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Active workplace – Association between workplace layout and physical activity among employees: A cross-sectional study

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ABSTRACT

Active design is the translation of health research into design solutions that amplify the role of architecture and urban planning in enhancing public health. It also focuses on the elements of the built environment that can encourage daily physical activity. Office employees are one of the demographics "at risk" for insufficient physical activity and prolonged sitting time. The spatial environment of the workplace has indeed been recognized as a correlate of workers' active and sedentary behaviors. This study aims to examine the association between workplace layout typology and employees' physical activity, sedentary behavior, and health. A multi-method approach was conducted for collecting data in four government office buildings in Erbil between April 2022 and June 2022. Qualitative data collection included architectural plan analysis and photography. Quantitative data collection included a self-reported questionnaire by 132 desk-based employees measuring daily physical activity, sedentary behavior, and physical and mental health. IBM SPSS (statistical package for the social sciences) software V.25 was adopted to analyze the collected responses from the desk-based employees of government office buildings. The result showed that there is a significant difference in the mean value of physical activity among employees. Despite the low level of physical activity, employees working in buildings with a linear layout were more physically active than those in buildings with a radial layout (linear = 1.31, P-value < 0.000; radial = 1.13, P-value<0.000). The result also showed that there is a significant positive relationship between sedentary behavior and physical health (r = 0.191, P-value<0.05) and mental health (r = 0.172, P-value<0.05). On the basis of these findings, we can infer that improving the quality of the built environment and implementing active design solutions contribute to promoting physical activity, decreasing sedentary behavior, and enhancing occupational health.

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1. Introduction

Sedentary behavior and physical inactivity are the main global risk factors for noncommunicable diseases and early death. Many people in modern societies have a daily energy that is just 1.5 times their resting metabolic rate, which is indicative of a sedentary lifestyle [1]. Work has shifted from physically active performance-based work to sedentary knowledge-based work over the past several years, with occupational activity contributing less to people's overall physical activity [2]. Office workers are the population "at risk" due to lack of physical activity and excessive sitting time. One-third of the adult population of the globe does not achieve the minimum physical activity needed for health and well-being [3].

Sedentary lifestyles have a wide range of negative effects on the body, including an increase in all-cause mortality, cardiovascular disease mortality, cancer risk, and risks of metabolic disorders like diabetes mellitus, hypertension, and dyslipidemia, as well as musculoskeletal

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disorders like arthralgia and osteoporosis, psychiatric disorders like depression, and cognitive impairment [4,5,6,7,8]. A sedentary lifestyle is currently the fourth biggest risk factor for mortality worldwide [9].

Promoting public health requires both a decrease in sedentary behavior and an increase in physical activity. This can be achieved by improving building design quality by adopting active design strategies to increase incidental physical activity and improve general health. There is mounting evidence that changing the built environment can affect behavior, including in and around the workplace. The construction of buildings, in particular, can have a positive impact on health. Buildings can influence a broad population over time and include support for physical and mental health, as well as active living and decreased sedentary time [10]. According to a recent study, the built environment, programming, and the policies that influence them are all crucial in providing a conducive atmosphere where moderate levels of physical activity can be attained [11]. Reducing noncommunicable illnesses, overweight, and obesity requires increased physical activity. The WHO highlights that increasing physical activity will be one of the primary objectives of disease prevention and health promotion in the coming decade [12].

The active design concept, a multidisciplinary design approach that aims to design and adapt living and working spaces to encourage activity in everyday lives, has recently been introduced in several countries, including the United States, United Kingdom, Australia, Canada, and the Netherlands, making the active lifestyle an easy choice [2]. The concept of "active design" merges architectural and design concepts to promote physical exercise and reduce sedentary behavior. The objective of the multidisciplinary approach of active design is to translate evidence-based research into practical design solutions by addressing features of the built environment that promote daily physical activity and reduce workers' sitting time. Active Design provides urban designers, architects, and interior designers with a guide to developing healthier buildings, streets, and urban environments based on the most recent academic research and best practices in the industry [13]. Despite the calls for architects to include active design principles and physical exercise in their designs, there hasn't been much of a response in terms of both research and practical application.

