AMERICAN JOURNAL OF
Preventive Medicine

REVIEW ARTICLE

A Systematic Review of Interventions to Increase Stair Use

Cally A. Jennings, PhD, Lira Yun, MS, Christina C. Loitz, PhD, Eun-Young Lee, PhD, W. Kerry Mummery, PhD

Context: Stair climbing is an accessible activity that can be incorporated into one's daily lifestyle to increase physical activity levels and provide health benefits. This review summarizes the effectiveness of stair interventions and explores key differences that may influence intervention effectiveness.

Evidence acquisition: Interventions to increase stair use published from January 1990 to July 2015 were identified in PubMed, Sport Discus, Web of Science, Environment Complete, CINAHL, Trial Register of Promoting Health Interventions, Embase, Scopus, and PsycINFO. Eligibility criteria included original studies, published in peer-reviewed journals, targeting adult samples, and clearly describing intervention design and results. Studies were also required to measure the use of stairs compared with an elevator, escalator, or moving stairway at baseline and during at least one timepoint when the intervention was in effect. Studies were required to provide data to determine if the intervention resulted in significant changes in stair use/climbing.

Evidence synthesis: The search results yielded 2,136 articles in total; 54 articles met the criteria, which resulted in a final sample of 67 studies included in the analyses. Interventions settings included public sites (75%), worksites (21%), or a combination of both (4%). For Phase 1 results, 72% of studies reported significant improvements in stair use (n=10 of 14) and stair climbing (n=38 of 53).

Conclusions: Evidence from the review demonstrates support for the effectiveness of interventions to increase stair use and stair climbing. Although evidence supports the effectiveness of stair interventions in public settings, less support is provided for worksites.
Am J Prev Med 2017;52(1):106–114.

CONTEXT

Significant health benefits, such as reducing the risk of cardiovascular disease and other chronic conditions, including obesity, diabetes, some forms of cancer, and osteoarthritis, can be achieved by engaging in moderate to vigorous physical activity throughout the day.[1] Yet, physical inactivity is widespread; only 49.1% of American adults[2] and 52.5% of Canadian adults engage in regular moderate-intensity physical activity.[3] Physical inactivity can be partially attributed to cultural and societal influences associated with decreased daily energy expenditure, including the reduction in occupational physical activity, greater use of automated transportation, and increase in energy-saving devices.[4,5] One strategy to increase energy expenditure is accumulating regular physical activity across multiple short bouts throughout the day.

Taking the stairs is a practical form of daily moderate to vigorous physical activity. Unlike structured exercise and sports, stair use does not require specialized gear and can be easily incorporated into one's daily routine. Stair use has been recommended to the general public, as it has been associated with a number of health benefits, including improved maximal aerobic capacity,[6] reduced low-density lipoprotein cholesterol,[7,8] improved body composition,[9] and muscle strengthening.[10] Moreover, stair ascent is considered a vigorous physical activity, equivalent to running at a pace of approximately 9.6 km/hour.[11] As such, stair use represents a well-rounded form of moderate to vigorous physical activity that is easily accessible to the general public and populations at risk of

From the Faculty of Physical Education and Recreation, University of Alberta, Alberta, Canada

Address correspondence to: Cally A. Jennings, PhD, Faculty of Physical Education and Recreation, University Hall, University of Alberta, Alberta, T6G 2H9, Canada. E-mail: cally1@ualberta.ca.

0749-3797/$36.00
http://dx.doi.org/10.1016/j.amepre.2016.08.014

ill health such as sedentary, overweight, and individuals with low fitness levels.

Increasing stair use is an important public health initiative. As such, a number of stair use interventions have been conducted to date. Stair use interventions have been highly varied in the approaches and methods used to promote stair use, and the settings in which they are conducted. Previous reviews have assessed the effectiveness of various stair use interventions,[12–19] such as point-of-choice prompts[15] and changes to the environment,[16] in specific intervention settings, such as workplaces[17,19] and shopping malls.[18] A recent systematic review examined stair use interventions in worksites and public settings published before June 2013.[20] The review provided a summary of the effectiveness of interventions and examined components that contributed to effectiveness.[20] It demonstrated the effectiveness of stair use interventions in both public and workplace settings; however, the evidence was stronger for public settings. Evidence also supported greater effectiveness in worksites when posters consisted of a combination of motivational and directional messaging. The previous review suggests the need for process evaluation of stair use interventions. The current paper seeks to expand upon the previous systematic review's findings by providing an updated review and further exploring key difference in intervention components that may influence effectiveness through a qualitative synthesis of stair interventions.

EVIDENCE ACQUISITION

Search Strategy and Study Selection

To identify stair interventions, two of the researchers and a health science librarian developed tailored search strategies for nine electronic databases: PubMed, Sport Discus, Web of Science, Environment Complete, CINAHL, Trial Register of Promoting Health Interventions, Embase, Scopus, and PsycINFO. To locate potential studies a combination of the following search terms were used: *stair**, *climb**, *use*, *take*, *taking*, *utiliz**, *ustilis**, *environment**, *architectur**, *poster*, *posters*, *prompt**, *reminder**, *email**, *messag**, *banner**, *persuad**, *persuasion*, *motivat**, *promot**, *sign**, *campaign**, *point of choice*, *incentive**, *elevator**, *escalator**. The original search strategy was conducted in December 2013, with an updated search undertaken in July 2015. Search results were imported into EndNote (bibliographic software). Reference lists of all relevant review articles were manually searched to identify any additional articles.[12,14,15,17,18] The systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines.[21]

Eligibility Criteria and Screening

Articles considered for inclusion were limited to peer-reviewed journal articles written in the English language and published between January 1990 and July 2015. Additional inclusion criteria were:

1. stair use (ascent and descent) or stair climbing (ascent only) included as a primary outcome behavior;
2. elevator, escalator, or moving stairway used as the comparison behavior;
3. a quantitative assessment of the outcome behavior undertaken before the intervention was implemented and at a later time-point when the intervention was still in progress; and
4. data presented to determine if intervention was significant versus baseline.

