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Research Article

Study of Fall Modes and Associated Fracture Patterns in an Iranian Population

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Abstract

Introduction: Falls are considered to be one of the significant public health problems worldwide, and are associated with increased mortality, hospitalization, and severe fractures. Fall-related injuries lead to socio-economic impacts, including psychological distress and decreased work productivity. This retrospective study aimed to study the correlation between falling height and the frequency and types of fall fractures in accidental high falls (AHF) and intentional high falls (IHF).

Method: The study concluded that 268 patients were hospitalized between June 1, 2011, and June 1, 2017, for the treatment of fall-related injuries. The gender, age, falling height, and fall fractures and traumas were analyzed for each individual.

Results: The results showed that there is no significant correlation between all types of fractures and the age of individuals. Furthermore, the correlation study of the falling height and different types of fractures also illustrated that there is no significant correlation between these factors in both groups, AHF and IHF. These findings showed that the pattern of fractures can be used to distinguish AHF from IHF.

Conclusion: Since fractures are more common in older adults, particularly in older women, it is essential to implement comprehensive injury prevention programs and facilitate the diagnosis, treatment, and rehabilitation methods for this population to minimize the overall burden.

Keywords: Fall; Fracture; Trauma.

Introduction

Falls are considered to be one of the significant public health problems worldwide [1, 2], and are associated with increased mortality, hospitalization, and severe fractures [3-5]. Due to the increasing number of serious injuries resulting from falls, the cost of healthcare is on the rise [6]. Fall-related injuries lead to socio-economic repercussions, including psychological distress and decreased work productivity. As a result, it is essential to focus more on prevention to avoid lasting harm [7]. Nevertheless, a few studies have focused on the incidence of fall-related injuries and their associated factors [8-11]. Studies suggest that women are more susceptible to foot fractures than men, and there are several potential reasons for this increased vulnerability to fall injuries. Firstly, there are inherent differences in muscle strength between men and women. A study in Japan found that, among individuals aged 75 and older, women had a shorter one-leg standing time compared to men. Secondly, osteoporosis, which is more prevalent in women, plays a significant role in these gender disparities [12-14]. Osteoporotic fractures are a public health burden, costing €37 billion in the European Union and $16 billion in the United States each year [15]. Fractures are a significant public health problem, and their incidence is steadily increasing worldwide. In 2019, more than 178 million fractures were reported worldwide, with the incidence increasing significantly in older age groups due to osteoporosis. On the other hand, it has been estimated that by 2025, the rate of osteoporosis-related fractures among Americans will exceed 3 million cases, with an economic burden of more than 25 billion dollars per year [16-18].

Same-level falls (SLF), Accidental high falls (AHF), and Intentional high falls (IHF) are three common falling types. SLFs often occur in older individuals with balance issues. AHFs are more common in rural areas. IHFs, linked to psychiatric illnesses, are predominant in urban settings, often due to suicidal intent or psychosis-induced beliefs like flying or immortality [19]. Sleep disruptions can interfere with bone metabolism rhythms, potentially leading to fractures. These disturbances may directly influence bone resorption due to factors such as hypoxemia, inflammation, hormonal changes, and others. Additionally, poor sleep can increase the risk of falls and fractures by causing inflammation and reducing muscle strength and physical performance [20].

Falls from a height are the leading cause of fractures, accounting for 39%, followed by traffic accidents at 26.5%. Car accidents result in a significant number of cervical and thoracic spine fractures. Specifically, 65% of cervical and 80% of multi-segmental injuries come from traffic incidents. Those with these injuries face a higher spinal cord injury risk: 11.2% have total motor-sensory deficits, 13.5% partial, and 75.3% none. Notably, 19.7% of cervical spine fractures had complete neurological deficits [21].

There is a considerable amount of research on various types of injuries in Iran, each of which examines injuries in a specific area over a short period [22-25]. In a study of 7,132 elderly patients, the risk of fracture from a shortfall was 0.963 for low-dose aspirin users, while those with a parent with osteoporosis had a risk factor of 1.23[16].

