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Original Research Article

The Impact of Criteria Air Pollutants on Occurrences of Falling, Fear of Falling, and Imbalance in the Older Adults in Southwestern Iran

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Summary

Background: The southwest of Iran is among the most polluted regions worldwide. The health risks associated with air pollution are a global concern, specifically for the older population. Evidence on the impact of air pollution on older adults' falling incidents has been rather overlooked. The present study thus seeks to examine how air pollutants affect the count of falling incidents, fear of falling, and imbalance in older adults.

Materials and methods: The present cross-sectional analysis examined all the older adults in the southwest of Iran (140,215 people) and their experience of falling, fear of falling, and imbalance and how these variables were associated with standard air pollutants. Statistical analyses were performed through linear regression, ANOVA, and the Post Hoc Tukey test in IBM-SPSS v.28 and JAMOVI v.2.4.5.

Results: The cities differed in terms of fear of falling; however, this difference was not statistically significant and did not impact the incidence of falls or imbalance among the elderly ($p > 0.05$). Shoushtar and Abadan were similar in terms of fear of falling, while Ahwaz was distinct from them. Among the studied pollutants, only SO_2, $PM_{2.5}$, and PM_{10} affected the fear of falling. Significant differences were observed throughout the seasons in SO_2, NO_2, $PM_{2.5}$, and PM_{10} in Ahwaz and Shoushtar and in $PM_{2.5}$ and PM_{10} particulates in Abadan ($p < 0.05$).

Discussion and conclusion: Results showed that implementing health policies and taking environmental measures in favor of the vulnerable older adults residing in polluted regions such as the southwest of Iran would be necessary.

Keywords: pollutants, air pollution, older adults, falling, imbalance, fear of falling.

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Влияние основных загрязнителей атмосферного воздуха на число случаев падения, страх падения и нарушение равновесия у пожилых людей в Юго-Западном Иране

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Резюме

Введение. Юго-запад Ирана является одним из самых загрязненных регионов мира. Риски для здоровья, связанные с загрязнением воздуха, являются глобальной проблемой, в особенности для пожилого населения. Данные о влиянии загрязнения атмосферного воздуха на случаи падения пожилых людей были в значительной степени упущены из виду, в связи с чем *целью* данного исследования было установить, как именно загрязняющие вещества влияют на число случаев падения, страх падения и нарушение равновесия у пожилых людей.

Методы. В настоящее поперечное исследование были включены все пожилые люди, проживающие в Юго-Западном Иране (140 215 человек), изучены их случаи падения, страха падения и нарушения равновесия, а также связь этих переменных с основными загрязнителями атмосферного воздуха. Статистические анализы проводились с помощью линейной регрессии, ANOVA и постфактум-теста Тьюки в IBM-SPSS v.28 и JAMOVI v.2.4.5.

Результаты. Были установлены различия между городами Шуштар и Абадан и городом Ахваз в отношении страха падения, однако они не были статистически значимыми и не влияли на частоту падений и нарушения равновесия у пожилых людей ($p > 0.05$). Из всех изученных загрязняющих веществ только SO_2, $PM_{2.5}$ и PM_{10} оказывали влияние на страх падения. Значимые различия в концентрациях SO_2, NO_2, $PM_{2.5}$ и PM_{10} наблюдались на протяжении всего года в городах Ахваз и Шуштар, а также в уровнях взвешенных частиц $PM_{2.5}$ и PM_{10} в г. Абадан ($p < 0,05$).

Обсуждение и заключение: Результаты работы показали необходимость реализации политики в области здравоохранения и принятия мер по охране окружающей среды в интересах уязвимых пожилых людей, проживающих в загрязненных регионах, включая юго-запад Ирана.

Ключевые слова: загрязняющие вещества, загрязнение воздуха, пожилые люди, падение, нарушение равновесия, страх падения.