This study investigates the role of architectural design in increasing physical activity and reducing sedentary behavior. In addition, it also investigates the impact of sedentary behavior on employees' physical and mental health. To achieve this aim, a cross-sectional analysis of governmental office buildings was conducted aiming to examine the interaction between the building layout, building programming, physical activity, and sedentary behavior as well as employees' health.

Case studies were selected from Erbil governmental office buildings based on their typology and number of floors. Four office buildings with two different layout typologies linear and radial were selected to be included in this study. The research methodology consists of qualitative and quantitative methods. The qualitative method involves a case study's plan preparations, photographic documentation, and analysis. While the quantitative method entails a self-reported questionnaire from 132 participants. The questionnaire is administered to employees of government office buildings to assess physical activity and sedentary behavior in terms of sitting, standing, and walking percentage as well as daily stair and elevator usage. The IBM SPSS (statistical package for the social sciences) software version V.25 was selected to conduct a statistical analysis of the responses gathered from desk-based personnel working in government office buildings.

2. Literature review

2.1 Physical activity

Physical activity is any movement produced by skeletal muscles that need energy expenditure. There are several ways to engage in physical activity: walking, cycling, sports, and active kinds of recreation (for example, dance, yoga, and tai chi). Additionally, physical exercise can be performed at work and around the house. All types of physical activity can bring health advantages if they are performed frequently and for long enough and with adequate intensity. According to the World Health Organization, physical activity at the community level is the first indication of health [14]. Since humans spend 90% of their waking hours in the indoor environment and more than half of that time in the workplace, the best practice to maintain regular Physical activity in daily life is through incorporating incidental Physical activity into the workplace. There are four levels of physical activity based on energy expenditure and metabolic equivalent rate; sedentary activity, light physical activity, moderate physical activity, and vigorous physical activity [15]. Figure (1) illustrates the type of activity related to the metabolic equivalent of task METs and the type of activity.

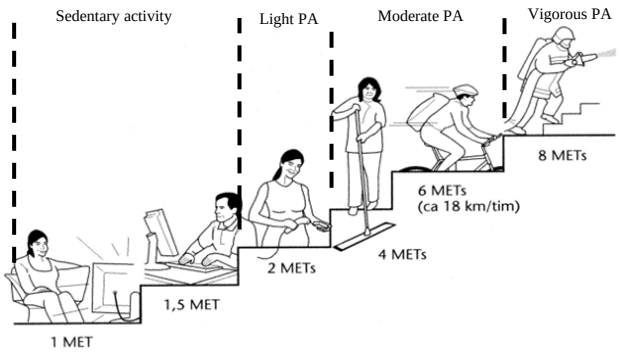


Figure 1. Four levels of physical activity [15]

2.1.1 Sedentary Activity

The sedentary activity was defined as having MET <2.0 e.g., equivalent to sitting or lying down [16]. Sedentary behavior is the absence of physical activity due to prolonged sitting [17]. Long periods of sitting have a severe negative impact on health, psychological issues, and work dissatisfaction, which can impair productivity [18]. The primary causes of sedentary behavior in modern life include advancements in technology, an increase in the usage of motor vehicles, and a lack of exercise routines due to long working hours [19].

2.1.2 Light physical activity

Light physical activity is defined as consuming < 3 METs, equivalent to standing or walking. This can also involve light exercise, taking a shower, or other incidental activities that do not significantly raise the heart rate or breathing rate [20,21].

2.1.3 Moderate physical activity

Activities between 3 and 6 METS are deemed to be of moderate intensity. Compared to light activities, these activities need increased oxygen consumption. Sweeping the floor, quick walking, leisurely dancing, vacuuming, cleaning windows, and shooting a basketball are a few instances of moderate exercise [20,21].