In Iran, road traffic accidents are the primary cause of injuries, accounting for 50.1%, with falls coming next at 22.3%. Fatal falls are most prevalent among adults over the age of 60 [22, 26, 27].

There are correlations and effects of age, gender, and the cause of the accident on the type of vertebral fracture and the distribution of the fracture, as well as on the probability of injury or associated neurological deficit [21]. Regional reports in Iran indicate that falls are the leading cause of injuries, especially in urban areas [19]. Research on fall traumas in Iran is limited, and much of what we know about risk factors and outcomes comes from studies conducted in other countries.

There was no significant difference in femur and spine bone density (BMD) in the two groups (low-dose aspirin use and non-use). Women were 5.6 times more likely than men to have a fracture related to falling from a standing height or less (1 time or more) [16]. Aspirin use has been reported not to affect the incidence of falls or fractures in older adults. Also, the use of low-dose aspirin to prevent fractures in older people has been reported to be statistically insignificant [16].

In forensic medicine, differentiating between AHF and IHF is crucial, especially when multiple blunt-force injuries are present. Bone fractures, while representing only a minority of all patients, have a larger socio-economic impact [21]. This study focused on pathological features of falls from height in Iranian individuals hospitalized for fall-related injuries, aiming to elucidate the modes of falls (AHF, IHF) [16].

Methods

Study Design and Setting

The present study was a retrospective study conducted at the trauma center of Shafa Hospital in Tehran, Iran. The study included 268 patients who were hospitalized for the treatment of fall-related injuries between June 1, 2011, and June 1, 2017.

Data Collection

Data regarding gender, age, the height of fall, and the nature of fall fractures and traumas were collected for each patient. Fractures were categorized into five distinct subgroups: head and face fractures, rib fractures, spinal fractures, pelvic fractures, and limb fractures. Each case was also classified as either AHF or IHF based on the evidence in the case file and consultation with a forensic expert. Patients with missing or incomplete data were excluded from the analysis.

Ethical Considerations

Before commencing the study, ethical clearance was obtained from the Ethics Committee of Iran University of Medical Sciences, Tehran, Iran (No.: IR.IUMS.FMD.REC.1399.638), which ensured that the research conformed to established ethical guidelines for medical research involving human subjects. Patient confidentiality was strictly maintained, with all personal identifiers removed or anonymized prior to data analysis.

Data Analysis

Data analysis was carried out using SPSS statistical software version 24 (IBM, Armonk, NY, USA). Descriptive statistics, including means, standard deviations, and standard errors, were computed for all

measurements. The Shapiro-Wilk test and Levene's test were used to assess the normality of the data and equality of variance. All acquired p-values were greater than 0.05, indicating normal distributions with consistent variances. The Independent Samples t-test and the Kendall correlation coefficient test were employed to evaluate the relationships between variables.

Results

In the current study, 268 people (151 men and 117 women) have participated. All of them are hospitalized due to falls from height. Two hundred thirty-seven people have been categorized in the group of AHF (144 men and 93 women), and 31 patients were in the group of IHF (7 men and 24 women).

The prevalence of different fractures in the AHF and IHF groups is shown in Figure 1. It shows that the distal radius and supracondylar arm fractures were the most frequent injuries in AHFs, and the fractures of both heels, distal radioulnar, femur shaft, and spinal cord have been observed in IHFs. Furthermore, the prevalence of different fractures, categorized by gender, in the AHF and IHF groups is presented in Tables 1 and 2, respectively.

