Effect of Innovative Building Design on Physical Activity

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ABSTRACT

Stair climbing can be a low-cost and relatively accessible way to add everyday physical activity, but many building stairwells are inaccessible or unpleasant and elevators are far more convenient. This study explores the use of and attitude toward stairs in an innovative office building where the main elevators for able-bodied users stop only at every third floor ("skip-stop" elevators). These users are expected to walk up or down nearby stairs that have been made open and appealing ("skip-stop" stairs). The study takes advantage of a natural experiment. Some workers' offices were clustered around the skip-stop elevator and the stairs, whereas others had access to a traditional elevator core, that is, an elevator that stopped at each floor with nearby fire exit stairs. Stair use on the open skip-stop stairs and enclosed fire stairs was measured using infrared monitors and card-reader activity logs. An online survey of employees ($N = 299$, a 17.4% response rate) gathered information on stair use and attitudes and behaviors toward physical activity; interviews with key personnel identified major implementation issues. The skip-stop stair was used 33 times more than the enclosed stair of the traditional elevator core, with 72% of survey participants reporting daily stair use. Although implementation issues related to organizational objectives, costs, security, barrier-free accessibility, and building codes exist, the skip-stop feature offers a successful strategy for increasing stair use in workplaces.

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INTRODUCTION

A significant proportion of the adult population does not perform sufficient physical activity to reduce the risk of obesity, sustain cardiovascular health, and prevent muscle mass loss due to aging (1–3). Everyday activities, such as stair use, provide important opportunities for incidental physical activity, especially for people who find it difficult to participate in moderate physical activity through recreation and planned exercise. Unfortunately, although every multi-story workplace building has stairs, the stairs are rarely used compared with elevators.

Many health promotion professionals use "push-pull" strategies to bring about healthy behavioral changes. To date, most stair use research has focused on "pull" strategies that combine education, activity programs, and environmental interventions to make engaging in voluntary stair use both attractive and routine in existing buildings. These studies have focused on the use of motivational signage (4–9), aesthetic improvements (10), or the spatial attributes of the location of stairs within the floor plan (11,12).

"Push" strategies include interventions designed to mandate new behaviors and change attitudes toward physical activity. This paper reports on the evaluation of a "push" strategy that mandates stair use by reducing access to elevators through the provision of "skip-stop" elevators (for able-bodied users, that do not stop at every floor, thereby requiring users to take the stairs to access skipped floors) and adjacent stairs in the Caltrans (California Department of Transportation) District 7 Headquarters Building in Los Angeles. The 13-story office building includes two vertical circulation cores: one with skip-stop elevators serving one side of the building and a traditional elevator core serving the other side of the building (Figure 1).

The circulation core with skip-stop elevators has four that stop at every third floor, an open staircase adjacent to the skip-stop elevator lobby that provides access to the floor below and above not served by the skip-stop elevator, an elevator that is compliant with the Americans with Disabilities Act and requires a security pass for access, and an enclosed fire exit stairwell. The other circulation core consists of six conventional elevators that stop at every floor and an enclosed fire exit stairwell.

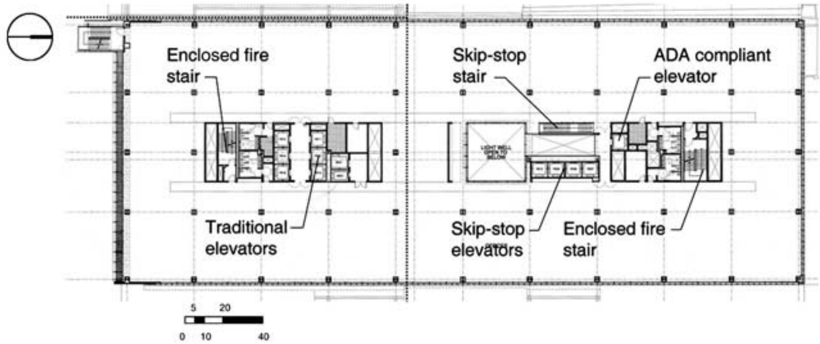

Figure 1
Caltrans typical office floor plan and vertical circulation core

The skip-stop elevators and stair design was envisioned as a means of organizing the high-rise building into a more human scale, increasing personal interaction and office cohesion among employees, and increasing physical activity while decreasing non-productive time spent waiting for elevators.

