ORIGINAL RESEARCH

Prevalence, Characteristics, and Associated Risk Factors of the Elderly with Hip Fractures: A Cross-Sectional Analysis of NHANES 2005–2010

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Objective: This cross-sectional study was aimed to update the assessment of prevalence, characteristics, and risk factors of the elderly with hip fractures in a non-institutionalized American population.

Methods: This current study included a total of 31,034 participants from the existing National Health and Nutritional Examination Survey (NHANES) database from 2005 to 2010, and 4,265 participants aged 65 years and older were ultimately identified. Their condition of hip fractures was determined by method of questionnaires according to the orthopedic surgeons' diagnosis, and related epidemiological and demographic data were further collected. The univariate analysis was used to screen the risk factors of hip fractures in the elderly, and the logistic regression model was established to conduct the multivariate analysis.

Results: Of the total 4,265 participants with clear information of hip fractures in elderly, 127 individuals with hip fractures were identified according to results of questionnaires, exhibiting a prevalence of 28.49 per 1,000 (95% confidence interval [CI]=21.38–35.60) for males and 31.03 per 1,000 (95% CI=23.72–38.35) for females. The mean age of the elderly with hip fractures was 77.12±5.88 years and tumble (48.0%) was the primary factor. In univariate analysis, age, race, smoking, drinking alcohol, and combined with osteoporosis were regarded as risk factors. Multivariate analysis showed that age (80 years and older), living alone, smoking, combined with diabetes and osteoporosis were the independent risk factors.

Conclusion: Our nationwide data indicate the prevalence of hip fractures in the elderly is generally on the rise, and the female occupies a higher proportion. Age (especially aged 80 years and older), race (mainly Non-Hispanic white), smoking, drinking alcohol, living alone, combined with diabetes and osteoporosis may be closely linked to the occurrence of hip fractures in the elderly, although these variables still need to be verified in further prospective investigations.

Keywords: hip fracture, the elderly, prevalence, risk factor, NHANES

Introduction

Recently, the elderly with hip fractures have become an increasingly serious public health problem worldwide. As the global society continues to age, the number of elderly patients with hip fractures has increased dramatically. It is estimated that by the middle of this century, more than 6 million individuals will suffer from hip fractures each year around the world, and most of them are elderly.[1–3] Meanwhile,

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the disease conditions of elderly patients with hip fractures tend to be complicated, and the pressures that the medical and health service system must face is becoming more and more severe. Thus, due to the poor prognosis, various kinds of complications and high mortality, the elderly with hip fractures are often regarded as "the last fracture of whole life".[4–6] With regard to this, common risk factors of hip fractures in the elderly have also been reported in previous literature, which mainly includes advanced age, gender, smoking, drinking alcohol, hypertension, diabetes, and osteoporosis, and so on.[5,6]

However, the health management of elderly patients with hip fractures still has a long way to go. In this process, it is necessary to emphasize the prevention work before fractures, so as to avoid the domino effect caused by fracture as much as possible, such as the continued disability or even lethal effect, and the severe burden and consumption of financial, material and human resources.[7–9] Regarding this, effective recognition of the associated risk factors of the elderly with hip fractures can provide a theoretical basis for the effective prevention of hip fractures. Therefore, this study is aimed to comprehensively investigate the prevalence, characteristics, and associated risk factors of the elderly with hip fractures based on a population from the NHANES 2005–2010. To the best of our knowledge, this is the first time to extract and analyze the relevant data of hip fractures in the elderly through the NHANES database, so as to provide a certain reference value for the related research in the future.

Methods
Data Source and Study Participants

The overall data in this study was obtained from the NHANES database during 2005–2010. In order to address the emerging public health issues and provide objective data on health conditions for American civilians, the NHANES database was set up and constantly updated and improved by American Centers for Disease Control and Prevention (CDC). Moreover, the representative sample of the non-institutionalized American civilians in each 2-year data collection cycle, such as health information and laboratory data, were selected by CDC via a multistage and complicated clustered probability design, which are all accessible for the researchers on the internet.[10]

In this study, we included a total of 31,034 participants from NHANES 2005–2010, and 4,265 participants aged 65 years and older remained after exclusion of three subjects with unclear memory of self-experienced hip fractures. Moreover, Figure 1 reveals the flow chart of the sample selection. During the process of extracting data from the NHANES database, the sequence of fracture history and risk factors were matched to each other by collection circles, which was also a fixed circle with continued information updated. In addition, it is worth noting that this is an exempt study due to the fact that the current study only involved secondary data analysis of the existing NHANES database, which is publicly available and have been de-identified, thus there is no need to apply an IRB approval from our own institution.