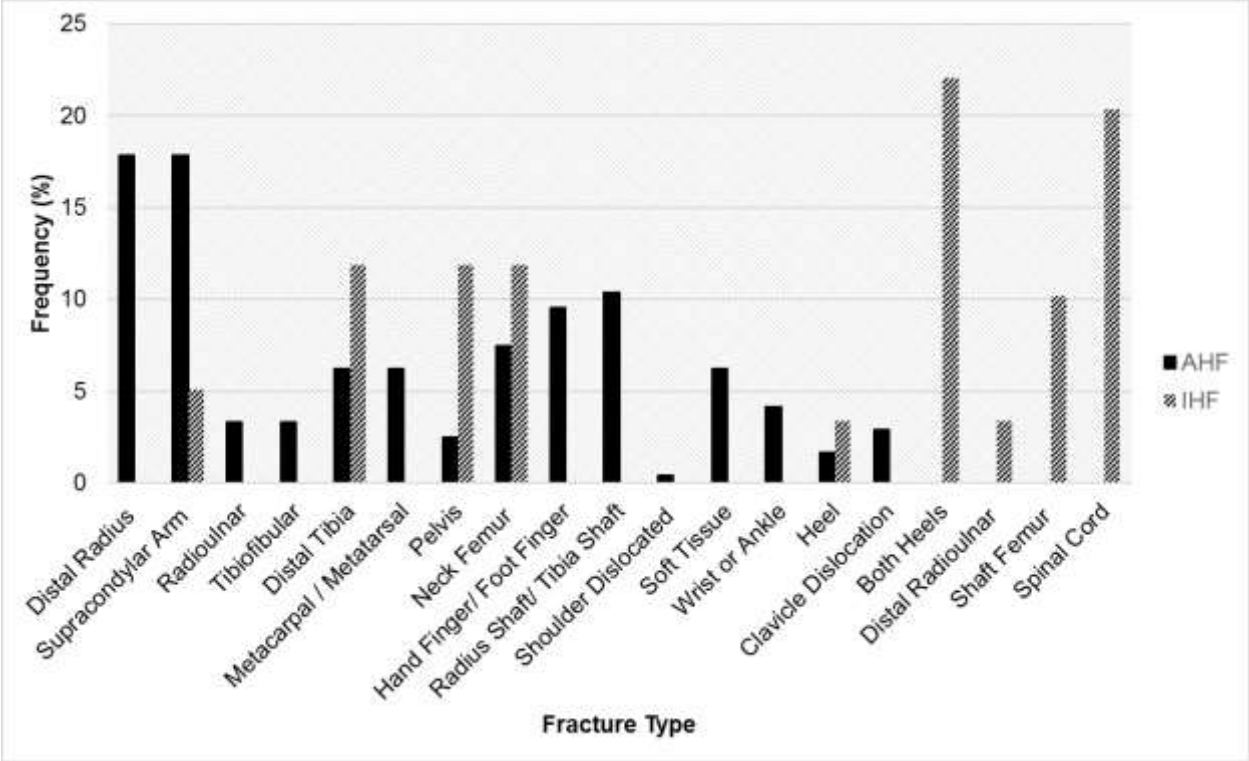

Figure 1: The prevalence of different fractures in the AHF and IHF groups.

Table 1: Prevalence of different fractures based on gender in the AHF group.

Fractures Type	Male	Female
Distal Radius	16.22%	20.43%
Supracondylar Arm	14.86%	22.58%
Radioulnar	4.05%	2.15%
Tibiofibular	2.03%	5.38%
Distal Tibia	6.76%	5.38%
Metacarpal / Metatarsal	8.78%	2.15%
Pelvis	2.7%	2.15%
Femur Neck	6.08%	9.68%
Hand Finger/ Foot Finger	10.14%	8.6%
Radius Shaft/ Tibia Shaft	11.49%	8.6%
Shoulder Dislocation	0.68%	0%
Soft Tissue	6.76%	5.38%
Wrist or Ankle	5.41%	2.15%
Heel	2.03%	1.08%
Clavicle Dislocation	2.03%	4.3%

Table 2: Prevalence of different fractures by gender in the IHF group.