Articles were limited to adult samples (aged $\geq$18 years), and studies that did not clearly describe intervention design and results were excluded upon agreement of two independent researchers.

Once imported into Endnote, duplicate articles were removed. Two researchers screened the remaining articles using the inclusion criteria. Initially, articles were screened based on title and abstract. For the remaining articles, the full text was examined to identify the final selection of articles that met the inclusion criteria.

Data Extraction

Two researchers independently coded each article in the final sample; any discrepancies were discussed until consensus in coding was reached. A coding framework was developed to meet the requirements of the current review. Prior to commencing coding, the framework was pilot tested and revised. The coding framework extracted data on study characteristics, intervention characteristics, and intervention results. Methodologic quality was assessed according to an adapted protocol described by Downs and Black.[22] This protocol examines the methodologic quality of both randomized and non-randomized health intervention studies. The modified version used in the current review included 26 of the original 27 items, which assess the quality of reporting, external validity, internal validity for measurement bias, and internal validity for selection bias. The maximum score possible was 27 points, with higher scores indicating higher study quality.

For studies that included more than one intervention arm or the intervention was conducted in more than one location, each intervention arm/location that met the inclusion criteria was coded as a separate study. If studies included more than one intervention phase, these were coded as one study and results separated as Phase 1 and 2. For studies consisting of only one phase, where there was more than one measurement period, the measurement conducted most proximal to the intervention period defined was used as the intervention measure. Additionally, the final measurement period following the removal of the intervention was defined as the follow-up measure. The main outcome was defined as stair use (ascent and descent combined), stair ascent only, or stair ascent plus descent measured and reported separately. If studies reported multiple forms of stair measurement, stair ascent was selected as the main outcome to determine effectiveness. Stair outcome measures were extracted as the percentage of stair use/climbing compared with elevator/escalator/moving walkway at baseline, intervention (Phase 1 and 2), and follow-up. If studies reported percentages for subgroups only (e.g., by sex), the authors followed the procedure recommended by Dolan et al.[23] to calculate the overall mean percentage of stair use/climbing.

If percentages were not reported, ORs were extracted to provide sufficient information to determine if the intervention significantly improved stair use/climbing. Intervention results were then classified as significant or not significant for each of the specified measurement periods. Owing to the heterogeneity across studies, a meta-analysis was deemed inappropriate for the purpose of this review. A recent systematic review undertook a comprehensive quantitative synthesis of stair use intervention findings that included articles published prior to June 2013.[20] The focus of the aforementioned review was on the synthesis of results; therefore, the authors sought to complement their work by further exploring and focusing on a qualitative description of intervention characteristics, including methods and intervention components employed throughout interventions and the potential influence on effectiveness of stair use/climbing interventions.

EVIDENCE SYNTHESIS

The results of the two search strategies yielded 2,136 unique articles (Figure 1). Following the initial screening procedure, full text was obtained for 206 potentially relevant articles. Eligibility assessment identified 54 articles[13,24–75] that fulfilled the inclusion criteria of the systematic review. One article included four,[47] two included three,[31,53] and five contained two, distinct studies,[39,42,49,56,68] resulting in the final sample of 67 studies. Median quality score was 16, ranging from 13 to 21 of a possible 27 (Appendix 1, available online). Studies scored moderately well on most aspects, including reporting (median, 6 of a possible 10), external validity (median, 2 of a possible 3), measurement bias (median, 5 of a possible 7), and confounding bias (median, 3 of a possible 6).

Study Characteristics

Studies were conducted between 1995 and 2015; the majority (n=30) were conducted in the United Kingdom, followed by 15 in the U.S.; four in Belgium; three in Hong Kong and the Netherlands; two in Australia, Denmark, and Japan; and one each in Germany, Iran, Singapore, South Africa, Spain, and Turkey. Intervention designs ranged from 3 days to 2 years, with the actual intervention period varying greatly. Although the majority of studies included one intervention phase (n=38), studies also involved two (n=24), three (n=2), and four (n=1) intervention phases. Follow-up measures were included in 24 of 67 studies.

Studies were mainly conducted in public sites (75%, n=50) and less frequently in worksite settings (21%, n=14). The remaining studies used a combination of worksite and public settings (4%, n=3). The most commonly utilized public setting was public transit (48%, n=24), followed by shopping malls (30%, n=15), universities (18%, n=9), and other settings (4%, n=2). The most common worksite settings were office buildings, which were targeted in 12 (86%) of the 14 worksite studies, one of which used a combination of office and university buildings. The remaining two studies (14%) specifically targeted employees in university settings. Finally, the three studies that used a combination of worksite and public settings were implemented in hospitals, which have a dynamic mix of employees and general public and therefore could not be separated in terms of worksite or public settings. According to the domain in which stair use/climbing was targeted, the most common was workplace activity (39%, n=26), followed by transit (36%, n=24), leisure (24%, n=16), and other (1%, n=1).

