

Architectural Design and Physical Activity: An Observational Study of Staircase and Elevator Use in Different Buildings

David R. Bassett, Ray Browning, Scott A. Conger, Dana L. Wolff, and Jennifer I. Flynn

Background: The indoor built environment has the potential to influence levels of physical activity. However, the extent to which architectural design in commercial buildings can influence the percentage of people choosing to use the stairs versus elevators is unknown. The purpose of this study was to determine if buildings with centrally located, accessible, and aesthetically pleasing staircases result in a greater percentage of people taking the stairs. **Methods:** Direct observations of stair and elevator use were conducted in 3 buildings on a university campus. One of the buildings had a bank of 4 centrally located elevators and a fire escape stairwell behind a steel door. The other 2 buildings had centrally located staircases and out-of-the-way elevators. **Results:** The percentage of people who ascended the stairs was 8.1% in the elevator-centric building, compared with 72.8% and 81.1% in the 2 stair-centric buildings ($P < .001$). In addition, the percentage of people who descended the stairs was 10.8% in the first building, compared with 89.5% and 93.7% in the stair-centric buildings ($P < .001$). **Conclusions:** The results of the current study suggest that if buildings are constructed with centrally located, accessible, and aesthetically pleasing staircases, a greater percentage of people will choose to take the stairs.

Keywords: built environment, architecture, stair climbing, stair descending

The prevalence of obesity in the United States has quadrupled for children, adolescents, and adults over the past 50 years.¹⁻³ Physical activity is helpful in the prevention of obesity, diabetes, hypertension, and cardiovascular disease,⁴ but despite increasing knowledge concerning the health benefits of physical activity, only 43.5% of U.S. adults in 2008 reported meeting the minimum recommendation for aerobic physical activity.⁵ An even smaller percentage of U.S. adults met the recommendation, based on accelerometer measures of activity in 2003-04.⁶

In the past, physical activity levels were much higher due to the manual labor involved in obtaining food, shelter, and clothing. People living in traditional agrarian societies spent many hours per day performing moderate- to vigorous-intensity physical activity.⁷ Even during the industrial revolution (1800-1900 A.D. in the U.S.), factory jobs typically required a good deal of physical labor and walking was the main form of transportation. However, with the advent of automobiles, electrification, and labor saving devices, the need to be physically active was greatly diminished.^{8,9} Today, many people living in

modern societies have a total daily energy requirement that is only 1.5 times their resting metabolic rate, indicative of an inactive lifestyle.¹⁰

In 2002, the *Guide to Community Preventive Services (Community Guide)* summarized the evidence regarding various approaches for increasing physical activity of Americans,¹¹ based upon a systematic review.¹² One of the recommended strategies is to post signs next to escalators or elevators, with a message such as, "Take the stairs instead of the elevator, it is healthier for your heart," or "Walking up stairs burns almost 5 times more calories than riding an elevator." Known as point-of-decision prompts, these health promotion messages have been documented to increase the percentage of people who elect to take the stairs. In one study conducted in 1980, the percentage of people taking the stairs more than doubled, from 6.3%-14.4%, when signs were placed next to stairs and elevators.¹³ Stair climbing levels remained elevated even a month after the signs were removed. In 2010, a systematic review of point-of-decision prompts included 16 studies that have used this approach,¹⁴ including the 6 studies in the previous review.¹² Out of 11 studies that evaluated point-of-decision prompts using time-series designs, the median increase in stair use was 50% above baseline, which the authors concluded was a modest increase. Another systematic literature review reported that only 3 of 10 studies conducted in elevator settings found significant increases in stair climbing, while 28 of 32 results conducted in escalator settings found significant increases in stair climbing.¹⁵ This suggests that the

Bassett is with the Dept of Kinesiology, Recreation, and Sport Studies at the University of Tennessee, Knoxville, TN. Browning is with the Dept of Health and Exercise Science, Colorado State University, Ft. Collins, CO. Conger, Wolff, and Flynn are with the Dept of Kinesiology, Recreation, and Sport Studies, University of Tennessee, Knoxville, TN.

impact of point-of-decision prompts varies depending on the intervention setting. On the strength of the scientific evidence, the latest update of the *Community Guide* lists point-of-decision prompts as a recommended strategy for increasing physical activity.¹⁶ While the effect size is relatively small, point-of-decision prompts are among the most cost-effective strategies for promoting physical activity at the population level.¹⁷