Fractures Type	men	women
Supracondylar Arm	9.09 %	4.17%
Distal Tibia	9.09%	12.5%
Pelvis	0%	14.58%
Femur Neck	36.36%	6.25%
Heel	0%	4.17%
Both Heels	9.09%	25%
Distal Radioulnar	9.09%	2.08%
Femur shaft	9.09%	10.42%
Spinal Cord	18.18%	20.83%

The results of the correlation study between age and different fracture types showed a negative correlation between age and certain fractures, including supracondylar arm, distal radius, hand and foot, finger, as well as metacarpal and metatarsal fractures. With increasing age, the incidence of these types of fractures decreases in the AHF group. Furthermore, there is no significant correlation between other types of fractures and age (Figure 2). In the IHF group, there is no significant correlation between all types of fractures and the age of individuals (Figure 3). The study of the correlation between the height of fall and different types of fractures also illustrated that there is no significant correlation between these factors in both groups, AHF and IHF (Figures 4 and 5).

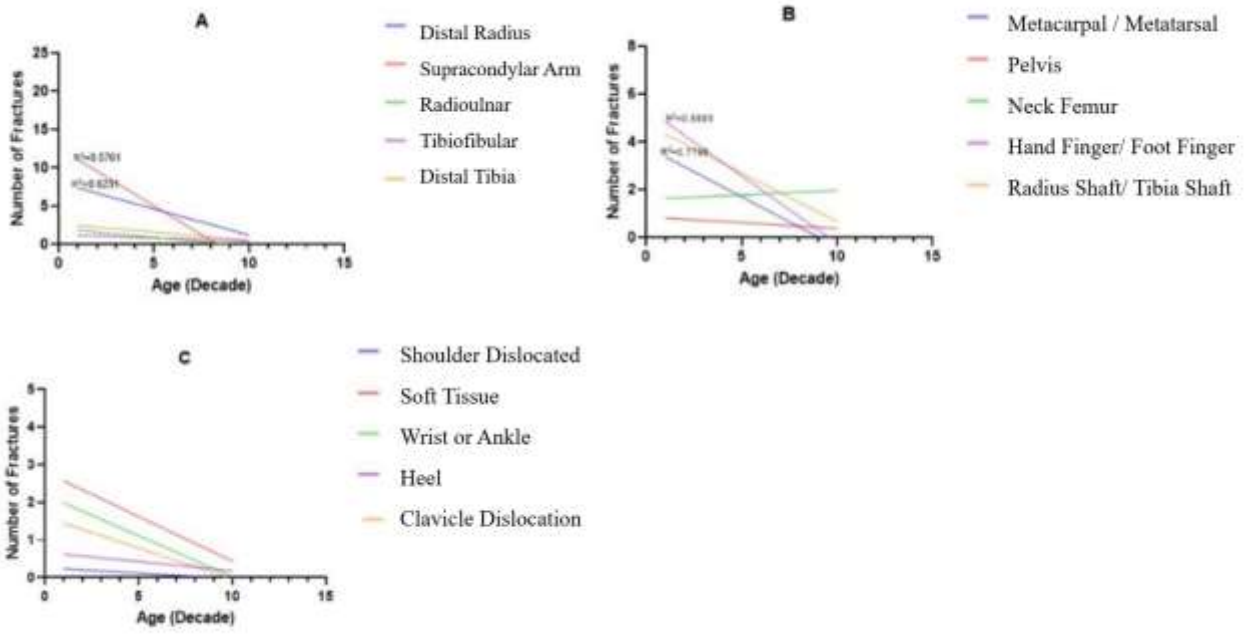

Figure 2: The correlation between the age of individuals and different types of fractures in the AHF group.