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Introduction

Falling and its consequent complications are among the most prevalent and critical problems in older adults, resulting in remarkable fatality figures [1]. According to the 2017 global study of the burden of diseases, injuries, and risk factors, the significant burden of falling is a global phenomenon, rendering it the second cause of fatality due to unintentional injuries [2]. One-third of the people older than 65 fall once or several times annually [3], considering that the reported falling incidents are considerably fewer than the actual figures as only cases leading to hospitalization are recorded [4]. Falling accompanies severe consequences on adults and high expenses for healthcare systems. Besides the physical injuries due to falling (e.g. bone fracture and brain impact), psychological consequences such as fear of falling (FoF) may have an adverse impact on the individual [5]. FoF is defined as a cautious concern for falling that eventually leads to the limitation of daily life activities and the adoption of an overly cautious attitude [6–7]. Reduced activity and physical performance increase the risk of falling in older adults, leading to frequent falls, lower social participation, and lower quality of life [8]. The FoF prevalence among the 65 and older population reported varies widely between 20 and 80 % [9]. Over 50 % of the older adults with FoF reported to never have fallen so far [10]. On the other hand, pollution is the leading environmental factor causing immature fatalities worldwide [11]. Air pollution ranks first among the environmental risk factors affecting health [12]. Exposure to air pollution and its risk to human health is a global concern, especially in the older adult population [13]. Air pollution is defined as the adverse effects caused by any source contributing to atmospheric pollution or ecosystem destruction. Air pollution is caused by both natural phenomena and human interventions [14]. Air pollution comes from various sources; however, motor vehicles and industrial processes make up a huge portion of it. According to the World Health Organization, the six major air pollutants include particulate matter (PM), ground-level ozone (O_3), carbon monoxide (CO), nitrogen oxides (NO_x), sulfur oxides (SO_x), and lead. Both short-term and long-term exposure to toxic particulates leaves various impacts on humans, including cardiovascular and respiratory diseases, neurological complications, skin diseases, eye irritation, and chronic diseases such as cancer [15]. Urban dwellers are at higher risk due to the increased industrialization and demand for motor vehicles and energy [16]. The health impacts resulting from air pollution impose enormous costs on society. Although all community members are exposed to such pollution, older adults (aged 60+) are more influenced [17]. They are more vulnerable to the adverse impacts of air pollution and environmental temperature due to such factors as chronic diseases, declined physiological protective mechanisms, and social isolation [18]. Many of the less developed countries are located in arid and semi-arid regions, where water scarcity and harsh climatic conditions pose significant challenges to health situation and as a result of that the dust in the winds with natural origins can play a prominent part in particulate concentration [19]. Iran has been reported to be among the most polluted regions in the world [20]. Situated in the southwest of Iran, Khuzestan province has suffered various pollutions including fine, industrial, and non-industrial pollutants over the years. The pollution level is increasing every day in Ahwaz, the capital of Khuzestan province [21, 22]. According to the 2022 report from the World Health Organization, Ahwaz was the most polluted city in the world in 2011 in terms of annual mean PM_{10} at 372 μg/m^3 [23]. The present study seeks to examine the influence of criteria air pollutants and particulates on the incidents of falling, FoF, and imbalance in older adults in the southwest of Iran during the second half of 2023.

Materials and methods

Research design and population

The present cross-sectional study was performed on the total older population inhabiting the southwest of Iran in terms of falling and imbalance in the three metropolises of Ahwaz, Abadan, and Shoushtar with populations of 95,182 (out of 99,150 older adults), 6,015 (out of 24,213 older adults), and 5,728 (24,213) cared for older adults, respectively. The necessary permits and approvals were received from the Shiraz University of Medical Sciences to ensure the reliability and legality of the research, and the required data was then collected from the respective organizations. Data extracted from the integrated healthcare system included the history of falling over the recent year, fear of falling, imbalance when walking or standing, and abnormal balance tests in moving positions in older adults.