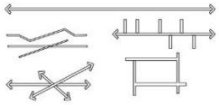
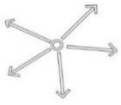
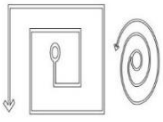
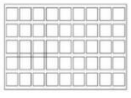
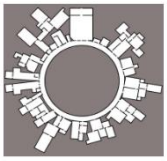
2.1.4 Vigorous physical activity

Activities that are 6 METS or more are considered to be of vigorous intensity. The greatest amount of oxygen must be consumed to finish vigorous tasks. Running at a speed of at least 5 mph, swimming, shovelling, playing soccer, jumping rope, and lifting large objects are some examples of strenuous physical activity [20,21].

2.2 Building layout typologies

The arrangement of a building's circulation is vital for navigation and movement flow in public buildings. In addition, it influences the relationship between spaces and spatial arrangement. Almost every scale of architectural practice necessitates the design of spatial configuration, which comprises arranging functional pieces according to specific objectives and constraints. The circulation of a building, which connects interior and outside spaces and reflects the structure's overall spatial arrangement, is a vital organizational mechanism for layout and communication space [22]. The circulation system is frequently described as the "skeleton" that supports the building [23]. Its effectiveness depends on clearly communicating the destination to the user (or groups of users) so that people can move in a way that is conducive to achieving their objectives. As a result, circulation effectively illuminates how spatial and organizational patterns influence users' mobility. Hillier et al. (1984) [24] assert that spatial arrangement affects the flows of human mobility (the behavior of people moving through space and the decisions they make). Table (1) illustrates seven building circulation typologies with their descriptions.

Table 1. Building circulation layout typologies

Typology	Explanation	Illustration
Linear [22]	All routes are linear. However, a straight line can often serve as the primary organizing principle for a cluster of rooms. It's possible for it to be segmented, curved, branched out, or even create a loop.	
Radial [22,23]	A radial configuration is characterized by linear routes emanating from or terminating at a central, shared point.	
Spiral [22]	A spiral arrangement is a single, continuous path that emanates from a central point, revolves around it, and moves further and further away from it.	
Grid [22]	A grid layout is a square or rectangle formed by intersecting sets of parallel lines.	
Network [22]	A network configuration is comprised of pathways that link places in space.	
Concentric [22,23]	Concentric type, where the core organizational approach is to produce concentric circulation while maintaining the topological relations' existing order. The passageways are arranged in a loop around the central courtyard, which is inaccessible. Additionally, all the connections inside the clusters of little units are as frequently as possible placed circularly.	
Composite (Ching, 2014, Natapov et al, 2015)	Typically, a building incorporates a blend of the preceding architectural patterns. Centers of activity, entrances to rooms and corridors, and areas for vertical circulation, such as stairways, ramps, and elevators, are important points in any plan. These points provide opportunities for halt, rest, and reorientation along the courses of travel within a building. To prevent the formation of a confusing maze, the paths and nodes of a building should be organized hierarchically by differentiating their size, shape, length, and location.	

3. Materials and methods

3.1 Study design

As mentioned previously, Office-based employees are one of the demographics "at risk" for insufficient physical activity and prolonged sitting time as they spend half of their waking hours in the workplace, a cross-sectional study conducted for office-based workers in governmental office buildings in Erbil city between April 2022 – July 2022. Four buildings were selected for this study based on their layout typology. Written consent was obtained by the researchers from responsible authorities in all four cases.

3.2 Sample size

A statistician was consulted to determine the statistically acceptable ratio sample size. Using a sample size calculator, the sample size for questionnaires is 132, with a population size of 393 (total number of office-based employees in all four case studies) equal to 33.5% of the total population.

3. 3 Measures and analysis

3.3.1 Qualitative measures

The existing structural, interior component, and organizational layouts of a building were determined using diagrammatic and descriptive analyses of architectural building plans. In addition, a photographic survey was done on every building included in the study. Circulation paths, stairways and elevators, view lines, and spatial quality were a primary emphasis of the photographic recording.