Settings most often compared stair use/climbing to escalators (60%, n=40), followed by elevators (40%, n=27). The majority reported results for stair climbing alone (69%, n=46), seven studies reported separate results for stair climbing and stair descent (10%), and the remaining reported result for stair use (combined ascent and descent; 21%, n=14). This resulted in a total of 73% (n=49) providing results for the effectiveness of stair climbing as the main outcome. Height of the building used for intervention delivery was coded as number of floors; 64 studies provided information to code this variable. The majority of interventions were delivered in settings with two or more floors (55%, n=35); the remaining were delivered in settings targeting a single floor (one flight or an incline of 12 steps). The method for measuring stair use/climbing was predominately through direct observation (82%, n=55), followed by counting machines (10%, n=7) and by video recording (7%, n=5). Appendix Table 1 (available online) outlines study characteristics in detail.

Intervention Characteristics

Studies used varying approaches to increase stair use/climbing (Appendix Table 2, available online). The majority used a simple strategy (defined as the use of signs only or a single strategy) to promote stair use/climbing (88%, n=59), whereas the remainder used multiple strategies (e.g., point-of-choice-prompts and environmental changes). Signs were used in all but one of the interventions using a single approach, with role modeling being the strategy used in the remaining study. The types of signs used consisted of posters and stair banners: 46 studies used posters, nine used stair banners, and three used both posters and stair banners. For the eight studies that included multiple strategies to promote stair use/climbing, signs were used in all eight studies. In three studies, a combination of posters and built environment strategies were used. Specifically, these consisted of posters and artwork; posters, artwork, and music; and posters, stair banners, and stairwell aesthetics. A further

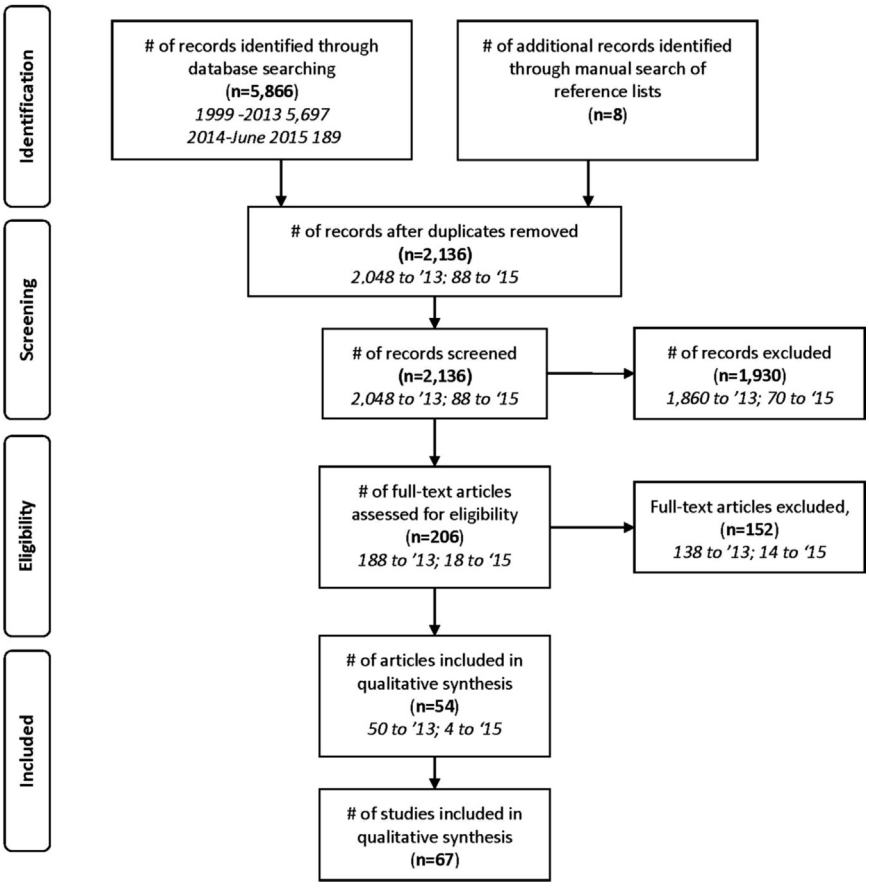

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses flowchart demonstrating study selection process.

three combined posters with an event designed to promote stair climbing, one of which also included leaflets. A single study combined the use of posters with an event to promote stair use/climbing and the final study used a combination of posters, stair banners, printed materials, and website promotion as their strategies.

Information to determine the number of messages used in each study was extracted for 60 studies. Based on the information presented in the remaining 60 studies, the mean number of messages used was 4.4 (SD=8.1). The minimum and most frequently reported number of messages being one (n=26), followed by two (n=13), and three (n=6), with the highest being 48 (n=1). Seven of the 60 studies used ten or more messages. The size of signage used (including posters, stair banners, and other printed material) was reported in 47 studies, 36 of which reported using one size sign; the remaining studies used two (n=9) and three (n=2) different sizes for their signage. Sizes were recoded to meet the International Standard Paper Size A Series. Actual sizes are presented in Appendix Table 2 (available online); for in-text reporting, these have been converted into small (A5–A2 or equivalent), medium (A1–A0 or equivalent), and large (larger than A0 size). Of the 47 studies, use of small-sized signs were reported in 19 and was the sole size used in eight of these; medium-sized signs were used in 27 studies and was used solely in 24; large-sized signs were used in four and in all cases was the only size reportedly used.