Environmental changes within buildings can also result in increased stair use. A study was conducted in which the following items were added in sequence: new carpeting, artwork, motivational signs, and stereo music.¹⁸ By making the stairwell environment more appealing, the percentage of people taking the stairs increased by 9% over baseline. However, the systematic review published in 2010 concluded that there was insufficient evidence, due to an inadequate number of studies, to determine whether enhancements to stairs or stairwells are effective when added to point-of-decision prompts.¹⁴

Architects are concerned with the broad impact of their buildings on human health and health behaviors. In addition, many architects strive to construct buildings according to Leadership in Energy and Environmental Design (LEED) certification standards established by the U.S. Green Building Council.¹⁹ To achieve LEED certification, a project team must earn points from 7 categories: 1) sustainable sites, 2) water efficiency, 3) energy and atmosphere, 4) materials and resources that emphasize recycling, 5) indoor environmental quality, 6) innovative design strategies, and 7) regional priority.²⁰ LEED standards even take into account the energy used in transporting building materials to the construction site. However, architects are less likely to consider how the structural interiors of their buildings could promote physical activity, while simultaneously decreasing energy use.²¹ Well-designed staircases that encourage people to use the stairs instead of the elevator have the potential to do that.

The purpose of this study was determine if buildings designed with centrally located, accessible, and aesthetically pleasing staircases result in a greater percentage of people taking the stairs, compared with buildings with less convenient/appealing staircases. To fulfill this purpose, a cross-sectional study using direct observation methods was conducted in 3 different buildings on a university campus.

Methods

Research Participants

The participants in this study were comprised of university faculty, staff, students, and a few community members. Since we were observing public behavior of these individuals, no informed consent form was required. The university's Institutional Review Board (IRB) granted an exemption from IRB review.

Protocol

Student observers counted stair and elevator use in 3 buildings (Art and Architecture Building, Stokely Management Center, and the Law School) at the University of Tennessee, Knoxville. Stokely Management Center (Figure 1) has a bank of 4 centrally located elevators and a fire-escape stairwell that is farther from the entrance to the building and located behind steel doors. In contrast, the Art and Architecture building (Figure 2) has a centrally located, well-lit, easily accessible stairwell, in addition to 2 stairwells behind steel doors at each end of the building, and a freight elevator at one end of the building. The Law School (Figure 3) has an unobstructed, attractive staircase and 2 elevators; all are centrally located.

One observer was stationed on the first floor to count the number of people who ascended and descended the stairs. Another observer was stationed on the first floor to count the number of people who went up and came down in the elevator. People pushing carts, carrying heavy loads with arms, or using assistive devices (ie, wheelchair, cane, or crutches) were not counted because they likely used elevators out of necessity. The observers used a data sheet to count the number of people. Data were recorded in 1-hour intervals since the data sheets were set up in this manner (1 page per hour), and to allow observers to trade off at 2-hour intervals.

Testing was conducted over a 5-hour period on a weekday, during the month of April (7:30 AM to 12:30 PM). On the first floor of each building, the following variables were recorded:

1. the total number of people going up the stairs
2. the total number of people coming down the stairs
3. the total number of people going up the elevator
4. the total number of people coming down the elevator.

Statistics

A Chi-square test was used to determine if significant differences existed in the expected and observed frequencies of people ascending the stairs versus the elevators in different buildings. A Chi-square test was also used to determine if significant differences existed in the expected and observed frequencies of people descending the stairs versus the elevators.

Results

Table 1 shows the number of people taking the stairs and the elevators in each of the 3 buildings. The percentage of people who ascended the stairs was only 8.1% in the elevator-centric building, compared with 72.8% and 81.1%, in the 2 stair-centric buildings. In addition, the percentage of people who descended the stairs was only 10.8% in the first building, compared with 89.5% and 93.7% in the other 2 buildings. Chi-square analyses revealed that there were significant differences in the



Figure 1 — Photograph of a narrow, fire-escape stairwell in Stokely Management Center on the University of Tennessee–Knoxville campus. The staircase is located behind a heavy steel door around the corner from a bank of 4 elevators.



Figure 2 — Photograph of a wide, centrally located staircase in the University of Tennessee Art and Architecture Building.



Figure 3 — Photograph of a wide, centrally located staircase in the University of Tennessee Law School.