Related Epidemiological and Demographic Characteristics

According to the timeline defined by the NHANES database, the elderly with hip fractures were divided into the year groups of 2005–2006, 2007–2008, and 2009–2010. Moreover, the epidemiological characteristics of the elderly with hip fractures in this study were mainly described by 2-year as a cycle in the following variables: age, gender, total number of the elderly, prevalence of the elderly with hip fractures, times of hip fractures, and the specific age and factors of hip fracture in each time. In addition, it is also worth noting that, although this study included the information of the elderly (aged 65 years and older) with hip fractures, the first time they had a hip fracture might have been in childhood or adolescence.

Study Variables and Covariates

Furthermore, the overall individuals included in this study were naturally divided into the hip fracture group and non-hip fracture group according to the exact history of hip fractures. In the NHANES 2005–2010, the self-reported conditions of individuals in this study were collected through the method of questionnaires, including age, gender, race (Mexican American, Other Hispanic, Non-Hispanic White, Non-Hispanic Black, and Other Race), marital status (married, living with partner, widowed, divorced, separated, and never married), smoking, drinking alcohol, combined with diseases (hypertension, diabetes, and osteoporosis), the medication history of the prednisone or cortisone, and the parents' history of hip fractures. Moreover, it is essential to note that the
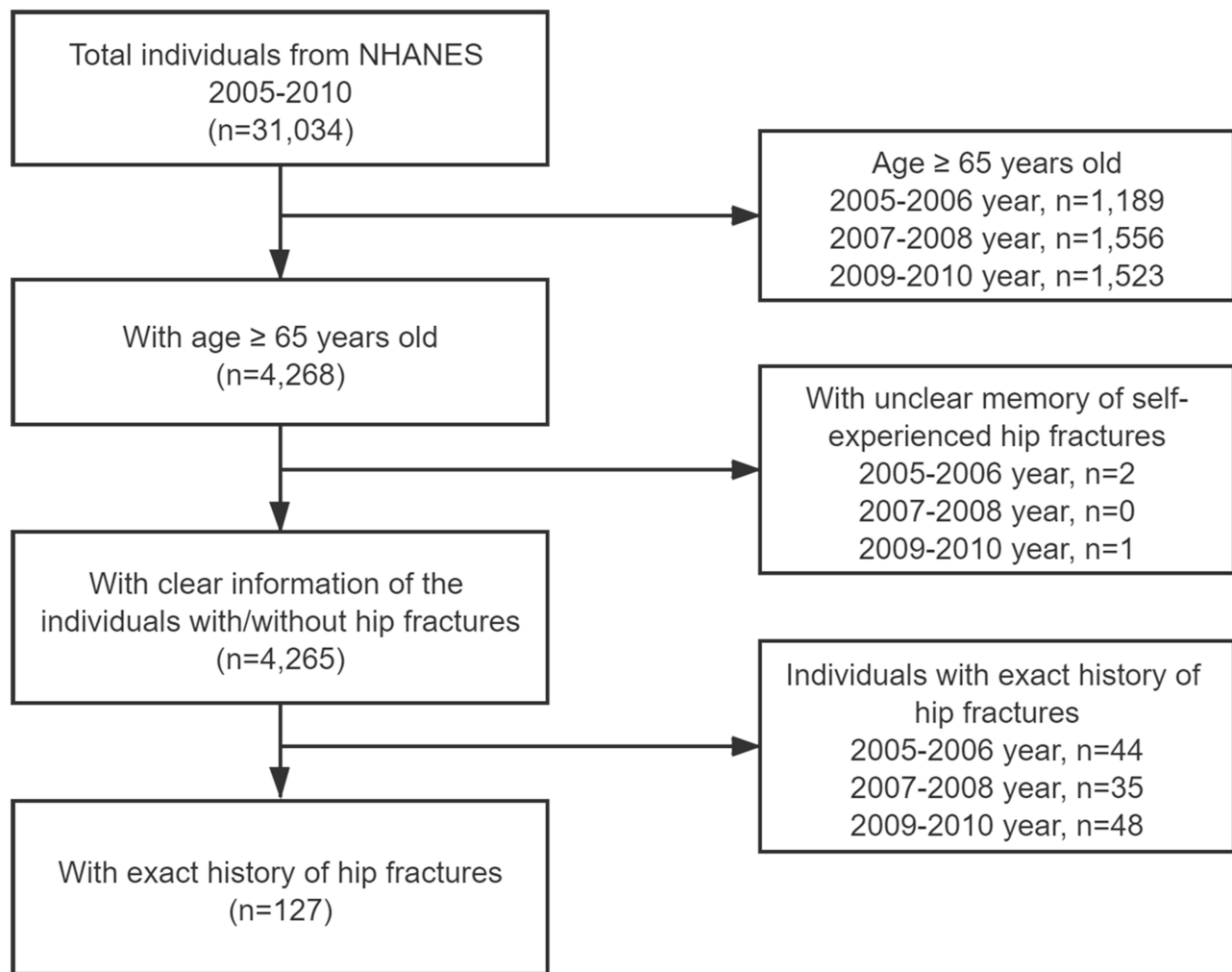
Figure 1 Flow chart of the sample selection from the NHANES 2005–2010.