Pollutants: Data on the four standard pollutants included particulate matter (PM), ground-level ozone (O_3), carbon monoxide (CO), and nitrogen oxides (NO_x). WHO air quality instructions have been designed to reduce the impacts of air pollution on health. The figures determined for each pollutant indicate the threshold of the limits within which no significant impact is left. This instruction suggests the mean annual concentration to be 10, 20, and 40 μg/m^3 for $PM_{2.5}$, PM_{10}, and NO_2 over the long term, respectively, approximately 100 μg/m^3 for ozone for an average of eight hours, and around 20 μg/m^3 for SO_2 for the daily average [24].

Health indicators in older adults: imbalance, fear of falling, and falling incidents

The health information of the older adults who entered the study was collected based on the 2023 census data available on the Iranian integrated health system (SiB) in care forms containing data on imbalance, FoF, and falling incidents recorded over the recent year. Care for imbalance and falling is performed once annually as routine care for older adults and is recorded in the SiB system as yes/no questions on FoF and imbalance while walking or standing and the number of falling incidents over the recent year. Older adults with positive answers to one or several questions would undergo a TUG balance test in which they would be asked to get up from a chair, walk in a straight line toward a mark three meters away at a normal pace, and get back and sit back down on the

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chair. The subject is timed from the moment they start getting up until they sit back down. The test result is considered normal if the task takes 12 seconds or fewer and abnormal if the test takes more than 12 seconds. Where the older adult walks using a cane or a walker, the test is performed while using the mobility aid. Air pollutant data was collected from the environmental organization of Khuzestan province.

Data collection

After the necessary approvals were obtained and coordination was made with the deputy of health in the studied cities, seasonal data on falling incidents, FoF, and imbalance were extracted from the SiB system between March 21, 2021 and March 29, 2022. The probability of subjects falling was categorized into the three classes: low, moderate, and high. Daily data on standard air pollutants between the second half of 2022 and the end of the first half of 2023 were collected from the Environmental Protection Organization of southwest Iran. Lost data was estimated through interpolation, outliers were excluded from the study, and the remaining data was ultimately normalized. Eventually, the AQI was calculated following a quantitative analysis of the air pollution data, and data on falling incidents, FoF, and imbalance in older adults obtained from the SiB system was investigated and analyzed.

Statistical analysis

Statistical data analysis was performed in SPSS v.28 and JAMOVI v.2.4.5 (2023). Mean and standard deviation were used to describe the data. Linear regression, ANOVA, and Post Hoc Tukey tests were performed to test research hypotheses, and Cohen's d-effect size and squared omega coefficients were used to measure the level of impact. A significance level of lower than 0.05 was considered in all tests.

Ethical research principles

This study was conducted in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. The study protocol was approved by the Ethics Committee of Shiraz University of Medical Sciences on December 6, 2022, with Ethical Approval Number: IR.SUMS.DENTAL.REC.1401.133. Written informed consent was obtained from all elderly participants prior to their inclusion in the study, ensuring their voluntary participation and full awareness of the research objectives and procedures.

Results

Table 1 demonstrates the frequency distribution of the variables of falling incidents, imbalance, and FoF per 100 older adults per year by season and city.

A comparison between the cities revealed that Ahwaz, Shoushtar, and Abadan were not significantly different in terms of fall incidents and imbalance, but a significant difference was observed in terms of the FoF ($p = 0.001$). As the table demonstrates, the highest FoF was observed in Ahwaz, Shoushtar, and Abadan during winter (26.7 %), spring (40 %), and summer (46.8 %). Additionally, the highest number of falls occurred during the winter season in all three cities, namely Ahwaz (17.4 %), Shoushtar (40.1 %), and Abadan (46.4 %). According to the table, the highest imbalance figures in Ahwaz, Shoushtar, and Abadan were observed in winter (25.7 %), summer (54.8 %), and summer (40.7 %).

As Table 2 demonstrates, hourly data on O_3, NO_2, SO_2, $PM_{2.5}$, and PM_{10} were obtained from the air pollution monitoring stations. After obtaining the raw frequency of data, they were calculated separately for each season in each city (Table 2). The pollutants with concentrations over the WHO standards are in bold.