3.3.2 Quantitative measures

Self-reported questionnaire. The first section consists of demographic data, including age, gender, height, weight, and office type. Employees' body mass index is calculated from their reported height and weight using the formula BMI = kg/m2. Body mass index was categorized into four groups for this study: underweight16kg/m2, normal17-25kg/m2, overweight25-30kg/m2, and obese>30kg/m2. The second section focuses on variables of physical activity and sedentary behavior in the workplace, as measured by the proportion of sitting, standing, and walking, as well as stair and elevator use. The measurement was based on a five-point scale utilizing percentage intervals (0-20%), (20-40%), (40-60%), (60-80%), and (80-100%) through using an occupational sitting and physical activity questionnaire OSPAQ, an easy-to-use instrument for the self-reported assessment of the percentage of sitting, standing, and walking in the workplace. It is a low-cost and simple-to-use instrument that is also scalable. Given the high validity of sitting as measured by the OSPAQ and the substantial amount of occupational sitting, this questionnaire could make a significant contribution to studies with large sample sizes in elucidating the link between sitting time and health outcomes [25]. For measuring the extent of

stair use, the measure was also on a five-scale using intervals (0-2), (2-4) (4-6), (6-8), and (8-10) times.

Additionally, health-related results Physical health was examined using a 5-Likert scale with items collected from the literature addressing employees' physical health at work, whereas mental health was measured using the Kessler Psychological Distress Scale (K10). The ten-item scale is based on questions regarding anxiety and depression symptoms encountered during the preceding four weeks and measures the amount and severity of discomfort. The Kessler psychological distress scale (K10) is a commonly used, uncomplicated self-report measure of psychological distress that can be used for assessing anxiety and depression [26,27]. This instrument was designed for use with the general public, yet it may also be applicable in therapeutic workplace contexts. The K10 is comprised of ten Likert scale questions graded on a five-point scale (where 5 equals always and 1 equals never).

3.4 Analysis

For analysing the collected responses from 132 participants, IBM SPSS statistical package for the social sciences software V.25 was adopted. Descriptive analysis was performed to provide a general overview of the data. One-way ANOVA test is used to compare the mean between variables in each typology. Bivariate correlation analysis was used to investigate the relationship between dependent, independent, and outcome variables. Mean values, correlation coefficients, and P- values were checked to state the relationship between variables. Figure (2) illustrates the analytical summary of the structure of the research methodology and analysis conducted in this study.

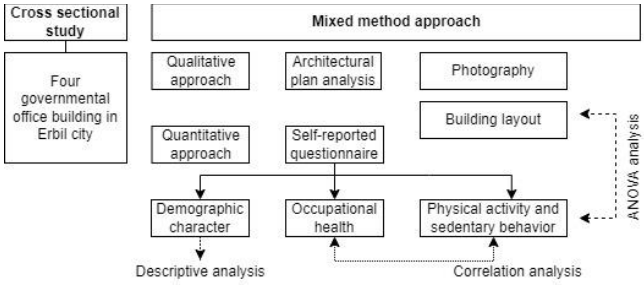


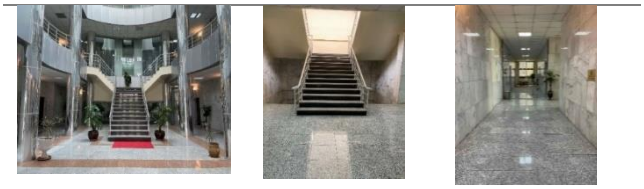
Figure 2. Analytical structure of research methodology.

4. Results and discussions

4.1 Descriptive results analysis

This section provides a descriptive analysis of the architectural plan of four workplaces in terms of their layout, corridors, and staircase design quality based on architectural plans and photos taken by the researcher:

