# Workplace building design and office-based workers' activity: a study of a natural experiment

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## Abstract

**Objective**: This opportunistic natural study investigated the effects of relocation of office workers from a 30-year-old building to a new purpose-built building. The new building included an attractive central staircase that was easily accessed and negotiated, as well as breakout spaces and a centralised facilities area. The researchers aimed to determine the impact of the purpose-built office building on the office workers' sedentariness and level of physical activity.

**Method**: In 2013, a natural pre-post study was undertaken with office-based workers in their old conventional 1970s building and on relocating to a new purpose-built 'activity permissive' building. Objective movement data was measured using accelerometers. Anthropometric and demographic data was also collected.

**Results**: Forty-two office-based workers significantly decreased their percentage of daily sitting time (T1 = 84.9% to T2=79.7%; $p$<0.001) and increased their percentage of daily standing time (T1=11.2% to T2 17.0%; $p$<0.001) in the new building. Moderate activity significantly declined (T1=3.9% to 3.2%=T2; $p$=0.038). There was a significant decrease in mean minutes of sitting time (19.62 minutes; $p$<0.001) and increase in standing time (22.03 minutes; $p$<0.001).

**Conclusions**: The design of a building can influence activity. This opportunistic study on the impact of workplace relocation on office-based workers' activity showed modest positive outcomes in sitting and standing. Evidence is required to inform building design policy and practice that supports physical activity and reduces levels of sedentariness in the workplace.

**Key words**: workplace, sedentary, physical activity

In recent years, the predominant mode of employment in high-income countries has been office-based,[1] which has resulted in many employees spending the majority of their day completing tasks supported by labour-saving devices and entrenched sedentary work practices.[2] For many office-based workers, occupational sitting time contributes to at least half their daily sitting time, with many sitting for more than three-quarters of their work day.[2-6] A large amount of the total time spent in occupational sitting is accumulated in prolonged bouts of greater than 20 minutes.[4]

The evidence is compelling around the impact of prolonged sitting as a risk factor for diabetes, cardiovascular disease and all-cause mortality,[7-9] with estimates suggesting that about 5.9% of deaths can be attributed to daily sitting time.[9] Researchers estimate that for each hour of sedentary time, there is an increase in the mortality risk by 2%. This risk substantially increases when an individual sits for more than seven hours a day, and increases by 5% for every hour of daily sitting time.[9,10] Although physical activity attenuates the adverse outcomes associated with prolonged sitting, it does not completely counteract the adverse health outcomes.[11]

It is important to note that research also indicates those individuals that accumulate sedentary time with longer uninterrupted bouts have worse metabolic risk factors than those whose sedentary time is interrupted, for example, by some standing and light activity,[12] while shorter sitting times may be protective against all-cause mortality.[10] Therefore, it is important to break up long periods of sitting with intermittent bouts of physical activity to reduce the risk of adverse health outcomes.[13] An international group of experts have recently developed guidelines based on current evidence to promote movement in the workplace, particularly in the office environment. The expert guidelines recommend that full-time desk-based workers stand and do light activity for two hours during the working day, aiming to progress to four hours a day in the longer term.[14] The workplace has a direct influence on the health of employees[15] and building design is increasingly recognised as having an impact on the occupants through how the available space encourages or discourages movement.[16] An activity-supportive physical environment is recognised as one that encourages movement through changes to office layout to promote physical activity:[17,18] standing hot desks and meeting rooms, changing

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Submitted: January 2015; Revision requested: April 2015; Accepted: June 2015

The authors have stated they have no conflict of interest.
*Aust NZ J Public Health*. 2016; 40:78-82; doi: 10.1111/1753-6405.12464

facilities;[19] breakout spaces, sit-to-stand workstations;[13,20-24] and attractive, accessible stairs.[25]

A relatively new but growing research area is that of Active Building Design, which seeks to analyse the drivers of movement in different building layouts to see how buildings might affect incidental physical activity and, conversely, sedentary behaviours. In regards to stairs, point-of–decision prompts have been shown to be effective in encouraging stair use, e.g. signs placed near stairs and lifts.[26,27-30] A limited number of studies have indicated that the location and design of stairs may influence frequency of use, with appeal, convenience, comfort, access and safety being identified as important design factors.[26,31,32] Nicoll[32] suggested that 50% of stair use could be explained by three variables: stairs encountered prior to the lift, area of stair visibility and difficulty reaching the lift.