The authors extracted the type of poster content in terms of text and image use for 38 studies. According to data reported, the majority combined the use of text and image (68%, n=26) and the remainder (38%, n=12) used text only. Content of messages was designed to target different individual motivations for stair use/climbing. Message content from 65 studies was summarized into six categories, including health, time, energy expenditure (in reference to caloric expenditure), weight, fitness, and other. In 28 studies, messages were categorized as having a single motivational target (health, n=17; energy expenditure, n=6; time, n=1; and other, n=4). The remaining 37 studies targeted two (n=26), three (n=6), and four (n=4) categories, with only one study targeting all five categories (excluding "other"). In total, 119 message targets were extracted from the 65 studies;

health-based motivation was the most frequently reported message target used in 68% of the studies (*n*=44), followed by energy expenditure (45%, *n*=29), fitness (25%, *n*=16), weight (20%, *n*=13), time (19%, *n*=13), and messages coded as other (8%, *n*=5).

Intervention Effectiveness

For all 67 studies, intervention effectiveness could be determined for at least one phase, which was labeled Phase 1; in a further 26 studies, effectiveness was determined for Phase 2. Finally, 23 studies reported effectiveness for a follow-up measure (Appendix 2, available online). For Phase 1, some 48 of 67 studies (72%) reported significant improvements in stair use (*n*=10 of 14) and climbing (*n*=38 of 53). In Phase 2, some 24 of 26 studies (92%) reported significant improvements in stair use (*n*=6 of 7) and stair climbing (*n*=18 of 19). For the follow-up measure, 17 (74%) reported significant improvements in stair use (*n*=5 of 7) and stair climbing (*n*=12 of 16). This resulted in a total of 116 study phases reporting data, and 89 (77%) reporting significant improvements in stair use (79%, *n*=26 of 33) and climbing (76%, *n*=63 of 83).

To examine potential influences on intervention effectiveness, results for Phases 1 and 2 were separated and treated as separate study arms. Therefore, for this section, the results of 93 study arms are considered. Overall, 77% (*n*=72) reported a significant increase in stair use (76%, *n*=16 of 21) or stair climbing (78%, *n*=56 of 72). The following results are presented with stair use and stair climbing outcomes combined to describe effectiveness. Eighty-eight studies could be categorized as public (*n*=70) or worksite (*n*=18); among interventions conducted in a public setting, 80% reported significant improvements. Significant improvements were also reported in 67% of studies conducted in worksite settings. Of the 92 studies that could be classified into one domain, studies reporting effectiveness were highest for leisure (84%, *n*=21 of 25), followed by transit (81%, *n*=26 of 32) and work (29%, *n*=24 of 35). For the alternative to stair use, 82% of studies comparing escalators reported a significant improvement (*n*=46 of 56) compared with 70% of studies that compared stairs with elevators (*n*=26 of 37). When comparing these according to setting, however, all of the worksite studies compared the choice of stairs with an elevator, of which 67% reported significant improvements (*n*=12 of 18). The majority of studies were conducted in public settings, compared stair use with escalators, and reported significant improvements (80%, *n*=56 of 70). Of these studies, 82% (*n*=46 of 56) comparing stair use with escalators versus 71% (*n*=10 of 14) of those comparing stair use with elevators reported significant improvements. In the 87 studies in which information was provided to code floors in the intervention building, effectiveness for studies that targeted settings with one floor (79%, *n*=30 of 38) was similar to studies targeting settings with more than one floor (78%, *n*=38 of 49).

A similar number of studies reported effectiveness that used a single strategy (76%, *n*=61 of 80) or multiple strategies (85%, *n*=11 of 13) to increase stair use. For the 84 studies that reported data for messages, similar percentages of studies reported significant improvements for the use of one (77%, *n*=27 of 35) or two to ten messages (76%, *n*=32 of 42), with all but one study[13] reporting significant improvements when using ten or more messages (86%, *n*=6 of 7). The number of studies reporting significant improvements in stair use was similar when looking at the differences in poster sizes used (small, 68%; medium, 76%; large, 75%; mixed size, 80%). Of the 52 studies from which data were extracted, studies that used text and images on their signage more often reported significant improvements than studies that used text-based signs only (89%, *n*=32 of 36 vs 75%, *n*=12 of 16). Finally, for messages displayed on intervention material, 90 studies reported content that could be categorized. As some signs included messages targeting more than one category, messages were separated and coded into each category they targeted. This resulted in a total of 154 messages coded into categories. Intervention material that targeted time and fitness most often reported effectiveness (88%, *n*=15 of 17 and 85%, *n*=17 of 20, respectively), followed by health (78%, *n*=49 of 63), weight (72%, *n*=13 of 18), and energy expenditure (69%, *n*=25 of 36).

DISCUSSION

This review aimed to summarize the effectiveness of stair interventions and explore differences in intervention components and their subsequent influence on effectiveness. The findings demonstrate that although the majority of interventions promoting the use of stairs were effective, results varied according to intervention setting and characteristics.

Similar support was found for both studies that examined stair climbing specifically and those that measured overall stair use. This is similar to the findings of Bellicha and colleagues,[20] who found that among workplaces specifically, studies that measured stair use reported positive effects more often than studies measuring stair climbing. They also determined that the median increase in stair use and climbing was similar between settings. The current results appear to support interventions conducted in public settings and stair interventions that targeted the leisure and transit

domains of physical activity. However, these results should be interpreted with caution, as the evidence also showed that studies comparing stair use with escalators versus elevators more commonly reported effectiveness. Furthermore, escalators were only used as the comparison behavior in public settings. Therefore, it would not be advised to link the effectiveness of public settings compared with workplaces. It is, however, clear that the evidence supports the effectiveness of stair interventions in public settings.