Table 1. **Comparison of frequency distribution of relative scores of FoF, falling and imbalance**

Таблица 1. **Сравнение частотного распределения относительных показателей страха падения, падения и нарушения равновесия**

Index / Показатель	Season / Время года	Ahwaz / Ахваз		Shoushtar / Шуштер		Abadan / Абадан		*p*
		n	%	*n*	%	*n*	%	
Fear of falling / Страх падения	Spring / Весна	9	24.5	3	40	4	26.8	0.002
	Summer / Лето	9	23.1	1	15.6	7	46.8	
	Fall / Осень	10	25.7	2	20.5	1	9.9	
	Winter / Зима	10	26.7	2	23.9	2	16.5	
	All / Все	38	100	8	100	15	100	
Fall / Падение	Spring / Весна	2	23.9	2	7.6	2	11.9	0.175
	Summer / Лето	2	21.6	7	30.1	3	16.2	
	Fall / Осень	3	27.4	5	22.1	5	25.5	
	Winter / Зима	3	27.4	9	40.1	8	46.4	
	All / Все	9	100	23	100	18	100	
Imbalance / Нарушение равновесия	Spring / Весна	7	24.7	3	15.5	4	27.3	0.239
	Summer / Лето	6	24.3	9	54.8	6	40.7	
	Fall / Осень	7	25.4	14	23.1	2	14.9	
	Winter / Зима	7	25.7	1	6.6	2	17.1	
	All / Все	27	100	16	100	14	100	

Note: Frequencies are the ratio of occurrences per 100 older people in the past year.

Примечание: частота – это число случаев на 100 пожилых людей за последний год.

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Table 2. **Comparison of the frequency distribution of air pollutants by cities and seasons**

Таблица 2. **Сравнение частотного распределения загрязнителей атмосферного воздуха по городам и временам года**

Cities / Города	Pollutants / Загрязнители	Spring / Весна	Summer / Лето	Fall / Осень	Winter / Зима	p^a	All seasons / Все сезоны		p^b	ESc
							Mean / Среднее	SD / CO		
Ahwaz / Ахваз	O_3, ppm	43.538	40.926	37.121	43.575	0.487	41.290	3.043	0.645	–0.091
	NO_2, ppm	55.538	**98.883**	**96.440**	**53.000**	0.002	**75.965**	25.094	0.028	0.547
	PM_{10}, μg/m³ / мкг/м³	117.634	**122.553**	**122.824**	**70.701**	0.001	**108.428**	25.264	0.347	0.031
	SO2, ppm	9.473	9.713	8.176	7.690	0.004	8.763	0.984	0.006	0.583
	$PM_{2.5}$, μg/m³ / мкг/м³	32.710	**40.170**	**40.736**	**26.782**	0.001	**35.099**	6.643	0.752	–0.133
Shoushtar / Шуштер	O_3, ppm	26.077	44.325	43.042	37.630	0.246	37.768	8.317		
	NO_2, ppm	22.319	35.820	21.982	**68.252**	0.002	**37.093**	21.749		
	PM_{10}, μg/m³ / мкг/м³	**222.151**	**129.043**	**151.429**	**153.678**	0.003	**164.075**	40.283		
	SO_2, ppm	**24.247**	**37.321**	**31.866**	12.346	0.001	**26.445**	10.821		
	$PM_{2.5}$, μg/m³ / мкг/м³	**55.538**	**32.261**	**37.857**	**38.828**	0.006	**41.121**	10.038		
Abadan / Абадан	O_3, ppm	41.065	37.862	41.066	38.851	0.578	39.711	1.615		
	NO_2, ppm	**73.839**	**77.138**	**71.253**	**94.218**	0.658	**79.112**	10.355		
	PM_{10}, μg/m³ / мкг/м³	**76.548**	**318.926**	**170.791**	**135.253**	0.009	**175.380**	103.286		
	SO_2, ppm	8.731	8.989	13.648	9.126	0.647	10.124	2.355		
	$PM_{2.5}$, μg/m³ / мкг/м³	22.323	**74.000**	**37.044**	36.644	0.007	**42.503**	22.087		