However, architects' codes and guidelines for the design of office buildings do not take into account the building users' health, and the concept of encouraging users to move more in the work space is not considered. For example, the *Property Council Guide to Office Building Quality (2006)* has clear quality and experience specifications for lift use but none for stairs,[33] while the *National Codes of Construction*[34] prioritises lift performance and neglects to promote stair use.[25]

Evaluating the impact of environmental workplace interventions is challenging,[25,35] and the natural study provides a valid method to better understand the impact of the workplace environment on workers' health.[35] This opportunistic natural study investigated the relocation of office workers from a 30-year-old building to a new purpose-built building that was designed to achieve a Grade A Property Council rating. The organisation requested the contracted architectural firm to include an attractive central staircase that was easily accessed and negotiated; as well as breakout spaces and a centralised facilities area. The researchers aimed to determine the impact of purpose-built office building on the office workers' sedentariness and levels of physical activity.

### *Study setting*

The office-based workplace employed 80 staff and was located in Perth, Western Australia's central business district. The organisation's primary roles are advocacy and service and product agreement negotiations, and it is responsible for policy, marketing, management and accounts. The organisation considers itself a peak industry body that aims to show leadership through actions and policies.

The scheduling of the pre-move (November 2013) and post-move (April 2014) data collection was timed to capture the participants' movement in the old building a month before relocation, and four months after relocating to the new building. The pre-move measurement was timed to gather data before the disruption of packing to leave, while the post-move measurement was timed to avoid the initial few weeks of unpacking and settling in.

**Pre-relocation:** At baseline, the organisation was located in a 30-year-old office building. The floor area was 1,219 m$^2$ in total over two levels (level one and two). The street entry to the building was via a short flight of stairs (8 steps), which led to a small foyer on the ground floor, with the option to go right into the reception or straight ahead to the lifts and fire stairs (see Figure 1), which were located behind a door. On level one, desk furniture was arranged in cellular patterns forming clusters of four desks divided by 1.3 m high partitions.

**Post-relocation:** The new purpose-built building was less than one kilometre from the old building, across one level (level one). The floor space was 1,646 m$^2$. As with the previous building, desk furniture was arranged in a cellular pattern with 1.3 m high partitions. Workspaces were adjacent to windows on the north, south and east sides of the building. There were breakout spaces, centralised facilities (printer, kitchen, and toilets) and a layout providing space that facilitated easy movement within the office space. Entry to the building was via a ground-floor foyer with clear access to a glass-encased open staircase leading up to the first floor and the organisation's office space.

Figure 1: Foyer entrance and stair pre-relocation.

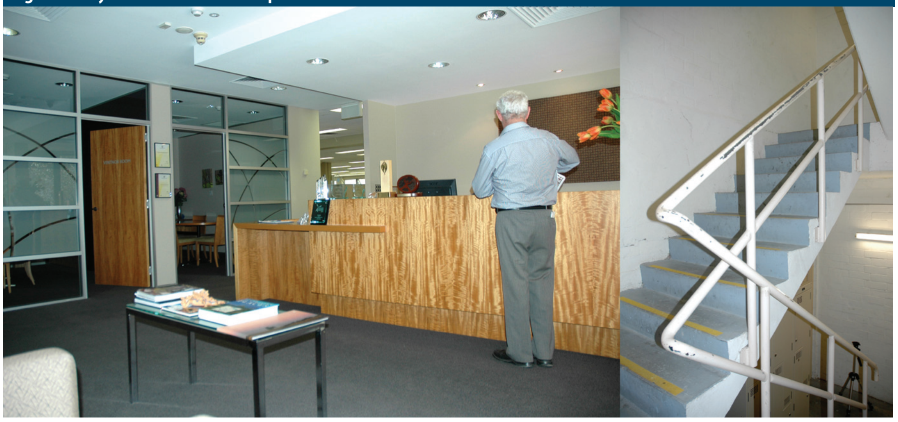
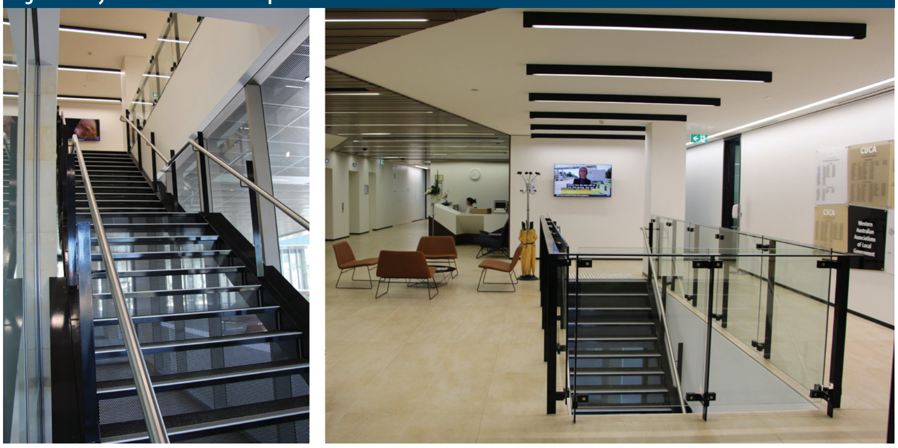