The support for effectiveness in public settings is not surprising, and has been reported in previous reviews.[15,17,20] The most recent review conducted by Bellicha et al.[20] reports results similar to the current review in that, although public settings received greater support, support was still provided for interventions conducted in worksite settings. It should be noted that in the current review, a number of worksite studies were excluded in the final screening process because their study design compared pre- and post-stair use at an individual level opposed to frequency of stair use in comparison to elevator/escalators, which is the common study design in public settings.[76–78] Additionally, as noted, where public settings only compared stair use with escalators, worksites included a mix of escalators and elevators as their comparison behavior to stair climbing. This is an important distinction, as research highlights the proximity of stairwells to elevators in worksites is often a greater distance compared with public settings, where stairwells are primarily situated adjacent to escalators.[12] These environmental differences may have an impact on the effectiveness of stair climbing interventions.

Among the examined intervention characteristics, the strongest support was found for studies that used a combination of text and images on their signage, used time- and fitness-based motivational messaging, included stair banners when using a simple strategy, and used medium, large, or a variety of sign sizes. Perhaps the most noteworthy finding is related to the motivational messaging used. Health-based messages are the most frequently used message types; however, it appears that time- and fitness-based messages are more effective in producing behavior change. The support provided for time-based messages as the motivational target to prompt stair use fits within the theme of public settings, particularly within public transit and university settings. In this context, time-based messages may appeal to the target audience who will mostly be commuters or university staff/students focused on getting from Point A to Point B in a timely and efficient manner. As was the case in a number of the studies, time-based messages could be included in addition to other benefits, such as health and fitness. Therefore, it is important to consider intervention settings when selecting strategies, intervention material, and content such as messages.

Limitations

The findings should be interpreted with caution, as there are several limitations of the current review. Given the variability in settings, design, and characteristics of the included studies, neither a meta-analysis nor a quantitative analysis of the results was conducted. Rather, a qualitative synthesis was undertaken; therefore, any interpretation of the effectiveness of interventions should be interpreted within this context. Additionally, only published peer-reviewed journal articles written in English were included. As such, the results may be subject to publication bias and are not generalizable across studies published in languages other than English. Although every precaution was taken to code data accurately and consistently, this was limited within the scope of the information provided in the original articles. Finally, included studies mostly used a time series design with no true control group; this is the most pragmatic design for the studies being reviewed.

CONCLUSIONS

Overall, the results demonstrate that the majority of interventions report significant improvements in stair use. Evidence supports the effectiveness of stair interventions in public settings; however, support remains limited for worksite settings. Further exploration of study design and characteristics that lend themselves to higher rates of effectiveness include multiple intervention strategies and using medium to large signs with text and images, as well as time-based motivational messages. Strategies used should be selected to specifically match the desired setting.

ACKNOWLEDGMENTS

We would like to thank research librarian, Linda Slater, for her contribution to this review. This research was undertaken on behalf of the UWALK program. UWALK is a physical activity promotion program developed by the Faculty of Physical Education and Recreation, University of Alberta, in partnership with the Alberta Centre for Active Living and a multitude of partners. Funding has been provided by the Government of Alberta. We thank the UWALK team past and present for their valuable contribution to this research.

No financial disclosures were reported by the authors of this paper.

SUPPLEMENTAL MATERIAL

Supplemental materials associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.amepre.2016.08.014.