Notes: The standard index of pollutants according to the WHO guidelines: accordingly, the minimum of range in which significant effects are not observed is as follows: the annual average for NO_2, PM_{10}, $PM_{2.5}$ pollutants is 10, 20 and 40 micrograms per cubic meter respectively as a long-term guideline. For ozone, it is about 100 micrograms per cubic meter for an 8-hour average, and for SO_2 about 20 micrograms per cubic meter for a 24-hour average. These values in terms of ppm for NO_2 and SO_2 pollutants are 21.25 and 11.11, respectively [24]. The concentrations of pollutants higher than the limit set by the WHO are in bold.

[a] Significant within seasons for each city.

[b] Significant within cities for each pollutants.

[c] ES = Effect size measure using Omega square.

Примечания: Стандартный индекс загрязняющих веществ согласно рекомендациям ВОЗ: минимальный диапазон, в котором не наблюдается значительных эффектов, следующий: среднегодовое значение для загрязняющих веществ NO_2, PM_{10}, $PM_{2.5}$ составляет 10, 20 и 40 микрограммов на кубический метр соответственно в качестве долгосрочного ориентира. Для озона он составляет около 100 микрограммов на кубический метр для 8-часового среднего значения, а для SO_2 около 20 микрограммов на кубический метр для 24-часового среднего значения. Эти значения в пересчете на ppm (частей на миллион) для загрязняющих веществ NO_2 и SO_2 составляют 21,25 и 11,11 соответственно [24]. Концентрации загрязняющих веществ, превышающие предел, установленный ВОЗ, выделены жирным шрифтом.

[a] Статистически значимо в пределах времен года для каждого города.

[b] Статистически значимо в пределах городов для каждого загрязняющего вещества.

[c] ES = измерение размера эффекта с использованием омега-квадрата.

NO_2: The mean annual concentration of this pollutant was above the standard threshold in all three cities. Mean concentration varied significantly in Ahwaz and Shouhstar, with the highest figures for the two cities to be recorded in summer and winter, respectively.

SO_2: This pollutant varied significantly across the studied cities, with the highest figures having been reported in Shoushtar. Mean concentrations varied significantly in Ahwaz and Shoushtar throughout the seasons of the year, with the highest figures registered in summer.

PM_{10}: The highest acceptable annual mean PM_{10} has been reported to be 20 μg/m³ according to WHO, suggesting that all three cities had PM10 concentrations extremely higher than the standard value. The cities were not significantly different, but the concentration varied significantly in each city throughout the seasons, with the highest figures in Ahwaz, Shoushtar, and Abadan observed in fall, spring, and summer, respectively.

$PM_{2.5}$: According to the table, all three cities exceeded the WHO recommended levels for $PM_{2.5}$. The figures varied significantly in each city throughout the seasons, with the highest figures in Ahwaz, Shoushtar, and Abadan observed in fall, summer, and spring, respectively.

Table 3 shows that the cities varied significantly only in terms of the FoF variable (p = 0.001). However, Post Hoc and Tukey tests were also performed for pairwise comparison of the cities, which suggested that Shoushtar and Abadan were similar in terms of FoF and fall into a coherent group (p = 0.001), whereas Ahwaz differed significantly from the two (p = 0.175).

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Among the pollutants, only SO_2, $PM_{2.5}$, and PM_{10} had significant effects on the FoF variable. As the table demonstrates, the effect coefficient of omega

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Table 3. **Results of the one-way ANOVA for rFalling, rImbalance, and rFoF[a]**

Таблица 3. **Результаты однофакторного дисперсионного анализа для r-значений[a] переменных падения, нарушения равновесия и страха падения**

Variables / Переменные	Sum of Squares / Сумма квадратов	Df	Mean square / Средний квадрат	*F*	*p*	Partial Eta square / Частичный эта-квадрат	Omega squared / Омега-квадрат
rFoF / rСП	123.7	2	61.86	26.5	0.001	0.855	0.810
rImbalance / rНарушение равновесия	18.9	2	9.43	1.72	0.239	0.301	–
rFalling / rПадение	25.5	2	12.75	2.13	0.175	0.321	0.158

Notes: [a]To facilitate mathematical interpretation and improve comparability between variables, the raw scores for falling incidents, imbalance, and fear of falling (FoF) were log-transformed and standardized. These transformed and standardized values are denoted by the prefix "r" in the analyses. This approach ensured a normal distribution of data and allowed for meaningful comparisons with other numerical air pollutant indices.