The provision of the two different circulation cores provided a natural experiment that could be used to explore how a relatively simple building-scale intervention affects attitudes and behaviors toward physical activity in a workplace setting. Thus, the study investigated four key questions:

(1) Was there a difference in stair use patterns between the skip-stop stairs and enclosed fire stairs in the building?
(2) How did the provision of skip-stop elevator/stairs affect employee attitudes toward the workplace?
(3) How did the provision of skip-stop elevator/stairs affect employee behaviors and attitudes toward physical activity and stair use?
(4) What key issues exist in applying this building design to other buildings?

METHODS

Measuring Stair Use

Stair use was measured between four non-executive floors of the building (Levels 4–8), where stair use is not traditionally expected in high-rise office buildings. Usage was measured for a 24-week period between May and November 2006 by securing Trailmaster 1550 active infrared monitors (13) to the underside of handrails on the skip-stop stairs, and by collecting the data from card-reader activity reports of stair access for the enclosed fire stairs.

Measuring Employee Attitudes and Perceptions

An online self-report survey was distributed via e-mail to all Caltrans District 7 Headquarters employees during a 2-week period in February 2007 ($N = 1{,}700$). The survey collected data on employee opinions about the new building, the elevator and stair design, employee attitudes and behaviors toward physical activity in general, and workplace physical activity habits. The survey design was modular and used some questions from the *Occupant Satisfaction Survey* (14) to explore changes in employees' attitudes and perceptions about their work patterns and movement in relation to their previous building. The survey asked employees to recall their experience and attitudes upon occupying the Caltrans building 22 months earlier, and to report their current attitudes at the time of the survey. The survey also incorporated questions from the International Physical Activity Questionnaire (15) survey on various domains of physical activity, including general questions about moderate- and vigorous-intensity physical activities and specific questions about stair use in the Caltrans building.

Statistical Analysis

The study used descriptive statistics to identify and compare stair use between the two vertical circulation cores and employees' self-reported behaviors to national levels of physical activity as well as employee attitudes and behaviors about physical activity (especially stair use) at the time of occupancy of the building and at the time of the survey. Linear regressions were used to analyze the relationship between stair use and survey results. The number of flights of stairs climbed daily (dependent variable) was regressed against individual attitude and behavior (independent) variables collected from the responses of the Caltrans employee attitude survey. Table 1 identifies

Table 1: Relationship between number of stair flights climbed per day and various independent variables

Independent variables (Selected demographic, employee attitude, and behavioral variables from Caltrans Employee Questionnaire)	*Questionnaire measures (as described in the Caltrans Employee Questionnaire)*	*Regression analysis (Y=dependent variable=# of stair flights climbed per day X=independent variable measures listed below)*	*Adjusted R^2*	*P*
Level of education	*What is your highest level of education?* Some high school or less; high school graduate; attended some college; associates degree; bachelors degree; postgraduate degree	Bachelors degree or higher=1, other=0	0.0009	0.60
Age	*What is your age (in years)?* 18–24; 25–29; 30–34; 35–39; 40–44; 45–49; 50–54; 55–59; 60–64; >65	X=mean of each age group	0.001	0.56
Weight	*What is your weight (in pounds)?* <120; 120–140; 141–160; 161–180; 181–200; 201–220; 221–240; >240	X=mean of each weight group	0.002	0.47
Race	*How do you describe your race/ethnicity?* White; Black/African American; Asian; Pacific Islander; American Indian/Alaska Native; Hispanic; Other	White=1, Other=0	0.007	0.16
Gender	*What is your gender?* Male; female; transgender	Male=1, other=0	0.002	0.40
General health	*How do you rate your overall health?* Excellent; very good; good; fair; poor; do not know	Good to excellent=1, other=0	0.0001	0.85