REFERENCES

1. Warburton DE, Nicol CW, Bredin SS. Health benefits of physical activity: the evidence. *Can Med Assoc J*. 2006;174(6):801–809. http://dx.doi.org/10.1503/cmaj.051351.
2. Haskell WL, Lee IM, Pate RR, et al. Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Med Sci Sports Exerc*. 2007;39(8):1423–1434. http://dx.doi.org/10.1249/mss.0b013e3180616b27.
3. Colley RC, Garriguet D, Janssen I, et al. Physical activity of Canadian children and youth: accelerometer results from the 2007 to 2009 Canadian Health Measures Survey. *Health Reports*. 2011;22(1):15–23.
4. Foster C, Hillsdon M. Changing the environment to promote health-enhancing physical activity. *J Sports Sci*. 2004;22(8):755–769 http://dx.doi.org/10.1080/02640410410001712458.
5. Owen N, Healy GN, Matthews CE, Dunstan DW. Too much sitting: the population health science of sedentary behavior. *Exerc Sport Sci Rev*. 2010;38(3):105–113. http://dx.doi.org/10.1097/JES.0b013e3181e373a2.
6. Donath L, Faude O, Roth R, Zahner L. Effects of stair-climbing on balance, gait, strength, resting heart rate, and submaximal endurance in healthy seniors. *Scand J Med Sci Sports*. 2014;24(2):e93–e101. http://dx.doi.org/10.1111/sms.12113.
7. Boreham CA, Kennedy RA, Murphy MH, et al. Training effects of short bouts of stair climbing on cardiorespiratory fitness, blood lipids, and homocysteine in sedentary young women. *Br J Sports Med*. 2005;39(9):590–593. http://dx.doi.org/10.1136/bjsm.2002.001131.
8. Boreham CA, Wallace WF, Nevill A. Training effects of accumulated daily stair-climbing exercise in previously sedentary young women. *Prev Med*. 2000;30(4):277–281. http://dx.doi.org/10.1006/pmed.2000.0634.
9. Meyer P, Kayser B, Kossovsky MP, et al. Stairs instead of elevators at workplace: cardioprotective effects of a pragmatic intervention. *Eur J Cardiovasc Prev Rehabil*. 2010;17(5):569–575. http://dx.doi.org/10.1097/HJR.0b013e328338a4dd.
10. Loy SF, Conley LM, Sacco ER, et al. Effects of stairclimbing on VO2max and quadriceps strength in middle-aged females. *Med Sci Sports Exerc*. 1994;26(2):241–247. http://dx.doi.org/10.1249/00005768-199402000-00016.
11. Teh KC, Aziz AR. Heart rate, oxygen uptake, and energy cost of ascending and descending the stairs. *Med Sci Sports Exerc*. 2002;34(4):695–699. http://dx.doi.org/10.1097/00005768-200204000-00021.
12. Eves FF, Webb OJ. Worksite interventions to increase stair climbing; reasons for caution. *Prev Med*. 2006;43(1):4–7. http://dx.doi.org/10.1016/j.ypmed.2006.03.011.
13. Adams J, White M. A systematic approach to the development and evaluation of an intervention promoting stair use. *Health Educ J*. 2002;61(3):272–286. http://dx.doi.org/10.1177/001789690206100308.
14. 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(suppl 4):73–107. http://dx.doi.org/10.1016/S0749-3797(02)00434-8.
15. 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(suppl 2):S292–S300. http://dx.doi.org/10.1016/j.amepre.2009.10.028.
16. Zimring C, Joseph A, Nicoll GL, Tsepas S. Influences of building design and site design on physical activity: research and intervention opportunities. *Am J Prev Med*. 2005;28(suppl 2):186–193. http://dx.doi.org/10.1016/j.amepre.2004.10.025.
17. Nocon M, Müller-Riemenschneider F, Nitzschke K, Willich SN. Increasing physical activity with point-of-choice prompts—a systematic review. *Scand J Public Health*. 2010;38(6):633–638. http://dx.doi.org/10.1177/1403494810375865.
18. Webb OJ, Eves FF, Kerr J. A statistical summary of mall-based stair-climbing interventions. *J Phys Act Health*. 2011;8(4):558–565.
19. Dugdill L, Brettle A, Hulme C, McCluskey S, Long A. Workplace physical activity interventions: a systematic review. *Int J Workplace Health Manag*. 2008;1(1):20–40. http://dx.doi.org/10.1108/17538350810865578.
20. Bellicha A, Kieusseian A, Fontvieille AM, et al. Stair-use interventions in worksites and public settings—a systematic review of effectiveness and external validity. *Prev Med*. 2015;70:3–13. http://dx.doi.org/10.1016/j.ypmed.2014.11.001.
21. Moher D, Liberati A, Tetzlaff J, Altman DG, PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Ann Intern Med*. 2009;151(4):264–269. http://dx.doi.org/10.7326/0003-4819-151-4-200908180-00135.
22. Downs SH, Black N. The feasibility of creating a checklist for the assessment of the methodological quality both of randomised and non-randomised studies of health care interventions. *J Epidemiol Community Health*. 1998;52(6):377–384, W264. http://dx.doi.org/10.1136/jech.52.6.377.
23. Dolan MS, Weiss LA, Lewis RA, et al. 'Take the stairs instead of the escalator': effect of environmental prompts on community stair use and implications for a national 'small steps' campaign. *Obes Rev*. 2006;7(1):25–32. http://dx.doi.org/10.1111/j.1467-789X.2006.00219.x.
24. Adams MA, Hovell MF, Irvin V, et al. Promoting stair use by modeling: an experimental application of the behavioral ecological model. *Am J Health Promot*. 2006;21(2):101–109. http://dx.doi.org/10.4278/0890-1171-21.2.101.
25. Aksay E. Do simple warning signs enhance the use of stairs? *Health Educ J*. 2014;73(6):683–692. http://dx.doi.org/10.1177/0017896913511810.
26. Andersen RE, Franckowiak SC, Snyder J, Bartlett SJ, Fontaine KR. Can inexpensive signs encourage the use of stairs? Results from a community intervention. *Ann Intern Med*. 1998;129(5):363–369. http://dx.doi.org/10.7326/0003-4819-129-5-199809010-00003.
27. Andersen RE, Franckowiak SC, Zuzak KB, et al. Effects of a culturally sensitive sign on the use of stairs in African American commuters. *Soz Praventivmed*. 2006;51(6):373–380. http://dx.doi.org/10.1007/s00038-006-5095-5.
28. Andersen RE, Bauman AE, Franckowiak SC, Reilley SM, Marshall AL. Prompting health professionals to be activity role models—motivating stair use at the 2001 ACSM Scientific Meeting. *J Phys Act Health*. 2008;5(4):607–618.
29. Auweele YV, Boen F, Schapendonk W, Dornez K. Promoting stair use among female employees: the effects of a health sign followed by an e-mail. *J Sport Exerc Psychol*. 2005;27(2):188–196.
30. Blamey A, Mutrie N, Tom A. Health promotion by encouraged use of stairs. *BMJ*. 1995;311(7000):289–290. http://dx.doi.org/10.1136/bmj.311.7000.289.
31. Boen F, Maurissen K, Opdenacker J. A simple health sign increases stair use in a shopping mall and two train stations in Flanders, Belgium. *Health Promot Int*. 2010;25(2):183–191. http://dx.doi.org/10.1093/heapro/daq001.
32. Boutelle KN, Jeffery RW, Murray DM, Schmitz MKH. Using signs, artwork, and music to promote stair use in a public building. *Am J Public Health*. 2001;91(12):2004–2006. http://dx.doi.org/10.2105/AJPH.91.12.2004.
33. 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.
34. Cooley PD, Foley SJ, Magnussen CG. Increasing stair usage in a professional workplace: a test of the efficacy of positive and negative message prompts to change pedestrian choices. *Health Promot J Austr*. 2008;19(1):64–67. http://dx.doi.org/10.1071/HE08064.