Abbreviations: DF, degree of freedom; *F*, *F*-test of ANOVA; *F* represents the *F*-statistic, which is used in the analysis of variance (ANOVA) to test the null hypothesis that the means of different groups are equal. A larger *F*-value indicates greater differences between group means relative to the variation within groups.

Примечания: [a]Для облегчения математической интерпретации и улучшения сопоставимости между переменными исходные баллы для случаев падения, потери равновесия и страха падения были логарифмически преобразованы и стандартизированы. Эти преобразованные и стандартизированные значения обозначаются префиксом r в анализах. Такой подход обеспечил нормальное распределение данных и позволил провести содержательные сравнения с другими числовыми индексами загрязнения воздуха.

Сокращения: DF, степень свободы; *F*, *F*-тест в ANOVA; *F* представляет *F*-статистику, которая используется в дисперсионном анализе (ANOVA) для проверки нулевой гипотезы о том, что средние значения разных групп равны. Большее значение *F* указывает на большие различия между средними значениями групп относительно вариации внутри групп.

squared for SO_2 (0.267) suggested that this pollutant explained 26.7 % of the increase in older adults' FoF. The same coefficient for $PM_{2.5}$ and PM_{10} (0.494) indicated that these two pollutants managed to contribute to older adults' FoF by 49.4 %.

The beta effect coefficient suggested that FoF increased by 60.7 % per unit of increase in SO_2 and 227.1 and 270.1 % per unit of increase in $PM_{2.5}$ and PM_{10}, respectively. The effect coefficient in this equation was 51.6, 30.5, and 51.6 % for SO_2 ($p = 0.036$), $PM_{2.5}$ ($p = 0.005$), and PM_{10} ($p = 0.006$), respectively.

Discussion and conclusion

Falling is among the most prevalent and critical problems in old age. Falling results from various reasons [25], which are divided into two internal and external factors [26]. External (environmental) risk factors refer to all the features of the environment that are external to older adults [27]. The present study was concerned with the role of air pollutants on the incidents of falling, FoF, and imbalance in older adults in the southwest of Iran, one of the most polluted regions in the world. Results of previous studies indicated that air pollutants influenced the disorders resulting from falling. The findings of the presented study indicated that among all studied variables, only SO_2, $PM_{2.5}$, and PM_{10} left significant impacts on FoF, whereas the same pollutants left no significant effect on imbalance and incidents of falling. The FoF generally results in reduced physical exercise and social activity, which could lead to depression and dependence on essential daily life activities (e.g. bathing or shopping) [28]. Reduced activity level and physical performance exacerbate the risk of falling in older adults, resulting in frequent falls, less frequent social cooperation, and lower quality of life [8]. Given the adverse consequences of FoF, this phenomenon may also be more harmful than actual falling in terms of psychological impacts [29]. According to Araya and Iriarte (2021), tangible air pollution can discourage people from doing outdoor activities. As $PM_{2.5}$ concentration increases, people are less inclined to go outside and miss their chances of meeting with friends and neighbors, which may exacerbate depression [30], according to Araya (2021), depression is also associated with FoF [31].