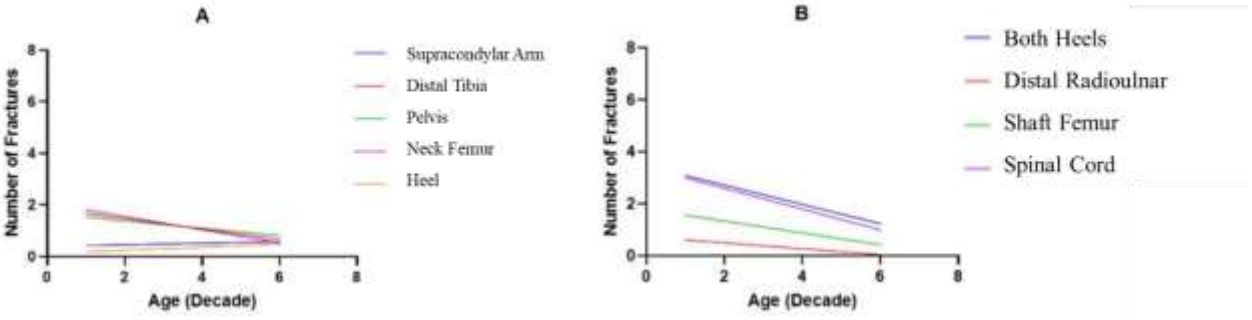

Figure 3: The correlation between the age of individuals and different types of fractures in the IHF group.

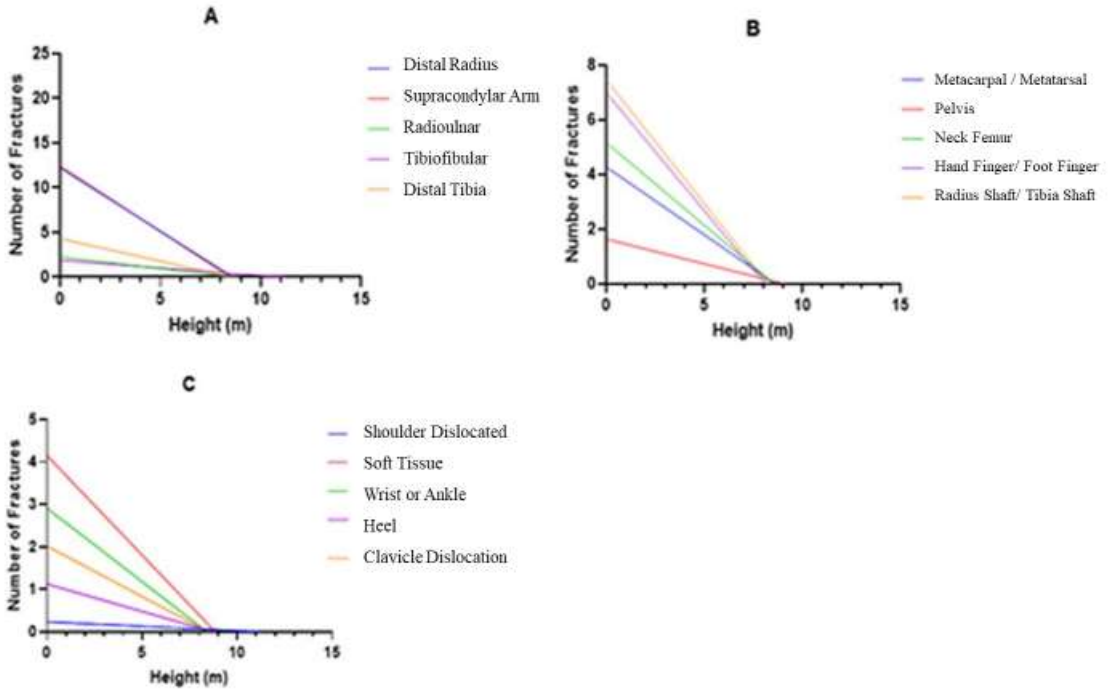

Figure 4: The correlation between the height of fall and different types of fractures in the AHF group.