35. Dorresteijn JAN, van der Graaf Y, Zheng K, Spiering W, Visseren FLJ. The daily 10 kcal expenditure deficit: a before-and-after study on low-cost interventions in the work environment. *BMJ Open*. 2013;3(1), http://dx.doi.org/10.1136/bmjopen-2012-002125.
36. Eckhardt MR, Kerr J, Taylor WC. Point-of-decision signs and stair use in a university worksite setting: general versus specific messages. *Am J Health Promot*. 2015;29(5):291–293. http://dx.doi.org/10.4278/ajhp.120816-ARB-398.
37. Eves FF, Webb OJ, Mutrie N. A workplace intervention to promote stair climbing: greater effects in the overweight. *Obesity*. 2006;14(12):2210–2216. http://dx.doi.org/10.1038/oby.2006.259.
38. Eves FF, Masters RS. An uphill struggle: effects of a point-of-choice stair climbing intervention in a non-English speaking population. *Int J Epidemiol*. 2006;35(5):1286–1290. http://dx.doi.org/10.1093/ije/dyl141.
39. Eves FF, Masters R, Mcmanus A, et al. Contextual barriers to lifestyle physical activity interventions in Hong Kong. *Med Sci Sports Exerc*. 2008;40(5):965–971. http://dx.doi.org/10.1249/MSS.0b013e3181659c68.
40. Eves FF, Olander EK, Nicoll G, Puig-Ribera A, Griffin C. Increasing stair climbing in a train station: the effects of contextual variables and visibility. *J Environ Psychol*. 2009;29(2):300–303. http://dx.doi.org/10.1016/j.jenvp.2008.10.002.
41. 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. *Psychol Sport Exerc*. 2012;13(2):170–176. http://dx.doi.org/10.1016/j.psychsport.2011.11.002.
42. Eves FF, Webb OJ, Griffin C, Chambers J. A multi-component stair climbing promotional campaign targeting calorific expenditure for worksites; a quasi-experimental study testing effects on behaviour, attitude and intention. *BMC Public Health*. 2012;12(1), http://dx.doi.org/10.1186/1471-2458-12-423.
43. Ford MA, Torok D. Motivational signage increases physical activity on a college campus. *J Am Coll Health*. 2008;57(2):242–244. http://dx.doi.org/10.3200/jach.57.2.242-244.
44. Grimstvedt ME, Kerr J, Oswalt SB, et al. Using signage to promote stair use on a university campus in hidden and visible stairwells. *J Phys Act Health*. 2010;7(2):232–238.
45. Howie EK, Deborah Rohm Y. Step It UP: a multicomponent intervention to increase stair use in a university residence building. *Am J Health Promot*. 2011;26(1):2–5. http://dx.doi.org/10.4278/ajhp.091106-ARB-357.
46. Iversen MK, Händel MN, Jensen EN, Frederiksen P, Heitmann BL. Effect of health-promoting posters placed on the platforms of two train stations in Copenhagen, Denmark, on the choice between taking the stairs or the escalators: a secondary publication. *Int J Obes*. 2007;31(6):950–955. http://dx.doi.org/10.1038/sj.ijo.0803497.
47. 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. http://dx.doi.org/10.1348/135910701169296.
48. Kerr J, Eves F, Carroll D. Encouraging stair use: stair-riser banners are better than posters. *Am J Public Health*. 2001;91(8):1192–1193. http://dx.doi.org/10.2105/AJPH.91.8.1192.
49. Kerr J, Eves F, Carroll D. Can posters prompt stair use in a worksite environment? *J Occup Health*. 2001;43(4):205–207. http://dx.doi.org/10.1539/joh.43.205.
50. Kerr J, Eves F, Carroll D. Six-month observational study of prompted stair climbing. *Prev Med*. 2001;33(5):422–427. http://dx.doi.org/10.1006/pmed.2001.0908.
51. Kerr J, Eves FF, Carroll D. Getting more people on the stairs: the impact of a new message format. *J Health Psychol*. 2001;6(5):495–500. http://dx.doi.org/10.1177/135910530100600503.
52. Kwak L, Kremers SPJ, van Baak MA, Brug J. A poster-based intervention to promote stair use in blue- and white-collar worksites. *Prev Med*. 2007;45(2-3):177–181. http://dx.doi.org/10.1016/j.ypmed.2007.05.005.
53. Lee KK, Perry AS, Wolf SA, et al. Promoting routine stair use: evaluating the impact of a stair prompt across buildings. *Am J Prev Med*. 2012;42(2):136–141. http://dx.doi.org/10.1016/j.amepre.2011.10.005.
54. Lewis A, Eves F. Specific effects of a calorie-based intervention on stair climbing in overweight commuters. *Ann Behav Med*. 2011;42(2):257–261. http://dx.doi.org/10.1007/s12160-011-9283-z.
55. Lewis A, Eves F. Prompt before the choice is made: effects of a stair-climbing intervention in university buildings. *Br J Health Psychol*. 2012;17(3):631–643. http://dx.doi.org/10.1111/j.2044-8287.2011.02060.x.
56. Lewis AL, Eves FF. Prompts to increase stair climbing in stations: the effect of message complexity. *J Phys Act Health*. 2012;9(7):954–961.
57. Lewis AL, Eves FF. Testing the theory underlying the success of point-of-choice prompts: a multi-component stair climbing intervention. *Psychol Sport Exerc*. 2012;13(2):126–132. http://dx.doi.org/10.1016/j.psychsport.2011.10.001.
58. 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. http://dx.doi.org/10.1093/her/17.6.743.
59. Moghaddam KS, Farahani A, Shahbazi M. Can health-promoting posters increase stair climbing instead of using escalators? *Soc Sci*. 2011;6(6):507–512. http://dx.doi.org/10.3923/sscience.2011.507.512.
60. Müller-Riemenschneider F, Nocon M, Reinhold T, Willich SN. Promotion of physical activity using point-of-decision prompts in Berlin underground stations. *Int J Environ Res Public Health*. 2010;7(8):3063–3070. http://dx.doi.org/10.3390/ijerph7083063.
61. Nomura T, Yoshimoto Y, Akezaki Y, Sato A. Changing behavioral patterns to promote physical activity with motivational signs. *Environ Health Prev Med*. 2009;14(1):20–25. http://dx.doi.org/10.1007/s12199-008-0053-x.
62. Nomura T, Katayama K, Kashiwa T, Akezaki Y, Sato A. Maintenance of the rate of stair use over a long-term period using a stair climbing campaign. *J Occup Health*. 2014;56(6):511–518. http://dx.doi.org/10.1539/joh.13-0223-FS.
63. Olander EK, Eves FF. Effectiveness and cost of two stair-climbing interventions—less is more. *Am J Health Promot*. 2011;25(4):231–236. http://dx.doi.org/10.4278/ajhp.090325-QUAN-119.
64. Olander EK, Eves FF, Puig-Ribera A. Promoting stair climbing: stair-riser banners are better than posters … sometimes. *Prev Med*. 2008;46(4):308–310. http://dx.doi.org/10.1016/j.ypmed.2007.11.009.
65. Pillay JD, Kolbe-Alexander T, Achmat M, Carstene M, Lambert EV. Are point-of-decision prompts in a sports science and medicine centre effective in changing the prevalence of stair usage? A preliminary study. *S Afr J Sports Med*. 2009;21(2).
66. Puig-Ribera A, Eves FF. Promoting stair climbing in Barcelona: similarities and differences with interventions in English-speaking populations. *Eur J Public Health*. 2010;20(1):100–102. http://dx.doi.org/10.1093/eurpub/ckp059.
67. Russell W, Hutchinson J. Comparison of health promotion and deterrent prompts in increasing use of stairs over escalators. *Percept Mot Skills*. 2000;91(1):55–61. http://dx.doi.org/10.2466/pms.2000.91.1.55.
68. Ryan J, Lyon K, Webb OJ, Eves FF, Ryan CG. Promoting physical activity in a low socioeconomic area: results from an intervention targeting stair climbing. *Prev Med*. 2011;52(5):352–354. http://dx.doi.org/10.1016/j.ypmed.2011.03.004.
69. Sloan RA, Haaland BA, Leung C, Müller-Riemenschneider F. The use of point-of-decision prompts to increase stair climbing in singapore. *Int J Environ Res Public Health*. 2013;10(1):210–218. http://dx.doi.org/10.3390/ijerph10010210.
70. Swenson T, Siegel M. Increasing stair use in an office worksite through an interactive environmental intervention. *Am J Health Promot*. 2013;27(5):323–329. http://dx.doi.org/10.4278/ajhp.120221-QUAN-104.
71. van Nieuw-Amerongen ME, Kremers SPJ, de Vries NK, Kok G. The use of prompts, increased accessibility, visibility, and aesthetics of the stairwell to promote stair use in a university building. *Environ Behav*. 2011;43(1):131–139. http://dx.doi.org/10.1177/0013916509341242.