Table 4. **Results of one-way ANOVA for two significant pollutants affecting rFoF**

Таблица 4. **Результаты однофакторного дисперсионного анализа для двух загрязняющих веществ, влияющих на r-значение для страха падения**

Variables / Переменные		Sum of squares / Сумма квадратов	Df	Mean square / Средний квадрат	*F*	*p*	Omega squared / Омега-квадрат
rFoF	SO_2	53.306	1	53.306	5.833	0.031	0.287
	$PM_{2.5}$	87.388	2	43.694	6.861	0.006	0.494
	PM_{10}	87.388	2	43.694	6.861	0.005	0.494

Table 5. **Linear regression results for three pollutants predicting rFoF**

Таблица 5. **Результаты линейной регрессии для трех загрязняющих веществ, прогнозирующих r-значение для страха падения**

Pollutants / Загрязнители	Adjusted R^2 / Скорректированный R^2	β	95 % CI / ДИ	*p*
SO_2	0.305	0.607	0.01– 0.41	0.036
PM_{10}	0.516	2.771	0.05–0.24	0.005
$PM_{2.5}$	0.516	2.701	0.26–1.17	0.006

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Although the present study found no significant relationship between air pollutants and imbalance, previous studies have demonstrated that PM levels may be associated with health consequences. A multilevel analysis performed in six moderate-income and low-income countries found that the three-year $PM_{2.5}$ concentration was positively associated with injuries caused by falling [32]. Air pollution, both directly and indirectly, may increase the risk of injuries due to falling. High levels of pollutants, particularly fine particulate matter ($PM_{2.5}$), can impair vision, thereby increasing the likelihood of falls. Additionally, exposure to air pollutants such as PM_{10} has been linked to osteoporosis, a condition that weakens bones and further elevates the risk of fractures following a fall. For instance, Torkashvand et al. demonstrated that osteoporosis was significantly associated with elevated PM_{10} levels [33]. Thus, air pollution not only affects visual acuity but also contributes to bone fragility, both of which are critical factors in fall-related injuries. Although the association with $PM_{2.5}$ remained insignificant, particulate matter (PM) has been shown to contribute to osteoporosis and bone fractures by reducing UV-B exposure, which negatively impacts vitamin D synthesis. Furthermore, the adverse effects of certain medications on bone health may increase the risk of imbalance, falls, reduced bone mass, and other clinical disorders in older adults, potentially exacerbating the likelihood of hospitalization [34-36].

Limitations and suggestions

The lack of cooperation from Ahvaz University of Medical Sciences, despite extensive correspondence, was one of the limitations of this study. Additionally, missing pollution data during certain hours due to various reasons, such as power outages, posed another challenge. To address this issue, interpolation statistical methods were employed to estimate the missing data points. Furthermore, this study relied on regional primary data that did not include sex-specific information. As a result, we were unable to conduct a statistical analysis to explore potential sex-specific disparities in postural balance and gait parameters among older adults. Future studies should consider incorporating sex-specific data to better understand these differences and their implications for fall risk and prevention strategies.

Among the key recommendations of this study is a shift in policymaking toward promoting the health of older adults by the Ministry of Health, particularly in light of global warming, air pollution, climate change, seasonal shifts, and the expanded monsoon dust storm season in southwestern Iran, all of which have adverse impacts on the health of older adults. A notable gap in health policymaking in Iran is the lack of attention to these global and climatic challenges and their detrimental effects on vulnerable populations, such as older adults. Addressing these issues should be a priority in future health policies.

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Compliance with ethical standards: This study was conducted in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. The study protocol was approved by the Ethics Committee of the Shiraz University of Medical Sciences on December 6, 2022, with Ethical Approval Number: IR.SUMS.DENTAL.REC.1401.133. Written informed consent was obtained from all elderly participants prior to their inclusion in the study, ensuring their voluntary participation and full awareness of the research objectives and procedures.

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Соблюдение этических стандартов: это исследование было проведено в соответствии с этическими стандартами, изложенными в Хельсинкской декларации 1964 года и ее более поздних поправках или сопоставимых этических стандартах. Протокол исследования был одобрен Этическим комитетом Ширазского университета медицинских наук 06.12.2022 (№ IR.SUMS.DENTAL.REC.1401.133). Письменное информированное согласие было получено от всех пожилых участников до их включения в исследование, что гарантирует их добровольное участие и полную осведомленность о целях и процедурах исследования.

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