Table 1 *(continued)*

Independent variables (Selected demographic, employee attitude, and behavioral variables from Caltrans Employee Questionnaire)	***Questionnaire measures (as described in the Caltrans Employee Questionnaire)***	***Regression analysis (Y=dependent variable=# of stair flights climbed per day X=independent variable measures listed below)***	***Adjusted R^2***	***P***
Overall job satisfaction	*How would you rate your satisfaction with your job?* Very satisfied; somewhat satisfied; neutral; somewhat dissatisfied; very dissatisfied	Very satisfied; somewhat satisfied=1, other=0	0.0006	0.68
Office cohesion	*How would you rate office cohesion in the new Caltrans building compared to your previous building?* More cohesive; less cohesive; about the same cohesiveness; not applicable	More cohesive=1, other=0	**−0.061**	**0.001**
Current satisfaction with the skip-stop design	*How would you rate your current satisfaction with the skip stop design?* Very satisfied; somewhat satisfied; neutral; somewhat dissatisfied; very dissatisfied	Very satisfied or somewhat satisfied=1, other=0	**−0.0385**	**0.001**
Participation in supplementary workplace physical activity	*How often do you suggest or act on supplementary workplace physical activity?* Never; seldom; sometimes; often	Sometimes or often=1, other=0	0.009	0.11
Taking lunchtime or break time walks	*How often do you suggest or accompany coworkers on lunchtime or break time walks?* Never; seldom; sometimes; often	Sometimes or often=1, other=0	**0.02**	**0.007**

Table 1 *(continued)*

Independent variables (Selected demographic, employee attitude, and behavioral variables from Caltrans Employee Questionnaire)	***Questionnaire measures (as described in the Caltrans Employee Questionnaire)***	***Regression analysis (Y=dependent variable=# of stair flights climbed per day X=independent variable measures listed below)***	***Adjusted R^2***	***P***
Achieving enough exercise	*Do you feel you get as much exercise as you need?* As much as I need; less than I need; do not know	As much as I need=1, other=0	0.007	0.16
Achieving recommended levels of moderate activity	*How many days per week do you achieve 30 min of moderate physical activity?* 0–7 days	0–7 days	0.0003	0.85
No. of days walk at least 10 min at a time	*How many days per week do you walk at least 10 min at a time?* 0–7 days	0–7 days	0.008	0.11
Sedentary behavior	*How many hours per day do you spend sitting?* 0–20 h	0–20 h	0.013	0.06
Reasons cited for use of the skip-stop elevator and stairs by employees who reported use of the skip-stop elevator and/or skip-stop stairs most frequently for travel	Fastest travel time	yes=1, no=0	−0.003	0.96
	Shortest route	yes=1, no=0	−0.002	0.57
	Prefer using stairs	yes=1, no=0	**0.03**	**0.002**
	Opportunity to meet people	yes=1, no=0	**0.02**	**0.01**
	Opportunity to avoid people	yes=1, no=0	−0.002	0.54
	Convenience	yes=1, no=0	0.0008	0.27

the survey measures; sets of variable measures were entered simultaneously into regression equations.

Identifying Implementation Barriers

Design decisions and implementation issues that occurred during the building's design, occupancy, and operations were documented through interviews with the architect, building administrative director, and chief safety and health officer as well as consultants for elevators, building codes, and costs. The open-ended interviews focused on the implementation of the skip-stop design in order to identify potential barriers to implementing the skip-stop design in other buildings.

RESULTS

Difference in Measured Stair Use Patterns

During the 24-week period of the study, the open skip-stop stair was used 33 times more than the enclosed fire stair in the traditional vertical circulation core (117,619 events recorded for the skip-stop stair compared with 3,570 entries from the stair in the traditional elevator core).

Survey Sample

The online survey was completed by 299 employees (a 17.4% response rate). Survey participants reflected the population attributes of the building's staff as reported by Caltrans officials (male 70%; college degree 90%; White 33.6%, Asian 34.6%, Black 6.2%, and Hispanic 11.4%). The sample had a normal distribution of ages, with 53% of participants aged between 40 and 54 years. Only 26.4% of survey participants responded that they exercised as much as they perceived was needed for good health, with only 12% achieving the recommended 30 min of moderate-intensity physical activity 3 days a week. Further, 27.8% did not achieve 30 min of moderate-intensity physical activity on any day.