72. Webb OJ, Eves FF. Promoting stair use: single versus multiple stair-riser messages. *Am J Public Health*. 2005;95(9):1543–1544. http://dx.doi.org/10.2105/AJPH.2004.046235.
73. Webb OJ, Eves FF. Promoting stair climbing: intervention effects generalize to a subsequent stair ascent. *Am J Health Promot*. 2007;22(2):114–119. http://dx.doi.org/10.4278/0890-1171-22.2.114.
74. Webb OJ, Eves FF. Effects of environmental changes in a stair climbing intervention: Generalization to stair descent. *Am J Health Promot*. 2007;22(1):38–44. http://dx.doi.org/10.4278/0890-1171-22.1.38.
75. Webb OJ, Cheng TF. An informational stair climbing intervention with greater effects in overweight pedestrians. *Health Educ Res*. 2010;25(6):936–944. http://dx.doi.org/10.1093/her/cyq043.
76. Graham DJ, Linde JA, Cousins JM, Jeffery RW. Environmental modifications and 2-year measured and self-reported stair-use: a worksite randomized trial. *J Prim Prev*. 2013;34(6):413–422. http://dx.doi.org/10.1007/s10935-013-0323-2.
77. Priebe CS, Spink KS. Less sitting and more moving in the office: using descriptive norm messages to decrease sedentary behavior and increase light physical activity at work. *Psychol Sport Exerc*. 2015;19:76–84. http://dx.doi.org/10.1016/j.psychsport.2015.02.008.
78. Schumacher JE, Utley J, Sutton L, et al. Boosting workplace stair utilization: a study of incremental reinforcement. *Rehabil Psychol*. 2013;58(1):81. http://dx.doi.org/10.1037/a0031764.