condition of hip fractures was determined according to the professional orthopedic surgeons' diagnosis. The details of study variables and covariates in this current study are all able to be wholly searched at the webpage of www.cdc.gov/nchs/nhanes.

Statistical Analysis

The overall data in this current study were extracted and statistically analyzed by the R version 4.0.3 software (R Foundation, Vienna, Austria) and SPSS 26.0 software (SPSS, Inc, Chicago, IL, USA), and manifested as mean ±standard deviation (SD) or count (percentage). Moreover, accounting for the complicated sample survey designs, the related epidemiological and demographic characteristics between the participants with and without hip fractures were evaluated by Student's *t*-test for continuous variables and Chi-square test for categorical variables. Moreover, for

the variables of age, gender, race, marital status, smoking, drinking alcohol, combined with diseases, the medication history of prednisone or cortisone and the parents' history of hip fractures were all assessed by the univariate analysis to screen the risk factors of hip fractures in the elderly. Then the logistic regression model was applied to conduct the multivariate analysis of associated risk factors in the elderly with hip fractures. In the logistic regression models, the link between the hip fractures and associated risk factors was exhibited as an odds ratio (OR) with a 95% CI. A *P*-value<0.05 was regarded as statistically significant.

Results

In a total of 4,265 participants with clear information of hip fractures in elderly, 127 individuals with hip fracture were identified according to the results of questionnaires, exhibiting a prevalence of 28.49 per 1,000 (95%

CI=21.38–35.60) for males and 31.03 per 1,000 (95% CI=23.72–38.35) for females. In addition, the mean age of elderly with hip fractures included in this study was 77.12±5.88 years, and the females occupied a higher proportion (67/127, 52.8%). As for the frequency of hip fractures in elderly, it mainly only occurred once (116/127, 91.3%), and the occurrence of five times was the peak among the included individuals. Moreover, excluding the missing data in the NHANES database, from the factors of hip fracture that all included individuals suffered in the first time, tumble was the first (61/127, 48.0%), and fall from height ranked the second (26/127, 20.5%). Compared with the young and middle-aged individuals with hip fractures, traffic accidents were much lower in elderly with hip fractures (6/127, 4.7%).[11] Besides, the proportion of individuals with multiple occurrences of fractures was 41/127 (32.3%). Related epidemiological and demographic characteristics of the elderly with hip fractures included in NHANES from 2005 to 2010 are summarized in Table 1, and the age and factors of

the second to fifth times hip fracture of partial elderly are presented in the Supplementary Table 1.