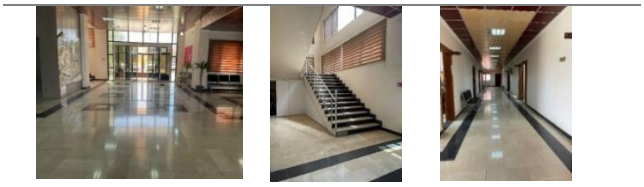
Case 1. It's a governmental office building located in Erbil. It's a three-story office building with approximately 57 office-based employees. The area of the floor is approximately 1266 sqm. The building has two entrances on different sides of the building; the front main entrance is used for VIP and protocol visitors; the side entrance is used as a staff and public visitors' entrance. The layout of the building is linear (L-shape) with a central linear space and offices distributed around it. The building contains four basic staircases and one elevator. One staircase and the elevator connect all three floors. The other two stairs provide connections between two floors only. Two of the staircases have a comfort dimension, and only one staircase has a view of the outside. The width of the corridors is about 2.5–3m, with some planting placed in the central space and corridor. The shared facilities in this workplace include only WC, there is no gathering or recreational area for employees. The central area provides some greenery features, but it is not utilized for gathering or recreational walking. Figure (3) illustrates interior shots of the lobby, staircase, and corridor of the office building.



Lobby Corridor Staircase

Figure 3. Interior photography of selected governmental office buildings - Case 1.

Case 2. It's a governmental office building located in Erbil city. It's a three-story office building with approximately 70 office-based employees. The area of the floor is approximately 954 sqm. The building has three entrances on different sides of the building; the front main entrance is used for VIP and protocol visitors; the side entrance is used as staff and public visitors' entrances. The layout of the building is linear (I-shaped), with spaces distributed along the linear path. The building contains two staircases and three elevators which connect all three floors. One staircase is located inside the building and is visible from the entrance, while the other is reached through a narrow corridor and is used as an emergency staircase. The staircase is basic with a view to the outside and comfortable dimensions. The width of the corridor is 3 m with no amenities, supportive infrastructure, or visually appealing elements. The shared facilities in this workplace include WC, cafeteria, prayer room, and meeting hall. However, the cafeteria prayer room and meeting hall are located on the third floor and are abandoned and not used by employees. there is no gathering or recreational area for employees. Figure (4) illustrates interior shots of the lobby, staircase, and corridor of the office building.



Lobby Corridor Staircase

Figure 4. Interior photography of selected governmental office buildings - Case 2.

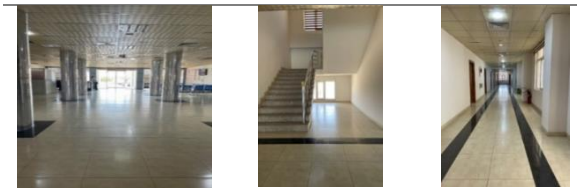
Case 3. It's a governmental office building located in Erbil city. It is a three-story office building with approximately 139 office-based employees. The area of the floor is approximately 1715 sqm. The building has five entrances on different sides of the building; the front main entrance is used for VIP and protocol visitors, and the side entrances are used as staff and public visitor entrances. The layout of the building is radial (X-shape), with a central space and linear paths extending from it. The building contains two staircases and two elevators that connect all three floors and are accessible to all employees. Both staircases are basic stairs with no internal or external view and poor natural and artificial lighting, they are visible only from the main entrance. However, they are safe and have comfortable dimensions. The width of the corridors is about 2.5m with no amenities, supportive

infrastructure, or visually appealing elements, as well as poor lighting. The shared facilities in this workplace include only WC, and no gathering or recreational areas are available for employees. Figure (5) illustrates interior shots of the lobby, staircase, and corridor of the office building.

Lobby Corridor Staircase

Figure 5. Interior photography of selected governmental office buildings - Case 3.

Case 4. It's a governmental office building located in Erbil city. It's a four-story office building with approximately 127 employees. The area of the floor is approximately 1265 sqm. The building has three entrances on different sides of the building; the front main entrance is used for VIP and protocol visitors; the side entrance is used as staff and public visitors' entrances. The layout of the building is radial (Z-shape), with a central lobby and linear paths extending from it. The building contains three basic staircases and two elevators which connect all four floors. The staircases have no view of the outside or inside. However, they are safe and have comfortable dimensions. The width of the corridor is 2.8m with no amenities, supportive infrastructure, or visually appealing elements. The shared facilities in this workplace include only WC, there is no gathering or recreational area for employees. Figure (6) illustrates interior shots of the lobby, staircase, and corridor of the office building.