Figure 2: Foyer entrance and stair post-location.



## Methods

### *Study design*

A pre- and post-quantitative survey design with objective measures of physical activity.

### *Participants*

Study participants were required to be: 18 years or older; engaged in full-time or part-time (FTE 0.8) employment; identifying as working in an office-based role; and moving from the old building into the new building. All staff received an invitation to participate via internal email (n=80). Those participants who expressed an interest in the study were sent a plain language statement and consent form (n=67).

### Procedures

Participants completed the online questionnaire and wore an accelerometer for five days (Monday to Friday) on two occasions (pre- and post-relocation). Links to the online questionnaire were sent via email to all participants. A trained researcher fitted the accelerometer and provided instructions for its use on-site. Participants were asked to remove the accelerometer before leaving work each day and were sent a reminder to attach it to their body when they arrived at work each morning.

In return for their participation, at the end of the study, all participants received feedback on their physical activity data and went into a draw for a prize (a Fitbit). The study was approved by the University Human Research Ethics Committee (SPH-34-2012).

### Measures

The online survey[36] collected data on self-reported stair use and demographics, e.g. age, gender and education level. Anthropometric measures were taken by a trained research assistant. *Height* was measured while the participant was barefoot to the nearest 0.1 cm with the Seca 217 Mobile Height Measuring stadiometer. *Weight* was measured (wearing light clothing without shoes) using Tanita BC601 body composition scales and recorded to the nearest 0.01 kg. *BMI* was calculated by weight in kilograms by height in $m^2$. This all followed standard protocol.[37]

Time spent in sedentary activity (sitting); light activity (standing); and moderate and vigorous activity were measured using an ActiGraph GT3X+ accelerometer. Participants wore the device on a belt positioned on the right hip. To be included in the data analysis, participants needed to wear the accelerometer for at least 75% of the day.[38] Accelerometer activity counts were recorded in 10-second epochs and downloaded and managed using ActiLife 6 desktop software. Wear time was validated by excluding periods of consecutive strings of zero-count epochs lasting 60 minutes or longer (non-wear time).[39] Freedson cut points were used to compute sedentary (<100 counts per minute), light (100–1,951 counts per minute), moderate (1,952–5,724 counts per minute) and vigorous activity (5,725+ counts per minute) as in previous studies.[38,40] Accelerometers do not have inclinometers; however, Chau states that "accelerometer cut points for <100 counts per minute (using the Actigraph accelerometer) agrees well with the activPAL for classifying behaviour as sedentary, which suggest the measurement of sitting time".[39] Data files were transformed and total time spent in each activity type was calculated, as well as the proportion of total work time spent sitting (sedentary activity), standing (light activity) and undertaking moderate and vigorous activity.

### Statistical analyses

Statistical analyses were undertaken using SPSS for windows package, version 22.[44] Comparisons between the baseline data and the post-relocation data were performed to determine changes in outcome measures. Paired sample t tests were performed to determine significant changes (statistical significance was set at $p<0.05$) in accelerometer data for physical activity and sedentary behaviour, reporting a mean minute change and a mean change in percentage (95%CI) of total work day spent in different activity types.

## Results

Of the 67 participants who entered the study, 42 (62.7%) completed the pre- and post- data collection. They were predominantly female (64.3%) and worked full time (97.6%), with the majority having a degree (78.6%), see Table 1. Reasons for attrition are attributable to a number of factors, including not being available at the time of the study due to leave (sick, holiday, maternity) and not wanting to participate in the follow-up.