Table 2 reveals the univariate analysis of associated risk factors in the elderly with hip fractures. Therein, the mean age was significantly older in the hip fracture group (77.12±5.88 years) than in the non-hip fracture group (74.14±5.69 years), (t=5.813, P<0.001). Furthermore, by further dividing the included individuals into the groups of 65–80 years and ≥80 years, it can be discovered that the hip fracture group has the higher age characteristics (χ^2=36.487, P<0.001). In terms of the factor of race, Non-Hispanic White exhibited a higher incidence of the elderly with the hip fractures than other ethnic groups (χ^2=20.212, P<0.001). Moreover, similar to the several previous reports,[12–15] the factors of smoking and drinking alcohol were also regarded as the risk factors for the elderly with hip fractures (χ^2=36.914, P<0.001; χ^2=8.292, P=0.004). Additionally, individuals combined with osteoporosis in hip fractures group also showed a significant difference with the non-hip fractures group (χ^2=19.832, P<0.001),

Table 1 Related Epidemiological and Demographic Characteristics of the Elderly with Hip Fractures Included in NHANES from 2005 to 2010

Parameters	2005–2006 Year (n=44)	2007–2008 Year (n=35)	2009–2010 Year (n=48)	Total (n=127)
Age, years	79.18±6.59 (65–85)	74.77±5.64 (65–80)	76.94±4.69 (65–80)	77.12±5.88 (65–85)
Gender (n, %)				
Male	22 (50.0)	14 (40.0)	24 (50.0)	60 (47.2)
Female	22 (50.0)	21 (60.0)	24 (50.0)	67 (52.8)
Total number of the elderly, n	1187	1556	1522	4265
Prevalence of the elderly with hip fractures, %	3.71	2.25	3.15	2.98
Frequency of hip fractures (n, %)				
Once	41 (93.2)	31 (88.6)	44 (91.7)	116 (91.3)
Twice	2 (4.5)	3 (8.6)	4 (8.3)	9 (7.1)
Three times	1 (2.3)	0	0	1 (0.8)
Four times	0	0	0	0
Five times	0	1 (2.8)	0	1 (0.8)
Age when 1st time hip fracture occurred, years	64.32±23.10 (7–85)	57.37±22.62 (7–80)	61.77±20.71 (1–80)	66.24±19.49 (1–85)
Factors of 1st time hip fracture (n, %)				
Tumble	23 (52.3)	13 (37.1)	25 (52.1)	61 (48.0)
Fall from height	6 (13.6)	9 (25.7)	11 (22.9)	26 (20.5)
Traffic accidents	3 (6.8)	2 (5.7)	1 (2.1)	6 (4.7)
Data missing	12 (27.3)	11 (31.5)	11 (22.9)	34 (26.8)
Combined with multiple occurrences of fractures	21 (47.7)	9 (25.7)	11 (22.9)	41 (32.3)

Abbreviation: NHANES, National Health and Nutrition Examination Surgery.

Table 2 Univariate Analysis of Associated Risk Factors in the Elderly with Hip Fractures Included in NHANES from 2005 to 2010

Parameters	Hip Fracture Group (n=127)	Non Hip Fracture Group (n=4138)	Statistics	P-value
Age, years	77.12±5.88 (65–85)	74.14±5.69 (65–85)	t=5.813	<0.001
65–80	59 (46.5)	2,949 (71.3)	χ^2=36.487	<0.001
≥80	68 (53.5)	1,189 (28.7)		
Gender (n, %)				
male	60 (47.2)	2,046 (49.4)	χ^2=0.239	0.625
female	67 (52.8)	2,092 (50.6)		
Race (n, %)				
Mexican American	13 (10.2)	469 (11.3)	χ^2=20.212	<0.001
Other Hispanic	7 (5.5)	261 (6.3)		
Non-Hispanic White	96 (75.6)	2,557 (61.8)		
Non-Hispanic Black	6 (4.7)	720 (17.4)		
Other Race	5 (3.9)	131 (3.2)		
Marital status (n, %)				
Not living alone	59 (46.5)	2,254 (54.5)	χ^2=3.242	0.072
(Married, living with partner)				
Living alone	68 (53.5)	1,879 (45.5)		
(Widowed, divorced, separated, never married)				
Smoking (n, %)				
Yes	63 (49.6)	894 (21.6)	χ^2=36.914	<0.001
No	64 (50.4)	3,242 (78.4)		
Drinking alcohol (n, %)				
Yes	47 (48.5)	1,323 (37.2)	χ^2=8.292	0.004
No	50 (51.5)	2,234 (62.8)		
Combined with hypertension (n, %)				
Yes	77 (61.6)	2,569 (62.2)	χ^2=0.020	0.888
No	48 (38.4)	1,560 (37.8)		
Combined with diabetes (n, %)				
Yes	26 (21.3)	902 (21.8)	χ^2=0.018	0.892
No	96 (78.7)	3,231 (78.2)		
Combined with osteoporosis (n, %)				
Yes	36 (28.6)	588 (14.3)	χ^2=19.832	<0.001
No	90 (71.4)	3,524 (85.7)		
Ever taken prednisone or cortisone daily (n, %)				
Yes	13 (10.7)	270 (6.6)	χ^2=3.075	0.079
No	109 (89.3)	3,810 (93.4)		
Did mother ever suffer from hip fracture? (n, %)				
Yes	13 (11.2)	339 (8.7)	χ^2=0.910	0.340
No	103 (88.8)	3,572 (91.3)		
Age when mother's hip fracture occurred, years	77.75±14.54 (50–100)	77.95±12.29 (32–101)	t=0.055	0.956
Did father ever suffer from hip fracture? (n, %)				
Yes	5 (4.4)	84 (2.2)	χ^2=1.582	0.208
No	108 (95.6)	3,755 (97.8)		
Age when father's hip fracture occurred, years	85.75±9.03 (80–99)	75.52±20.45 (9–103)	t=0.992	0.324