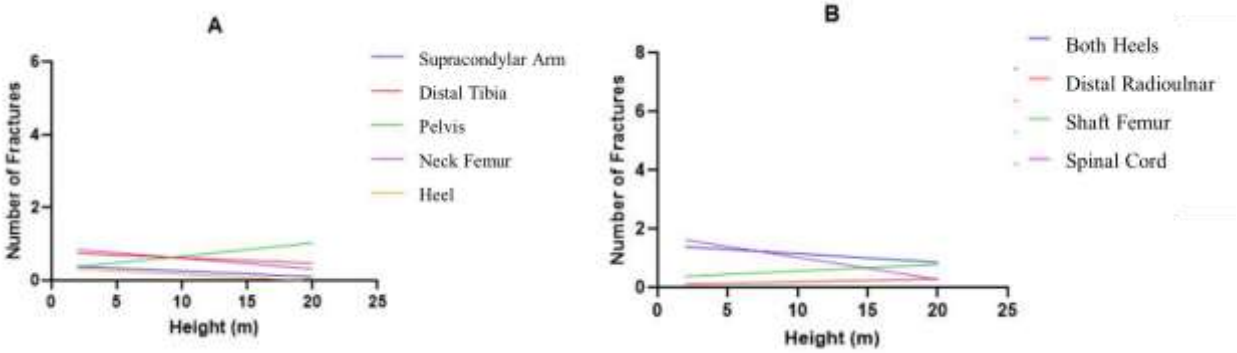

Figure 5: The correlation between the height of fall and different types of fractures in the IHF group.

The Kendall correlation study revealed no significant correlation between the gender of individuals and different types of fractures in both the AHF and IHF groups. The results are illustrated in Table 3.

Table 3: The correlation between gender and different types of fractures

Kendall's Tau_b		Fractures	Gender
Fractures	Correlation coefficient	1	0.069
	Sig. (2-tailed)		0
	N	300	300
Gender	Correlation coefficient	0.069	1
	Sig. (2-tailed)	0	
	N	300	300

Discussion

In this study, the individuals are categorized into AHF and IHF groups. The relationship between the fractures and the height of fall, as well as the gender and age of individuals, was investigated in each group. In forensic medicine, distinguishing between accidental falls and suicide is necessary, and understanding the type and manner of a person's fractures can help to find the mechanism of the fall. In accidental falls, the victim has no control over the initial velocity of the fall and the orientation of the body, and these factors may affect the types of fractures [28, 29].

In this study, the most common injuries in IHF were both heel and femoral shaft fractures, which are caused by a collision with both feet on the ground. In unintentional fractures, unilateral fractures are commonly observed, typically occurring in the hand and arm areas. In this study, the SLF has not been assumed to be a separate group. Therefore, they participated in the AHF group as the most common cases.

In a study, it was reported that falls from a height were more common among men and people younger than 75 years. However, falls on the ground were more common among women and people older than 75 years. Falls from a height were more common in autumn, while falls from ground level were more common in winter, but both mechanisms often occurred during the day [12.] The head and lower limbs are reported to be the most injured for people who have fallen from heights and the ground, respectively. Head, chest, spine, upper extremity, and hip injuries are standard among people who fall from height. However, injuries to the lower limbs have been common in ground-level fallers. Among people who have fallen from a height, women are more likely to sustain lower limb injuries than men. However, among ground-level fallers, men have more head injuries than women. The highest mortality rate was recorded for abdominal injuries among those who fell from height and head injuries among those who fell from the ground. In both injury mechanisms, the mortality rate of organs was the lowest [12].

In the present study, approximately 88.4% of the falls occurred in the AHF group, and 11.6% of patients were categorized in the IHF group. In the AHF group, the number of men exceeded that of women, a finding consistent with other research results [30, 31]. Falls in men usually happen during recreational and work-related circumstances [32]. The number of women in the IHF group is more than that of men. Previous research showed that IHFs are heavily associated with psychiatric disorders, where schizophrenia, depression, bipolar disease, and drug abuse predominate [33, 34]. Furthermore, studies have shown that cultural differences play a significant role in high falls. Falling from roofs, trees, or ladders can occur regionally, depending on the culture of that region [35, 36].