Percentage changes for daily sitting (sedentary), standing (light) and moderate and vigorous activity were assessed. In the new building (T2), the percentage of work time spent sitting significantly decreased (T1 = 84.9% to T2=79.7%; $p<0.001$), while the percentage of time spent standing significantly increased (T1=11.2% to T2 17.03%; $p<0.001$). However moderate activity showed a slight but significant decline (T1=3.8% to 3.2%=T2; $p=0.038$) and vigorous activity showed no change (T1=0.07% to T2=0.06%; $p=0.632$). There was a statistically significant decrease in daily mean minutes of sitting time (19.62 minutes; $p<0.001$) and an increase in standing time (22.03 minutes; $p<0.001$), while there was no change in moderate or vigorous activity (see Table 2). The average length of sedentary bouts (mean minutes) significantly increased (T1=18.56 to T2= 20.99; $p<0.001$), while minimum lengths of sedentary bouts (mean minutes) remained unchanged (T1=10.13 to T2= 10.13 minutes). The maximum length of sedentary bouts (mean minutes) increased significantly (T1=49.88 to T2=60.12; $p=0.006$). Reports indicated no significant change of the number of times stairs were used during a working day (T1=2.97 to T2=3.47; $p=0.257$) or for the levels travelled (T1=3.84 to T2=3.97; $p=0.881$), see Table 2.

## Discussion

Very little research has been conducted into the impact of building design on physical activity and sedentary behaviour of office workers.[25,35] This natural study provided a unique opportunity to review the impact of a new building incorporating design changes (e.g. central staircase) on physical activity and sedentary behaviour of office-based workers. In the new building, the percentage of work time spent in sedentary behaviour (sitting) significantly decreased ($p<0.001$) and the percentage of time spent in light activity (standing) significantly increased ($p<0.001$).

Although modestly encouraging in regards to sitting and standing behaviours, these statistically significant changes need to be considered in the context of the working day. In both the old and new buildings, participants spent on average more than 79% of their work day in sedentary behaviours and less than 17% standing. This is similar to other

**Table 1: Characteristics of the participants (n=42).**

| Characteristics | n (%) |
|---|---|
| **Gender** | |
| Male | 15 (35.7) |
| Female | 27 (64.3) |
| **Education** | |
| High school | 5 (11.9) |
| TAFE/Diploma | 4 (9.5) |
| Degree or higher | 33 (78.6) |
| | **Mean (SD)** |
| **Age (years)** | 40.31 (11.93) |
| **Weight (kg)** | 73.40 (14.79) |
| **Height (cm)** | 170.00 (8.81) |
| **BMI** | 25.37 (4.82) |

*SD = standard deviation*

Table 2: Percentage changes in physical Activity and sedentary behaviour in workplace (n=42).

| Variable | Old building Time 1 % SD | Old building Time 1 95%CI | New building Time 2 % SD | New building Time 2 95%CI | *p* value |
|---|---|---|---|---|---|
| **Intensity level** | | | | | |
| Sedentary | 84.88 (4.71) | 85.52-86.19 | 79.71(5.86) | 77.95-81.46 | <0.001* |
| Light | 11.20 (3.68) | 10.16-12.31 | 17.03 (5.15) | 15.52-18.67 | <0.001* |
| Moderate activity | 3.85 (1.80) | 3.31-4.38 | 3.20 (1.60) | 2.74-3.67 | 0.0038* |
| Vigorous | 0.07 (0.13) | 0.36-0.11 | 0.06 (0.14) | 0.02-0.11 | 0.632 |
| | Mean (SD) | | Mean (SD) | | |
| **Intensity level (min/day)** | | | | | |
| Sedentary | 401.30 (39.45) | 388.10-410.92 | 381.68 (28.01) | 372.81-389.58 | 0.001* |
| Light | 35.13 (12.33) | 31.76-38.78 | 57.16 (17.21) | 52.20-62.52 | <0.001* |
| Moderate | 36.13 (13.53) | 32.56-40.45 | 39.72 (14.80) | 35.34-44.77 | 0.109 |
| Vigorous | 0.33 (0.63) | 0.16-0.54 | 0.29 (0.68) | 0.11-0.53 | 0.658 |
| **Sedentary behaviour (mins)** | | | | | |
| Ave length of bouts | 18.56 (2.61) | 17.79-19.37 | 20.99 (4.65) | 19.71-22.35 | <0.001* |
| Min length of bouts | 10.13 (0.21) | 10.07-10.20 | 10.13 (0.29) | 10.05-10.23 | 0.968 |
| Max length of bouts | 49.88 (15.59) | 45.91-54.78 | 60.12 (23.07) | 53.74-67.18 | 0.006* |
| **Step counts** | | | | | |
| Max step count | 26.07 (10.90) | 23.10-29.55 | 63.60 (7.76) | 60.98-65.60 | <0.001* |
| Steps per minute | 6.82 (2.66) | 6.08-7.63 | 10.28 (3.45) | 9.33-11.37 | <0.001* |
| Steps per day | 3,238.17 (1,310.23) | 2,869.99-3,630.61 | 4,924.99 (1,651.63) | 4,470.93-5,443.86 | <0.001* |
| **Stair use (per day) (n=32)** | | | | | |
| No. of times used | 2.97 (1.66) | 2.42-3.55 | 3.47 (1.48) | 2.93-3.97 | 0.257 |
| Levels travelled | 3.84 (3.76) | 2.55-5.23 | 3.97 (3.83) | 2.87-5.57 | 0.881 |
| % time stairs use | 48.1% | | 63.0% | | |

