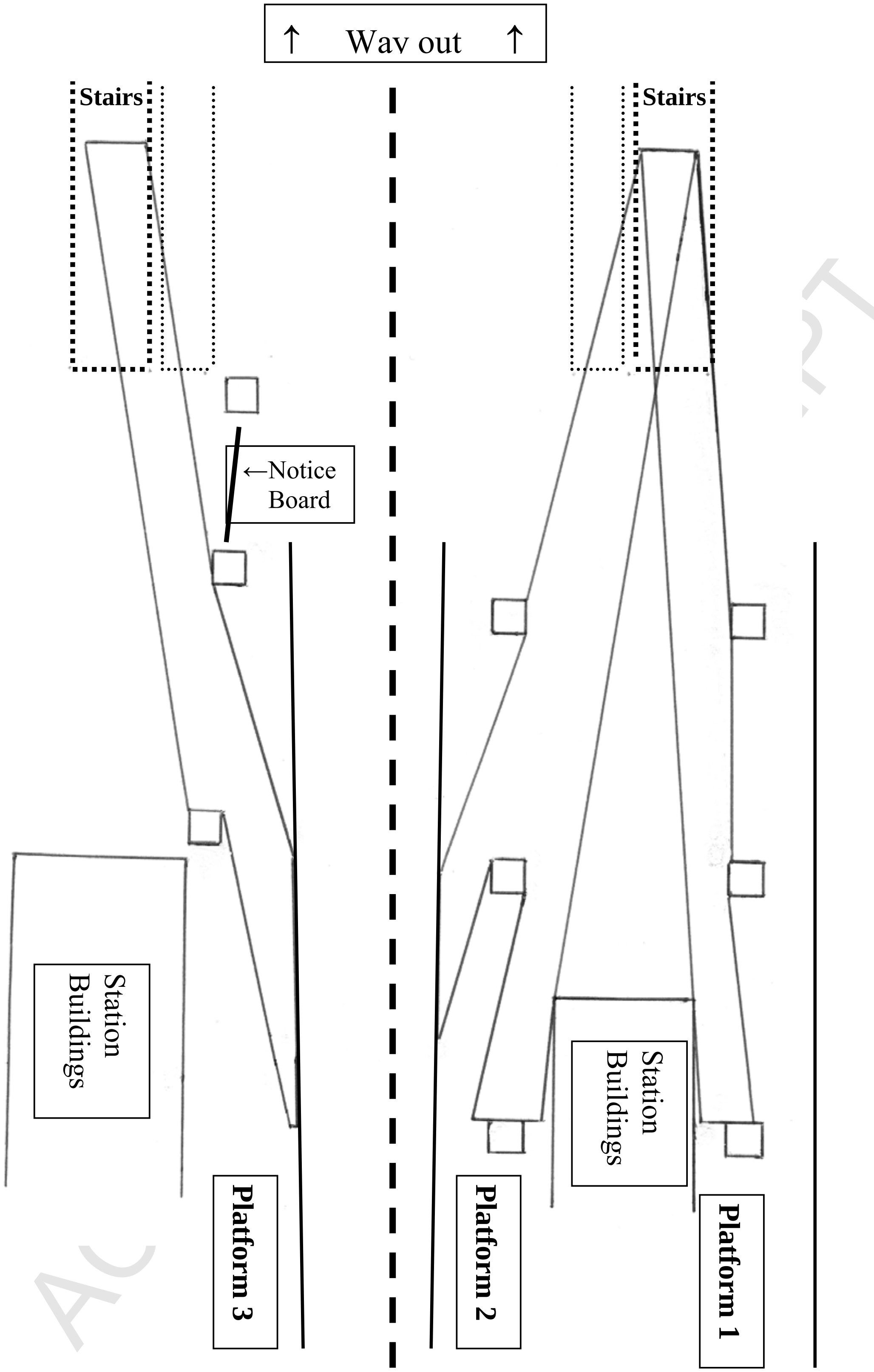
Table 1: The effects of demographic and contextual variables on stair climbing in a train station

Variable	OR	(95% CIs)
Intervention	0.84*	(0.73-0.84)
Intervention x Isovist	1.30**	(1.09-1.56)
Males>Females	1.10***	(1.05-1.14)
Stair proximal>Stair distal	1.09***	(1.03-1.15)
Time of day (8-9.00>9-10.00 am)	1.56***	(1.80-2.59)
Pedestrian traffic volume (continuous)	1.92***	(1.68-2.21)

* = p<.05 ** = p<.005 *** = p<.001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Stairs
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Station Buildings
Station Buildings
Platform 3
Platform 2
Platform 1