Table 1 Elevator and Stair Use Inside 3 University Buildings, as Determined by Direct Observation; Data Presented Were Aggregated Across 5-Hour Periods (From 1-Hour Counts) on 3 Different Days, 1 Day per Building

	Building 1 with central elevators (Stokely Management Center)	Building 2 with central staircase (Art & Architecture)	Building 3 with central staircase (Law School)
Going up			
Number of people ascending the stairs	14	526	248
Number of people riding up in elevator	160	197	58
Percentage of people taking stairs up (vs. elevator)	$14/(160+14) = 8.1\%$	$526/(526+197) = 72.8\%$	$248/(248+58) = 81.1\%$
Going down			
Number of people descending the stairs	17	468	493
Number of people riding down in elevator	140	55	33
Percentage of people taking stairs down (vs. elevator)	$17/(140+17) = 10.8\%$	$468/(468+55) = 89.5\%$	$493/(493+33) = 93.7\%$

Note. Going up: $P < .001$, Chi-square = 303.74 with 2 degrees of freedom; Going down: $P < .001$, Chi-square = 584.36 with 2 degrees of freedom.

expected and observed frequencies for staircase and elevator use in this study ($P < .001$ for ascending, $P < .001$ for descending).

In each of the buildings, the percentage of people who descended the stairs was slightly greater than the percentage of people who ascended the stairs. This is logical, since some people might choose to take the elevator up due to physical limitations (eg, aerobic fitness or osteoarthritis in the knees/hips), and then take the stairs down.

The buildings we observed had varying numbers of staircases and elevators. The stair-centric buildings had multiple staircases and 1 or 2 elevators, while the elevator-centric building had 4 elevators and only 1 staircase. We chose to focus on aggregate data for each building, rather than data for each individual staircase and elevator. In Art and Architecture, stair ascents on the central staircase ($N = 368$) exceeded those on the other 2 stairways ($N = 98$ and $N = 63$, respectively). Similarly, in the Law School stair ascents on the wide, central staircase ($N = 238$) exceeded that on the narrow, less accessible staircase ($N = 10$).

Discussion

The current study indicates that in buildings with centrally located, accessible, and aesthetically pleasing staircases, a greater percentage of people choose to take the stairs. The impact of architectural design appears to be rather dramatic. We observed that only about 10% of people took the stairs in an elevator-centric building, while the clear majority of people took the stairs in buildings that were stair-centric.

In the United States, buildings are often designed with a centrally located elevator, and the stairs are located in unattractive “fire escape” stairwells behind heavy steel doors. This design tends to discourage stair use, and the default decision is usually to ride the elevator. An alternative design, consisting of wide, centrally located staircases that provide a view of one’s surroundings, may encourage people to take the stairs.

The buildings we selected represent the extremes of indoor built environments that are conducive to stair use, or discourage stair use. Previously, Moore et al²² examined stairwells in 123 buildings in downtown Vancouver. They found that a number of factors influenced stair use, including a) stairs being visible from the front entrance of building, b) unlocked stairs, c) adequate lighting, and d) stair width sufficient for 2 people. They concluded that few buildings were designed in ways that encouraged stair use; however, they conducted no measurements of actual stair use. Bungum et al²³ examined 8 buildings in Las Vegas: 5 buildings had 2 floors, and 1 each had 3, 6, and 10 floors. They hypothesized that several factors would be associated with stair usage, including a) being able to see the stairs from the entrance, b) the proximity of the stairs from the elevator, c) the number of steps

between floors, d) whether a person was going up or down, e) the number of floors in the building, and f) the sex of the stairway user. Of these factors, only ascending vs. descending (odds ratio = 3.82, $P < .01$) and the number of floors in the building (odds ratio = 2.10, $P < .01$) predicted stair use in the baseline condition. Since their study was an intervention to increase stair use, the authors did not report the percentage of stair users in the various buildings. Instead, they reported the odds ratios for stair use, for each of the factors examined. Nevertheless, the findings of Bungum et al are consistent with the current study in showing that people are less likely to take the stairs when headed downward as opposed to upward.

One MET is equal to the resting metabolic rate of a reference man (ie, $3.5 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$).²⁴ The energy cost of stair climbing is about 8.6 METs, and that of stair descending is 2.9 METs.²⁵ A 70-kg individual expends approximately 1.5 calories in climbing 10 stair-steps, and 0.5 calories in descending 10 stair-steps.²⁵ Thus, if this individual were to go up and down 40 stair-steps per day at work (250 days \cdot yr⁻¹), it would result in an energy expenditure of approximately 2000 calories per year ($2.0 \text{ calories}\cdot\text{flight} \times 4 \text{ flights}\cdot\text{day}^{-1} \times 250 \text{ days}\cdot\text{yr}^{-1}$). The average U.S. adult gains approximately 1.8 pounds of body weight per year, indicating a small daily positive energy balance, also known as an “energy gap”²⁶. Assuming that the added body weight is comprised of fat tissue, this would equate to 6300 calories per year. If people opted to use the stairs instead of the elevator at work, other factors being equal, it would lessen the energy gap but it probably would not be enough to achieve energy balance, in most U.S. adults.