Australian research with office-based workers showing office workers were very inactive, spending more than 75% of their usual working day in sedentary activities.[4,5]

In addition, the average length and maximum length of sedentary bouts both increased in this study group. One can speculate on the reasons for this. Perhaps the increased sedentary bouts may be because the relocation offered an opportunity for the organisation to reorganise their seating arrangement into work clusters, with the clustering of teams potentially reducing the need to stand to talk to colleagues. Also, the new building comprised large windows, with most workers having views outside that may encourage longer time bouts at desks. It may be that comfortable, convenient spaces contribute to sedentary behaviour and perhaps provide evidence for an argument in support of the 'inconvenient' office[42] – an office that makes one want to move more.

Interestingly, there was an increase in the mean number of steps (T1=3,238 to T2=4,470), which may be due to the substantial increase in floor space in the new building (T1 =1,219 $m^2$ to T2=1,646 $m^2$), increasing the walking distance from desk to print room, kitchen and toilet area. Even if the average number of times that participants took steps to complete their normal workday routine did not change, their step count would increase.

Reports indicated no significant change in the number of times stairs were used during a working day (*p*=0.257) or the floor levels travelled (*p*=0.881). However, it should be acknowledged that the relocation to the new building and the exposure to the central staircase was not supported by any education in regards to the health risks of prolonged sitting, and the health benefits of moving and using the stairs. This research purely measured the impact of the changes to the building design on objective movement patterns. It is possible that an intervention that also incorporated an educational component on the health benefits of standing[43,44] and promoted stair use as an opportunity to increase activity would have supported more positive physical activity-related outcomes.

These findings contribute to the discussion around the impact of structural strategies aimed at increasing physical activity and decreasing sedentary time in office-based workers. This is a relatively small natural study that has methodological limitations, such as no control group (which would be extremely challenging to establish) and potential selection bias. However, the changes in movement patterns are positive and contribute new information to this research area.

The amount of activity completed by participants in this study is a long way from meeting the recently developed expert guidelines that recommend full-time desk-based workers stand and do light activity for two hours during the working day, aiming to progress to four hours a day in the longer term.[14] This further indicates the urgent need for innovative approaches that will support a decrease in sedentary behaviour and an increase in movement in office-based workers.

Very little research has been conducted into the effect of building design on physical activity and sedentary behaviour of workers.[25,35] More research is needed to examine the impact of the office design, so that more evidence can be gathered to strengthen the argument for policy that supports the design of 'buildings for health'. For example, although recognised as the preferred transport choice for health, stair quality, experience and use are not promoted through the *National Codes of Construction*, and the Property Council of Australia *Guide to Office Building Quality* is concerned with lift use, safety and universal access.[25] There is no mention of encouraging stair use, which encourages movement and leads to better health outcomes for office workers in the longer term.

## Conclusion

The office environment is a setting where sedentary behaviour is highly prevalent and where many adults spend the majority of their waking hours. Therefore, it presents an important environment for supporting the modification of employees' activity behaviours. Although this move by office-based workers to a building specifically designed with a central staircase did show statistically significant improvements in sitting and standing, in meaningful terms these changes were less than optimal. There needs to be more research to better understand worksite environments with the long-term view of health professionals, designers and architects working together to create active building designs for office-based workers, supported by appropriate guidelines and codes.

## Acknowledgements

This study was funded by HBF. The funder had no involvement in any aspect of the study or reporting of findings. We thank those who participated in this study

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