AJMB
eISSN: 2600-8173
https://doi.org/10.37231/ajmb.2023.7.1.605
https://journal.unisza.edu.my/ajmb
PENERBIT Universiti Sultan Zainal Abidin

Asian Journal of Medicine and Biomedicine

Energy Consumption by Lifts: Can Health Promotion of Stair Climbing Reduce Electricity Bills for Business?

Intan Suhana Munira Mat Azmi[1*], Frank F. Eves[2], and Michael J. White[2]

[1]Community Medicine Unit, Faculty of Medicine, Universiti Sultan Zainal Abidin, Medical Campus, 20400 Kuala Terengganu, Malaysia
[2]Reader, The School of Sport, Exercise & Rehabilitation Sciences, College of Life and Environmental Sciences, The University of Birmingham, Edgbaston, Birmingham

*Corresponding author: ismunira@unisza.edu.my

Received: 19th January 2023 Accepted: 24th March 2023 Published: 10th April 2023

Abstract

Lifts are almost ubiquitous in modern, high rise workplaces. The availability of lifts in most of the workplace buildings reduces stair climbing activity thus lessen physical activity at work. Despite of increase the risk of having diseases due to physical inactivity, the cost of electricity also rises with increase activities of lifts. This study tested the effectiveness of health messages displayed on posters to promote stair climbing and reduce the use of the lifts, and consequently their cost. There were six buildings at the university accommodation comprised of 11 lifts and 15 stair cases. Posters with a message based on the potential calorific expenditure from a single total ascent were displayed for four weeks. The stair climbing interventions were conducted in the spring and autumn of the subsequent academic year. Results showed no significant difference in electricity consumption between baseline and intervention, for either intervention period (p= .799).

Keywords

Stair climbing, lifts, electricity consumption, health promotion posters, point-of-choice prompts

Introduction

Physical well-being can be achieved by engaging in physical activities, endurance training as well as having a balanced dietary intake [1]. Recommended guidelines for adults to gain sufficient health benefits is to perform moderate to vigorous intensity activity for 30 minutes per day for at least five days per week, in bouts of 10 minutes or more [2]. Moderate to vigorous physical activities require 5 or more METs of energy expenditure, i.e. 5 times higher than the energy costs while resting. Activities such as brisk walking, cycling and playing outdoor games have been reported to meet the intensity requirements [3]. Stair climbing is a vigorous lifestyle physical activity due to the need to raise weight against gravity; typically, it requires more energy per minute than jogging [4]. In the field, Teh & Aziz (2002) estimated the energy expenditure during stair ascent as 9.6 METs when participants climbed at their own chosen rate whereas, even at lower step rates of 70 steps.min^{-1} [5], Bassett et al. (1997) estimated climbing at 8.6 METs [6]. In daily life, rather than in the laboratory, stair climbing is a vigorous physical activity that can be performed unplanned at anytime and anywhere without many constrictions for most of the population.

While stair climbing can reduce time costs of a journey at work, it is also beneficial for health. Increased stair climbing activity has been shown to improve cardiorespiratory fitness, lipid profiles and weight status in experimental [7-11], and been associated with reduced risk of strokes, heart attacks and osteoporosis in observational studies [12-15]. Thus, in accordance with the beneficial outcomes of increased stair climbing on health, numerous intervention programs have been conducted worldwide to increase stair climbing activity [16].

Most of these public health interventions were performed in worksites and public access settings such as train stations and shopping malls. Point-of-choice prompts were used as the strategy to encourage the public in choosing the method to reach their destination either by using the stairs rather than the lift or escalator. These simple interventions have been shown to increase stair climbing, though less consistent effects are evident for worksites than for public access settings [17-19]. Only one interesting intervention study to promote energy saving with stair climbing as health behaviour has been conducted previously. van Houten, Nau, and Merrigan (1981) used posters with printed health messages in an attempt to reduce energy consumption of the lifts by encouraging the use of stairs in university buildings. While there were no effects of health messages in van Houten and co-workers research, increases to the closing time of the lift reduced lift usage and energy [20].

Office buildings generated about 10 to 20 times higher of electricity usage compared to the residential flats [21] and lifts accounted for about 5% of total electricity consumption of an office building [22]. Thus, interventions that reduce the electricity costs of the lifts by encouraging choice of the stairs, especially in business buildings, may be beneficial for business costs. If such an effect could be demonstrated, it might encourage businesses to adopt health promoting signage in their workplace.