Our results suggest that good architectural design can promote physical activity. We acknowledge that elevators are needed to serve individuals with disabilities and ensure compliance with the American Disability Act (ADA) guidelines. Moreover, in very tall buildings, staircase use may not always be practical. Shorter buildings, however, can be designed in ways that cause people to consistently choose the stairs instead of the elevator. This not only increases the energy expenditure of the building occupants, but it should also result in significant energy savings. Currently, the US Green Building Council requires that LEED-certified buildings install energy efficient “vertical transportation equipment”²⁷, but they do not specifically award points for architectural designs that encourage people to choose to take the stairs instead of elevators. However, the council’s website references a paper that discusses increasing stair use by point-of-decision prompts and installing carpeting, lighting, artwork, and music in existing stairwells.²⁸ It also references the use of “skip-stop” elevators that stop only at every third floor, so that able-bodied people must walk up or down nearby stairs to access skipped floors.²⁹

The current study has both strengths and limitations. It goes beyond health promotion strategies (eg, point-of-decision prompts) and examines the role of architectural

design in promoting stairway use. One limitation of the study is that the buildings we examined were not equal in height. The more elevator-centric building had 7 floors above ground level, while the more stair-centric buildings had 3 and 4 floors, respectively. The greater number of floors that some people had to traverse probably contributed to more people in Stokely Management Center (with 4 central elevators) choosing the elevator over the stairs. However, even if one assumes that approximately one-half of the people who boarded the elevator on the first floor were going to floors 2, 3, and 4, and one-half were going to floors 5, 6, and 7, the elevator would remain the predominant choice even for those who were traveling between the lower floors. Based on this assumption, roughly 15% [ie, $14/(80+14)$] of individuals would have used the stairs to ascend to floors 2, 3, and 4, and 20% [ie, $17/(70+17)$] of individuals would have used the stairs to descend from these floors. Another limitation is that our study was restricted to comparing stair use to elevator use; we did not compare stair use to escalator use. Escalators are generally more inviting than elevators, partly because one can usually step onto an escalator without waiting.¹⁵

In summary, this study's observational data suggest that centrally located, accessible, and aesthetically pleasing staircase design contribute to increased stair use. We compared the percentage of people using the stairs in two buildings with well-designed staircases to another building with a centrally located bank of elevators and a narrow, fire-escape stairwell. The percentage of stair users was several times greater for the stair-centric buildings, as compared with the elevator-centric buildings. If implemented on a widespread basis, this architectural design change could boost population levels of physical activity and reduce electricity use.