Lobby Corridor Staircase

Figure 6. Interior photography of selected governmental office buildings - Case 4.

The result of the architectural plan analysis reveals two layout typologies linear and radial each of two different shapes. Two of the selected governmental office buildings are categorized as a linear layout with (I and L shapes) and the other two buildings are categorized as a radial layout with (X and Z shapes) as illustrated in Table (2).

4.2 Questionnaire results analysis

A descriptive analysis of the collected data shows that 43.9% of participants were male and 56.1% were female. Their age ranges from 25 to 65 years. 46.2% of participants were aged between 26 to 35 years and 34.8% were aged between 36 to 45 years. On another hand, 50.8% of participants were categorized as overweight, 14.4% as obese, while only 33.3% were categorized as having normal BMI as shown in Table (3). The result of the self-reports questionnaire revealed that employees spend the majority of their time engaging in sedentary behavior- sitting for a prolonged time at their desks. The mean values reveal that sitting is the most common activity in the workplace while standing and walking are less common. The mean value for sitting is 4.67 which refers to a high percentage of sitting among all selected governmental office buildings. While standing records the lowest mean value of 1.08 refers to a low percentage of standing among employees. walking was also detected to be very low but higher than standing with a mean value of 1.30.

Table 2. Architectural plan analysis in terms of circulation layout

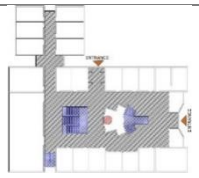
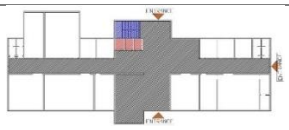
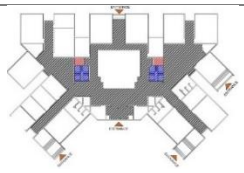
Linear layouts	**Case1**	**I-shape**	
	Case 2	L-shape	
Radial layouts	Case 3	X-shape	
	Case 4	Z-shape	

Table 3. Descriptive analysis of self-reported questionnaire

Items		N (%)	Items		M (SD)
Age	<= 25	2(1.5)	Physical activity	Standing	1.08 (0.57)
	26 - 35	61(46.2)		Walking	1.3(0.32)
	36 - 45	46(34.8)		Stair use	1.29(0.67)
	46 - 55	15(11.4)	Sedentary behavior	Sitting	4.67(0.84)
	56 - 65	8(6.1)		Elevator use	1.42(0.67)
BMI	under weight	2(1.5)	Physical health	Neck-shoulder pain	3.39(0.83)
	Normal	44(33.3)		Limb's pain	3.06(0.95)
	Over weight	67(50.8)		Lower back pain	2.91(0.99)
	Obese	19(14.4)		Joint pain	2.97(0.94)
Gender	male	58(43.9)		Headache	2.81(0.97)
	female	74(56.1)		Fatigue	2.81(0.95)
Office Type	Private	20(15.2)		Dizziness	2.22(1.00)
	shared-	84(63.6)		Overall	2.87(0.64)

			physical health	
	Open plan	28(21.2)	Mental health	Anxiety & Depression	2.15(0.65)

4.2.1 Results of One-way ANOVA analysis

Despite the low level of physical activity and high level of sedentary behavior, higher physical activity and lower sedentary behavior were recorded among employees in linear layout office buildings compared with employees in a radial layout based on the difference in the mean value of 1.31 in linear layout and 1.12 in radial layout, also the P-value of 0.007 show a significant difference in physical activity among employees in two layout building. as shown in table (4). It also demonstrates that sedentary behavior is higher among employees in a radial layout based on the mean difference of 4.4 in linear layout and 4.83 in radial layout, also the P-value of 0.000 shows a significant difference in sedentary behavior among employees in two layout buildings.