Materials and Methods

Study site

The study was conducted at Mason Hall, University of Birmingham; a student residence which comprised of six buildings with different heights of climb. The halls of residence were situated about 0.8 miles from the main university campus where academic sessions take place. These three to six storeys buildings provided flats, apartments as well as studios designed for primarily first year undergraduates and couples, with a few post graduate students who acted as wardens. There were eleven lifts, and a stairwell was located just opposite each of the lifts.

Study design

Two sizes of posters; A3 and A4, were used as a multi-component intervention to promote stair climbing. The A3 sized posters were placed on the notice board adjacent to the lift's door on the ground floor whereas the A4 sized posters were affixed onto the brick wall for the rest of the floors in each building by the staircases. Each poster displayed one message focussing on the amount of weight loss estimated when climbing the stairs daily for a year. The messages were adjusted based on the height of the climb at each stair/lift complex. The message for a three storey climb read, '*Stair climbing always burn calories. Did you know? If you've climbed to the top of this building, once each day, over a year that would burn 1lb of fat*' (see figure 1). The amount of fat loss differed depending on the number of stories for each climb. Based on the height of the climb, it was estimated to lose about 1 lb for a three-storey climb (n=2), 1⅓ lb for a four-storey climb (n=4) and at least 1⅔ lb for the five and the solitary six-storey climbs (n=5). The posters were checked regularly and any missing posters were replaced immediately.

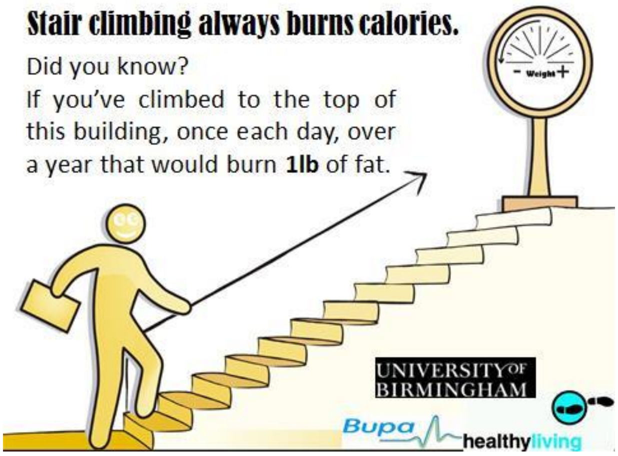

Figure 1 Poster used for intervention at Mason Hall

The study was conducted during autumn and spring terms. The four-week intervention started from 9th of February until 8th of March 2015 for spring term time and in next year's autumn term from 2nd November to 6th December 2015. As a result, different populations of first year students were exposed to the intervention in the spring and autumn terms. The four weeks baseline data was retrieved from the previous records of monthly energy usage data provided by the Head of Utilities, University of Birmingham. Energy consumption was measured as electricity usage for each lift in kilowatt hour (kWh) unit each half hour.

Ethical approval

As the study did not involve any individual participants but rather total electricity usage for each building, the chair of the ethics committee waived the need for full ethical approval.

Statistical analysis

Mixed between and within subjects repeated measure analysis of variance (ANOVA) was employed. The between subject factors were semester (spring vs. autumn), height of climb (3 vs. 4 vs. 5/6 storeys) and intervention (baseline vs. posters) and the within subject factor was time. The eighteen time points that were selected for analyses were those when students could have been expected to be using the lifts and stairs, with six time points with half an hour range in between for each morning (7:30 am to 10:00 am), afternoon (4:30 pm to 7:00 pm) and evening (7:30 pm to 10:00 pm). These were based on traffic for the residence a) getting up in the morning, going to breakfast and then to the university, b) coming back from the university classes and other academic activities, c) going out for dinner, going to the gym and meeting up with friends after academic sessions.

Results

According to the trend of lift usage, there was a generally positive increase in lift usage throughout the day, peaking at 18:30 to 19:00 after which it declined from early evening onwards. Within this general trend, there was an increase in the electricity consumption in the morning period. Nonetheless, between 6:00 to 6:30 pm the lift was in highest demand.

Mauchly's test indicated that the assumption of sphericity had been violated ($X^2(152) = 9730.2$, $p < .001$ for the repeated measures ANOVA. Therefore, the degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon = .296$). Results for the within-subject factor of time with Greenhouse-Geisser correction, summarised in table 1 below, revealed that a main effect of time interacted with the between subject factors of building height, and semester, with an interaction of all three as predictors of electricity consumptions ($p = .041$).