References

1. Flegal KM, Carroll MD, Ogden CL, Curtin LR. Prevalence and trends in obesity among US adults, 1999-2008. *JAMA*. 2010;303(3):235-241. [PubMed doi:10.1001/jama.2009.2014](#)
2. Ogden C, Carroll M. Prevalence of obesity among children and adolescents: United States, Trends 1963-1965 Through 2007-2008. Available at: http://www.cdc.gov/nchs/data/hestat/obesity_child_07_08/obesity_child_07_08.htm. Accessed February 15, 2011.
3. Ogden C, Carroll M, Curtin L, Lamb M, Flegal K. Prevalence of high body mass index in US children and adolescents, 2007-2008. *JAMA*. 2010;303(3):242-249. [PubMed doi:10.1001/jama.2009.2012](#)
4. US Department of Health and Human Services. *Physical activity and health: a report of the Surgeon General*. Atlanta, GA: DHHS, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion; 1996.
5. Carlson S, Fulton J, Schoenborn C, Loustalot F. Trend and prevalence estimates based on the 2008 Physical Activity Guidelines for Americans. *Am J Prev Med*. 2010;39(4):305-313. [PubMed doi:10.1016/j.amepre.2010.06.006](#)
6. Troiano RP, Berrigan D, Dodd KW, Masse LC, Tilert T, McDowell M. Physical activity in the United States measured by accelerometer. *Med Sci Sports Exerc*. 2008;40(1):181-188. [PubMed](#)
7. Bassett DR, Schneider PL, Huntington GE. Physical activity in an Old Order Amish community. *Med Sci Sports Exerc*. 2004;36(1):79-85. [PubMed doi:10.1249/01.MSS.0000106184.71258.32](#)
8. Katzmarzyk PT. The Canadian obesity epidemic: an historical perspective. *Obes Res*. 2002;10:666-674. [PubMed doi:10.1038/oby.2002.90](#)
9. Popkin BM. The nutrition transition in the developing world. *Dev Policy Rev*. 2003;21:581-597. [doi:10.1111/j.1467-8659.2003.00225.x](#)
10. Brooks GA, Butte NF, Rand WM, Flatt JP, Caballero B. Chronicle of the Institute of Medicine physical activity recommendation: how a physical activity recommendation came to be among dietary recommendations. *Am J Clin Nutr*. 2004;79(5):921S-930S. [PubMed](#)
11. Task Force on Community Preventive Services. Recommendations to increase physical activity in communities. *Am J Prev Med*. 2002;22(4S):S73-S107.
12. Kahn EB, Ramsey LT, Brownson RC, et al. The effectiveness of interventions to increase physical activity: a systematic review. *Am J Prev Med*. 2002;22(4S):S73-S107. [PubMed doi:10.1016/S0749-3797\(02\)00434-8](#)
13. Brownell KD, Stunkard AJ, Albaum M. Evaluation and modification of exercise patterns in the natural environment. *Am J Psychiatry*. 1980;137:1540-1545. [PubMed](#)
14. Soler RE, Leeks KD, Buchanan LR, et al. Point-of-decision prompts to increase stair use: a systematic review update. *Am J Prev Med*. 2010;38(2S):S292-S300. [PubMed doi:10.1016/j.amepre.2009.10.028](#)
15. Nocon M, Muller-Riemenschneider F, Nitzschke K, Willich SN. Increasing physical activity with point-of-choice prompts- a systematic review. *Scand J Public Health*. 2010;38:633-638. [PubMed doi:10.1177/1403494810375865](#)
16. CDC. Promoting Physical Activity: Environmental and Policy Approaches. Available at: <http://www.thecommunityguide.org/pa/environmental-policy/index.html>. Accessed May 3, 2011.
17. Wu S, Cohen D, Shi Y, Pearson M, Sturm R. Economic analysis of physical activity interventions. *Am J Prev Med*. 2011;40(2):149-158. [PubMed doi:10.1016/j.amepre.2010.10.029](#)
18. Kerr NA, Yore MM, Ham SA, Dietz WH. Increasing stair use in a worksite through environmental changes. *Am J Health Promot*. 2004;18(4):312-315. [PubMed doi:10.4278/0890-1171-18.4.312](#)
19. U.S. Green Building Council. An Introduction to LEED. Available at: <http://www.usgbc.org/DisplayPage.aspx?CategoryID=19>. Accessed January 22, 2012.
20. U.S. Green Building Council. LEED 2009 for New Construction and Major Renovations. Available at: <http://www.usgbc.org/DisplayPage.aspx?CMSPageID=220>. Accessed January 22, 2012.
21. Yellow Springs Instrument Co. *YSI Model 2300 Stat Plus Glucose and L-lactate Analyzer User's Manual*. Yellow Springs, OH: YSI Incorporated; 1994.

22. Moore E, Richter BA, Patton CK, Lear SA. Mapping stairwell accessibility in Vancouver's downtown core. *Can J Public Health*. 2006;97(2):118–120. [PubMed](#)
23. Bungum T, Meacham M, Truax N. The effects of signage and the physical environment on stair usage. *J Phys Act Health*. 2007;4(3):237–244. [PubMed](#)
24. Ainsworth BE, Haskell WL, Herrmann SD, et al. 2011 compendium of physical activities: a second update of codes and MET values. *Med Sci Sports Exerc*. 2011;43(8):1575–1581. [PubMed doi:10.1249/MSS.0b013e31821ece12](#)
25. Bassett DR, Vachon JA, Kirkland AO, Howley ET, Duncan GE, Johnson KR. Energy cost of stair climbing and descending on the college alumnus questionnaire. *Med Sci Sports Exerc*. 1997;29(9):1250–1254. [PubMed doi:10.1097/00005768-199709000-00019](#)
26. Hill JO, Wyatt HR, Reed GW, Peters JC. Obesity and the environment: where do we go from here? *Science*. 2003;299(7):853–855. [PubMed doi:10.1126/science.1079857](#)
27. Schindler Elevator Corporation. Going 'green' in elevator and escalator design. Available at: www.us.schindler.com/goinggreenwhitepaper082008.pdf. Accessed January 22, 2012.
28. Wellness Councils of America. StairWELL to Health: How the Centers of Disease Control and Prevention rejuvenated stairwells to increase physical activity. Available at: <http://www.absoluteadvantage.org/article/?article=354>. Accessed January 22, 2012.
29. Nicoll G, Zimring C. Effect of innovative building design on physical activity. *J Public Health Policy*. 2009;30(Suppl 1):S111–S123. [PubMed doi:10.1057/jphp.2008.55](#)