Table 4. Results of one-way ANOVA analysis

Type of Activity	Mean value		P-value
	Linear	Radial	
Sedentary behavior	4.40	4.83	0.0000
physical activity	1.3125	1.1250	0.0070

Regarding the low level of stair use, an open-ended question related to stair use ask the employees about the reason for not using the staircase in the workplace, 80% of employees stated that they don't need to go to the upper floors since their office related jobs and spaces are located in the same floor. This is true for employees working on the first or second floor, most of them use stairs twice a day, one time in the morning while coming to work and once when leaving. Another factor relating to programming is the absence of common shared facilities including a cafeteria, gathering area, etc. as mentioned in the descriptive analysis of office buildings.

4.2.2 Results of correlation analysis

Bivariate correlation analysis (Spearman's rho & Pearson Product Moment Correlation Coefficient Test) was used to investigate the correlations between sedentary behavior and the health of employees. The Pearson correlation showed that there is a significant relationship between sedentary behavior and overall physical health in terms of (Neck-shoulder pain, Limb pain, Lower back pain, Joint pain, Headache, Fatigue, and Dizziness) according to the r-value (0.191) and p-value (0.028) which is significant at a 0.05 level. Also, the result of the correlation analysis showed that there is a significant positive correlation between sedentary behavior and mental health according to the r-value (0.172) and p-value (0.049) which is significant at a 0.05 level. However, the Pearson correlation shows no significant relationship between sedentary behavior and body mass index referencing the p-value (0.229) which is greater than the (0.05) demonstrated in Table (5).

Table 5. Results of bivariate correlation analysis

Correlations		
		Sitting %
Body mass index	Pearson Correlation	.105
	Sig. (2-tailed)	.229
Overall physical health	Pearson Correlation	.191*
	Sig. (2-tailed)	.028
Mental health	Pearson Correlation	.172*
	Sig. (2-tailed)	.049
***. Correlation is significant at the 0.05 level (2-tailed).**		
c. Listwise N=132		

5. Conclusions and recommendations

5.1 Conclusions

This cross-sectional study explores the relationship between building layout and the behavior of employees in governmental office buildings in Erbil city. The results from the case studies have shown that although there is a significant effect of building layout on the physical activity of occupants, the layout in selected office buildings is developed specifically to meet only the function of connecting spaces. The layouts are not designed to promote physical activity as it doesn't comply with or fit any parameters which promote physical activity (walking) among users.

The analysis also shows that the walking routes on the building layout in selected buildings are also not designed to promote physical activity, it is just a means of connecting spaces. There is no intention or approach to encourage or promote walking or physical engagement to be carried out. For instance, there are no supporting facilities such as benches and water coolers for the users along the walking routes. However, the study concluded that the linear layout provides a better opportunity for movement an the radial layout.

In addition to the building layout, the descriptive analysis of building plans and photographs reveals that the staircases in all buildings are not designed to promote stair use. It is more to fulfill the functional requirement and as a means for vertical connecting of the floor without any design enhancements. The descriptive findings of this study also found that employees of government office buildings are more interested in sedentary behavior based on the result of personal behavior and attitude, however, personal behavior is affected by the quality of the built environment referring to the Winston Churchills quote "we shape our buildings and afterward our buildings shape us". In the case of Erbil office buildings, the quality of the built environment encourages sedentary behavior since it doesn't provide any encouragement for employees to leave their offices during their free time. On other hand, this study reveals the negative impact of sedentary behavior on physical and mental health.

Based on this, it can be concluded that improving the quality of the built environment by implementing active design strategies can significantly minimize sedentary behavior and encourage more physical activity in the workplace and improve employees' health.

5.2 Recommendations

The following recommendation was made in light of the research's results and conclusions. The research findings can provide a broad perspective and enable designers to improve the design quality of Erbil office buildings to reduce sedentary behavior and improve occupational health.

1 The study recommends architects and designers consider active design strategies in their design.
2 This study recommends architects and designers consider space programming e.g. providing shared facilities and locating them close to the stair to encourage breaking prolonged sitting times and increase stair climbing.

Authors' contribution

All authors contributed equally to the preparation of this article.

Declaration of competing interest

The authors declare no conflicts of interest.

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