Table 1 Summary for the effects on electricity usage of the between and within subject factors

Effect	F	*p* value
Time	56.156	< .001
Time*Height	7.592	< .001
Time*Baseline vs. Intervention	0.471	.799
Time*Semester	3.185	.007
Time*Height*Baseline vs. Intervention	0.578	.834
Time*Height*Semester	1.894	.041
Time*Baseline vs. Intervention*Semester	0.492	.784
Time*Height*Baseline vs. Intervention*Semester	0.370	.961

The significant interaction between semester and time reflects greater usage of the lift in the autumn term than in spring term in the period after students would have returned from the university after academic work (4:30 pm onwards). We have no explanation of this difference. Despite some minor differences in usage during baseline and intervention periods over time, the figure does not indicate any differences as a result of intervention. This impression was confirmed in the analyses. There was no overall significant difference for electricity consumption during baseline and intervention periods ($F_{(1, 868)} = 0.033$, $p = .856$) nor a significant interaction over time ($F_{(5, 4372.8)} = 0.471$, $p = .799$). Additionally, there were also no significant interactions between baseline and intervention periods with the other factors of time, height of climb and semesters which would indicate any effects of the intervention on trends of electricity usage ($F_{(10, 4372.8)} = 0.370$, $p = .961$).

Table 2 below summarises the between subject effects in the analysis. Concerning the intervention, there was no significant difference between the effects of the intervention for height of climb ($F_{(2, 868)} = 0.101$, $p = .904$) that would be consistent with differential effects of the message on the posters. Further, there was no significant difference between the effects of the intervention in the two semesters that would be consistent with greater effects in the autumn term when habits of usage were less well established than in the spring term ($F_{(1, 868)} = 0.243$, $p = .622$).

Table 2 Effects of electricity usage between subject effects

Effect	F	*p* value
Height	45.905	< .001
Baseline vs. Intervention	0.033	.856
Semester	7.349	.007
Height*Baseline vs. Intervention	0.101	.904
Height*Semester	4.561	.011
Baseline vs. Intervention*Semester	0.243	.622
Height*Baseline vs. Intervention*Semester	0.022	.978

Discussion

This study used simple and low cost posters in an attempt to influence the choice between choosing the lift or the stairs among the residents of university halls. Based on the results gathered from electricity consumption after the intervention, posters at the point-of-choice between stairs and lift did not improve stair usage in Mason Hall in either the spring or the autumn terms. The overall pattern of electricity consumption was for major increases after 4:30 pm that peaked around 6:30 pm whereas usage was lower during the morning period. Such a result suggests more ascending and descending traffic occurs after academic sessions at the university have been completed.

Electricity consumption by the lift includes journeys for both ascent and descent. Such a combined measure of lift usage, i.e. the converse of stair usage, typically provides stronger evidence of point-of-choice efficacy; stair usage is a variable more likely to change than the more specific measure of stair climbing [17, 18]. These data provide no evidence that weight control messages influenced first year student's behaviour when choosing between stairs and a lift at their residence. This failure to change behaviour means that the study was unable to test potential effects of habit development between autumn and spring terms or the different messages that were associated with different height buildings. As a result, all of the experimental hypotheses were rejected.

One possible explanation for the failure to change consumption could have been the message displayed on the posters. Despite emphasizing the amount of weight one could lose with daily stair climbing to the top floor of the building, it has failed to attract the residents to the stairs and away from the lift. Clearly, not every student who used the lift occupied rooms on the top floor, and hence might not have thought the message applied to them as they lived on a lower floor. Although previous studies recorded positive impacts of a weight control message on stair climbing in public access settings [23, 24] and workplaces [25], these interventions targeted the general population and were not pretested for their potential efficacy with students. For first year university students, weight control may not be a major concern. Another possible reason for the failure is that students could have preferred to walk in groups back from the university. Pedestrian traffic at the choice-point between lifts and stairs reduces stair climbing [18, 25, 26]. If one member of a group travelling together is unwilling to take the stairs, then the rest of the group could be constrained to use the lift, despite some having a positive view of the intervention. Further, lift usage increased at the end of the afternoon, following academic sessions. It is possible that a tiring day at university, coupled with the walk back from the campus, was a barrier to increased physical activity using the stairs.