The most common injuries were related to the supracondylar arm (15%) and distal radius (14%). The results showed that supracondylar fractures, distal radius fractures, and fractures of the fingers, hands, feet, metacarpals, and Metatarsals are the most common fractures in younger individuals. As age increases, fractures in the femoral neck become more common. However, no significant relationship was observed between the fractures and the age of individuals. No IHF was observed in people over 60 years of age, while AHF was observed in people up to 100 years of age. Sometimes, cranial fractures have occurred in these individuals, leading to death. In this study, individuals with skull fractures have been excluded; therefore, this can explain the decrease in the number of individuals.

The results of this study indicate that the height of the fall is not associated with the pattern or type of fracture. This result is similar to the results of Hahn et al., who investigated the 101 cases and found that there were no differences between the injury patterns after a fall from a height of more than 7 m or less than 7 m [37]. Consistent with these findings, Turgut et al. and Lohanathan et al. concluded that the height of the fall was associated with the likelihood of severe injuries and can influence the pattern of fractures in falls [38, 39].

Osteoporosis is a long-term disease characterized by decreased bone density and susceptibility to fracture at relatively low levels of trauma. It is usually associated with older age groups, as bone loss accelerates in postmenopausal women, and in men, decreased steroid production also plays a role. In addition, several studies have demonstrated that inflammatory mediators, including tumor necrosis factor (TNF)-α, interleukin (IL)-6, and C-reactive protein (CRP), can stimulate osteoclastic activity and contribute to bone loss. Accelerated prostaglandins have also been shown to have long-term effects on bone resorption [40-42]. Fractures caused by osteoporosis significantly put pressure on

patients and their families due to their high morbidity and mortality, disturb the quality of life of patients, and hurt their physical and mental health [16-18]. Prevention and treatment of osteoporosis at a younger age may reduce the risk of fall fractures in older age. Additionally, for older patients who are hospitalized, inpatient falls should also be considered and prevented [43]. The importance of preventing falls on the ground to reduce fall-related hospitalizations among the elderly is profound, as most fall-related injuries are caused by falls on the ground [12]. Further studies are necessary to collect information on the status of fall injuries in order to develop preventive measures, which, unfortunately, this study was unable to do. More detailed information, such as the environment, clothing, behaviors, and sequence of events that lead to injuries, will help in devising interventions and developing equipment or support tools for older adults to prevent falls.

Conclusion

Fractures are more common in older people, especially in older women. Therefore, broader injury prevention programs and access to osteoporosis prevention and diagnosis for older adults should be improved to minimize the overall burden [16]. This study aimed to evaluate the relationship between the types of fractures resulting from falls with different modes, including AHF and IHF. The results confirm that some fractures, such as distal radius and supracondylar humerus fractures in AHF, as well as fractures of both heels, Distal Radioulnar Joint, Femur shaft, and Spinal cord in IHF, can be used to investigate the mode of falling. Furthermore, the patterns of fractures have not been related to the height of falls, the age, and gender of individuals.

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Conflict of Interest Disclosures

The authors declared no conflict of interest.

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Authors' Contributions

The author's contributions are as follows: B.B. contributed to writing the paper and performing the statistical analysis. A.A., M.A., F.F., and A.G. participated in the design of the study and contributed to writing the paper. All authors read and approved the final manuscript.

Ethical Statement

The study was approved by the Ethics Committee of Iran University of Medical Sciences (No.: IR.IUMS.FMD.REC.1399.638), Tehran, Iran. All participants provided informed consent and were aware of their rights and responsibilities. Confidentiality was paramount, with data anonymization to protect identities. Ensuring transparency, participants had access to study findings and were informed of any protocol changes. The cultural norms and values of the Iranian community were respected. Data was securely stored, with access restricted to authorized individuals.

Declaration of Generative AI and AI-assisted technologies

None.

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