Skip-stop Design and Employee Attitudes toward Workplace Satisfaction

The survey asked employees to rate their satisfaction with the Caltrans building and the skip-stop elevators and stairs when the building first opened in April 2005 and at the time of the survey in February 2007. The majority of employees expressed a consistent level of overall satisfaction with the new building (65.1% in 2005; 66.2% in 2007). Upon occupancy in April 2005, initial attitudes toward the skip-stop design were evenly distributed with 32.4% expressing satisfaction, 32.1% neutral, and 35.4% expressing some degree of dissatisfaction. At the time of the survey, 22 months after occupying the building, survey results indicated a positive shift in attitude toward the skip-stop arrangement (47.5% expressing satisfaction), although 25% of participants remained dissatisfied. These attitudes suggest that mandated stair use from the skip-stop design became more acceptable over time, although a contingent of building occupants may have continued to resent and resist such a "push" strategy.

Attitudes about how the skip-stop elevator and stair arrangement affected employee perceptions of personal interaction and office cohesion (organizational unity) were mixed. The distribution of opinions showed that the skip-stop arrangement had more (17.7%), less (25.1%), the same (37.5%), or no (19.7%) influence on office cohesion. Employee perceptions of office cohesion and workplace satisfaction at the time of the survey both were negatively associated with the number of flights employees traveled (Table 1).

Skip-stop Design and Employee Behaviors and Attitudes toward Physical Activity

Survey data indicated that 72.8% of participants used the stairs daily, ranging from one to three (69%) and four to six (31%) flights per day. When prompted to provide reasons for the change in stair use compared with their previous building, respondents reported both "push" and "pull" rationales. "Push" reasons cited for more stair use included "work responsibilities made stair use necessary" (26.7%), and they had "no other choice as there was no available elevator nearby" (14.7%). Reasons cited for less stair use included their "work responsibilities no longer required stair use" (8.6%) and the enclosed "fire stairs [the continuous enclosed fire stairs] in the new building were not as accessible [required use of an access card] as the enclosed fire stairs they used in the old building." Reasons reflecting "pull" strategies included stair use being "more convenient than waiting for the elevator" (28.0%), and that people "enjoyed the health benefit of increased stair use" (22.6%).

Most physical activity behaviors measured (including number of days of moderate or vigorous physical activity, employee perceptions of whether they participated in enough physical activity, and participation in physical activities such as exercise breaks) were not associated with the number of stair flights traveled. Only participation in lunchtime and break time walks was significantly associated with stair use. In addition, no statistical relationship emerged between the number of stair flights traveled and such demographic variables as age, gender, weight, level of education, general health, and level of job satisfaction, nor was any significant correlation between these variables indicated.

Regression analysis of self-reported number of stair flights traveled (dependent variable) and various travel choice (independent) variables indicated that only fastest travel time and a preference for stair use related to frequency of stairs traveled (Table 1). There was no relationship between self-reported number of flights traveled and employee workstation's proximity to either vertical circulation core.

Implementation Issues in Adapting Skip-stop Design to Other Buildings

Although this strategy holds promise for increasing stair use effectively in high-rise buildings, the interviews with design and implementation personnel identified five key issues for consideration that may affect the decision to implement this strategy in other buildings.

(1) The Caltrans building has only one tenant, and internal organizational departments work with one another. The potential of this design to increase stair use in multi-tenant buildings needs further review.
(2) Creating the skip-stop stairs required a variance from building code requirements (16) to accommodate opening the separation between floors required to ensure protection in the event of a fire.

(3) Construction costs from eliminating four elevator stations on eight floors were offset by the construction of the open staircases. Differences in elevator energy and maintenance costs or health outcomes derived from stair use have not been reviewed.
(4) The design permitted open access throughout all three floors served by the single elevator station. This strategy may not satisfy security issues in other buildings.
(5) There was an unexpected increase in persons self-identifying a disability immediately upon occupancy of the Caltrans building in order to obtain an access card for the elevator that was compliant with the Americans with Disabilities Act, located near the skip-stop elevator.

DISCUSSION

The building design of the Caltrans District 7 Headquarters Building provides an example of a successful "push" strategy for incorporating stair use across the general population of a high-rise building (72.8% of employees reported daily stair use). This building design provided an innovative but cost-effective means to get people who might not otherwise engage in physical activity to take the stairs. It could be speculated that incorporating similar push strategies (e.g., locating important functions such as washrooms, copy rooms, or staff support rooms on alternate floors) could further increase the number of stair flights walked in some buildings. Although "pull" strategies such as signage can be readily applied to any building, these environmental "push" strategies require a fundamental change in the design of building typologies such as office buildings. Incorporating skip-stop design may be applicable to existing buildings, but possibly only where enclosed fire stairs are located adjacent to elevators.