Overall, there was more consumption for the lifts in the autumn term than in the spring term. One possible explanation for the finding was that this study performed two interventions whereby the first intervention was completed during the spring term in 2015 and followed by second intervention during the autumn term of the same year. As a result, primarily different student populations of first years would have been targeted in the different terms of the study. The greater usage in the autumn term overall may simply have reflected a population during that term that was less willing to climb stairs instead of use lifts. Alternatively, students in the autumn term may simply have made more journeys overall. A similar explanation may explain the differences between usage based on the height of climb. The lowest electricity consumption occurred for the least height of climb, three storeys, consistent with effects of potential height of climb on stair use [18, 25, 26]. Nonetheless, there was more consumption for the four-storey climb that the taller five and six-storey climbs. As height of climb was a between subject variable, different populations were exposed to the messages. Residents in the four-storey buildings may have been less willing to take the stairs than in the higher buildings or simply make more journeys entering and exiting the building as part of their daily life.

Conclusion

Overall, this study provided no evidence that point-of-choice prompts to encourage stair climbing based on weight control influenced first year's students lift usage. However, the findings could promote further research to test on different type of messages to be displayed at the point-of-choice prompts to encourage university students to increase stair climbing activity and reduce lift usage.

Acknowledgement

We thank Donna Willmetts, College Facilities Manager and Ian Gregory, Head of Utilities, University of Birmingham for continuous support and providing the data throughout the study.

References

1. Hong, S, Peltzer, K. Dietary behaviour, psychological well-being and mental distress among adolescents in Korea. *Hong and Peltzer Child Adolesc Psychiatry Ment Health*. 2017; 11: 56. https://doi.org/10.1186/s13034-017-0194-z
2. Tremblay MS, Warburton DER, Janssen I, Paterson DH, Latimer AE, Rhodes RE, Duggan M. Downloaded from www.nrcresearchpress.com by 103. *Appl. Physiol. Nutr. Metab*. 2011; 36: 36–46. https://doi.org/10.1139/H11-009
3. Strong W, Malina R, Blimkie C, Daniels S, Dishman R, Gutin B, Trudeau F. Evidence Based Physical Activity for School-age Youth. *The Journal of Pediatrics*. 2005; 146: 732–737. https://doi.org/http://dx.doi.org/10.1016/j.jpeds.2005. 01.055
4. Ainsworth BE, Haskell WL, Leon AS, Jacobs DR, Montoye HJ, Sallis JF, Paffenbarger RS. Compendium of Physical Activities: classification of energy costs of human physical activities. *Medicine & Science in Sports & Exercise*. 1993; 25(1): 71–80. https://doi.org/10.1249/ 00005768-199301000-00011
5. Teh KT, Aziz AR. Heart rate, oxygen uptake, and energy cost of ascending and descending the stairs. *Medicine and Science in Sports and Exercise*. 2002; 34(4): 695–699.
6. Bassett DR, Vachon JA, Kirkland AO, Howley ET, Duncan GE, Johnson KR. Energy cost of stair climbing and descending on the college alumnus questionnaire. *Medicine and Science in Sports and Exercise*. 1997; 29(9): 1250–1254. https://doi.org/10.1097/ 00005768-199709000-00019
7. Allison MK, Baglole JH, Martin BJ, Maccinis MJ, Gurd BJ, Gibala MJ. Brief Intense Stair Climbing Improves Cardiorespiratory Fitness. *Medicine & Science in Sports & Exercise*. 2007; 49(2): 298–307. https://doi.org/10.1249/MSS. 0000000000001188
8. Boreham CAG, Kennedy RA, Murph MH, Tully M, Wallace WFM, Young I. *Training effects of short bouts of stair climbing on cardiorespiratory fitness, blood lipids, and homocysteine in sedentary young women. British Journal of Sports Medicine.* 2005; 39(9): 590-593. https://doi.org/10.1136/ bjsm.2002.001131
9. Boreham CA, Wallace WF, Nevill A. Training effects of accumulated daily stair-climbing exercise in previously sedentary young women. *Preventive Medicine*. 2000; 30(4): 277–281. https://doi.org/10.1006/pmed.2000.0634

10. Kennedy RA, Boreham CAG, Murphy MH, Young IS, Mutrie N. Evaluating the effects of a low volume stairclimbing programme on measures of health-related fitness in sedentary office workers. ©*Journal of Sports Science and Medicine*. 2007; *6*: 448–454. Retrieved from http://www.jssm.org
11. Meyer P, Kayser B, Kossovsky MP, Sigaud P, Carballo D, Keller PF, Mach F. Stairs instead of elevators at workplace: cardioprotective effects of a pragmatic intervention. *European Journal of Cardiovascular Prevention and Rehabilitation : Official Journal of the European Society of Cardiology, Working Groups on Epidemiology & Prevention and Cardiac Rehabilitation and Exercise Physiology*. 2010; 17(5): 569–575. https://doi.org/10.1097/HJR.0b013e328338a4dd
12. Jakes RW, Khaw K, Day NE, Bingham S, Welch A, Oakes S, Wareham NJ. Patterns of physical activity and ultrasound attenuation by heel bone among Norfolk cohort of European Prospective Investigation of Cancer (EPIC Norfolk): population based study. *BMJ (Clinical Research Ed.)*. 2001; 322(7279): 140.
13. Lee IM, Paffenbarger RS. Physical activity and stroke incidence: the Harvard Alumni Health Study. *Stroke; a Journal of Cerebral Circulation*. 1998; 29(10): 2049–2054.
14. Paffenbarger RS, Hyde RT, Wing AL, Lee IM, Jung DL, Kampert JB. The Association of Changes in Physical-Activity Level and Other Lifestyle Characteristics with Mortality among Men. *New England Journal of Medicine*. 1993; 328(8): 538–545. https://doi.org/ 10.1056/NEJM199302253280804
15. Paffenbarger RS, Hyde R, Wing AL, Hsieh C. Physical Activity, All-Cause Mortality, and Longevity of College Alumni. *New England Journal of Medicine*. 1986; 314(10): 605–613. https://doi.org/10.1056/NEJM198603063141003
16. Armstrong T, Candeias V, Richards J. *Review of Best Practice in Interventions to Promote Physical Activity in Developing Countries*. 2005. WHO Headquarters. Retrieved from http://www.who.int/dietphysicalactivity/bestpractice PA2008.pdf
17. Bellicha A, Kieusseian A, Fontvieille AM, Tataranni A, Charreire H, Oppert JM. Stair-use interventions in worksites and public settings - A systematic review of effectiveness and external validity. *Preventive Medicine*. 2015; 70: 3-13. https://doi.org/10.1016/ j.ypmed.2014.11.001
18. Eves FF, Webb OJ. Worksite interventions to increase stair climbing; reasons for caution. *Preventive Medicine*. 2006; 43(1): 4–7. https://doi.org/10.1016/ j.ypmed.2006.03.011
19. Nocon M, Müller-Riemenschneider F, Nitzschke K, Willich SN, Muller-Riemenschneider F, Nitzschke K, Willich SN. Review Article: Increasing physical activity with point-of-choice prompts--a systematic review. *Scandinavian Journal of Public Health*. 2010; 38(6): 633–638. https://doi.org/10.1177/ 1403494810375865
20. Houten RV, Nau PA, Merrigan M. Reducing elevator energy use: A comparison of posted feedback and reduced elevator convenience. *Journal of Applied Behavior Analysis.* 1981; 14(4): 377-387.
21. Yang L, Lam JC, Tsang CL. Energy performance of building envelopes in different climate zones in China. *Applied Energy*. 2008; *8*5(9): 800–817. https://doi.org/10.1016/j. apenergy.2007.11.002
22. American Council for an Energy-Efficient Economy. Elevators energy consumption and saving. 2017. Retrieved from http://aceee.org/topics/elevators
23. Andersen RE, Franckowiak SC., Snyder J, Bartlett SJ, Fontaine KR. Can inexpensive signs encourage the use of stairs? Results from a community intervention. *Annals of Internal Medicine*. 1998; 129(5): 363–369. https://doi.org/10.1097/ 00008483-199901000-00016
24. Lewis AL, Eves FF. Testing the theory underlying the success of point-of-choice prompts: A multi-component stair climbing intervention. *Psychology of Sport and Exercise*. 2012; 13(2): 126–132. https://doi.org/10.1016/j.psychsport.2011. 10.001
25. Eves FF, Olander EK, Webb OJ, Griffin C, Chambers J. Likening stairs in buildings to climbing a mountain: Self-reports of expected effects on stair climbing and objective measures of effectiveness. *Psychology of Sport and Exercise*. 2012; 13(2): 170–176. https://doi.org/10.1016/ j.psychsport.2011.11.002
26. Olander EK, Eves FF. Elevator availability and its impact on stair use in a workplace. *Journal of Environmental Psychology*. 2011; 31(2): 200–206. https://doi.org/10.1016/ j.jenvp. 2011.03.001