The study had several limitations. The uniqueness of the building layout and low rate of survey response may limit the generalizability of some of the findings. The study did not make an in-depth examination of the organizational relationship patterns of the departments on the four floors studied, which might affect the amount of personal movement between these floors. Although the uniqueness of this building limits cross-sectional studies of this intervention among other similar buildings, it is recommended that a more in-depth longitudinal study of this important design precedent be conducted.

The skip-stop design strategy has great potential for increasing overall stair use in new and some existing buildings. The skip-stop strategy could be adapted to many existing buildings with elevators and adjacent fire stairs. Existing elevators could be reprogrammed to skip access to certain floors for most building users, requiring them to access other floors via openly accessible fire exit stairs. Access for persons in wheelchairs or with other mobility limitations could be maintained with the use of access control devices, thereby permitting elevator access to every floor for persons with disabilities. Further research into applying the skip-stop design strategy in various building types (residential and office) and typologies (new and existing low-rise, existing high-rise) should be considered.

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REFERENCES

1. Pate R, Pratt M, Blair SN, Haskell WL, Macera CA, Bouchard C, *et al.* Physical activity and public health. A recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. *JAMA*. 1995;273(5):402–7.
2. Lee IM, Paffenbarger RJ. Physical activity and stroke incidence: the Harvard Alumni Health Study. *Stroke*. 1998;29(10):2049–54.

3. Boreham CA, Wallace WF, Nevill A. Training effects of accumulated daily stair-climbing exercise in previously sedentary young women. *Prev Med*. 2000;30(4):277–81.
4. Blamey A, Mutrie N, Aitchison T. Health promotion by encouraged use of stairs. *BMJ*. 1995;311(7000):289–90.
5. Anderson RE, Franckowiak SC, Synder J, Bartlett SJ, Fontaine KR. Can inexpensive signs encourage the use of stairs? Results from a community intervention. *Ann Intern Med*. 1998;129(5):363–9.
6. Kerr J, Eves FF, Carroll D. Posters can prompt less active people to use the stairs. *J Epidemiol Community Health*. 2000;54(12):942–3.
7. Kerr J, Eves FF, Carroll D. The influence of poster prompts on stair use: the effects of setting, poster size and content. *Br J Health Psychol*. 2001;6(4):397–405.
8. Coleman K, Gonzalez E. Promoting stair use in a US-Mexico border community. *Am J Public Health*. 2001;91(12):2007–9.
9. Marshall AL, Bauman AE, Patch C, Wilson J, Chen J. Can motivational signs prompt increases in incidental physical activity in an Australian health-care facility? *Health Educ Res*. 2002;17(6): 743–749.
10. Kerr KA, Yore MA, Ham SA, Dietz WH. Increasing stair use in a worksite through environmental changes. *Am J Health Promot*. 2004; 18(4):312–5.
11. Nicoll G. Spatial measures associated with stair use. *Am J Health Promot*. 2007;21(4 Suppl.):346–52.
12. Eves FF, Webb OJ. Worksite interventions to increase stair climbing; reasons for caution. *Prev Med*. 2006;43(1):4–7.
13. Trailmaster TM1550 Active Infrared Monitor. Trailmaster, Lenexa, KS. Available at http://www.trailmaster.com/tm1550.php, accessed 28 October 2008.
14. Huizenga C, Zagreus L, Arens E, Lehrer D. *Measuring Indoor Environmental Quality: A Web-based Occupant Satisfaction Survey*. University of California at Berkley, 2003. Available at http://www.cbe.berkeley.edu/research/pdf_files/Huizenga2003_USGBC.pdf, accessed 28 October 2008.
15. Craig CL, Marshall AL, Sjöström M, Bauman AE, Booth ML, Ainsworth BE, *et al*. International physical activity questionnaire: 12-country reliability and validity. *Med Sci Sports Exerc*. 2003;35(8): 1381–95.
16. International Conference of Building Officials. *Uniform Building Code*. Pasadena, CA: International Conference of Building Officials; 2001.