Abbreviation: NHANES, National Health and Nutrition Examination Surgery.

Table 3 Multivariate Analysis of Associated Risk Factors in the Elderly with Hip Fractures Included in NHANES from 2005 to 2010

Risk Factors	β	Wald	P	OR	95% CI
Age (≥80 years)	0.133	49.850	<0.001	1.142	1.101–1.185
Marital status (Widowed, divorced, separated, never married)	0.780	13.006	<0.001	0.458	0.300–0.700
Smoking (Yes)	3.354	216.029	<0.001	0.035	0.022–0.055
Combined with diabetes (Yes)	0.492	5.424	0.020	1.636	1.081–2.475
Combined with osteoporosis (Yes)	0.639	9.414	0.002	1.895	1.260–2.850

Abbreviations: NHANES, National Health and Nutrition Examination Surgery; OR, odds ratio; CI, confidence interval.

and no significant difference between the two groups were identified in terms of other factors.

The multivariate analysis of associated risk factors in the elderly with hip fractures are summarized in Table 3, which indicates that individuals aged 80 years and older (OR=1.142, 95% CI=1.101–1185, $P<0.001$), living alone (OR=0.458, 95% CI=0.300–0.700, $P<0.001$), smoking (OR=0.035, 95% CI=0.022–0.055, $P<0.001$), combined with diabetes (OR=1.636, 95% CI=1.081–2.475, $P=0.020$), and combined with osteoporosis (OR=1.895, 95% CI=1.260–2.850, $P=0.002$) were the apparent independent risk factors of the elderly with hip fractures.

Discussion

With the increase of age, the functions of various organs and tissues of the elderly gradually degenerate, and the physical function and physiological reserve capacity also decline. Moreover, the elderly usually have a combination of osteoporosis and a variety of comorbidities, which easily results in the occurrence of hip fractures.[16,17] The result of this study reveals that the mean age of the hip fracture group is 77.12±5.88 years, and the female occupies a higher proportion (52.8%). This result may be related to the significantly higher incidence of postmenopausal osteoporosis in females than males. Osteoporosis in the elderly can bring about the increased fragility of bone, and only a slight trauma will cause the fractures.[18] Additionally, the prevalence of hip fractures in the elderly is generally on the rise. Based on the information collected

in NHANES 2005–2010, the prevalence of the elderly with hip fractures is 28.49 per 1,000 (95% CI=21.38–35.60) for males and 31.03 per 1,000 (95% CI=23.72–38.35) for females, which is generally higher than the previous reports between 1986 and 2005, with the annual mean number of hip fractures was 4.14 per 1,000 (95% CI=4.02–4.27) for males and 9.57 per 1,000 (95% CI=9.22–9.93) for females.[19] Meanwhile, this result also vividly interprets the severe test and heavy pressure brought by the geriatric hip fractures to the health service system, which emphasizes the significance of the prevention and control of it.

Furthermore, this study also indicates that tumble (48.0%) is the primary factor of the elderly with hip fractures, which is consistent with the report by Dontas and Yiannakopoulos.[20] Regarding this, in addition to the common factor of osteoporosis, the coordination and reaction abilities of the elderly also continue to decline with the increase of age. In this process, the muscle strength and the response of muscles around the hip joint are reduced, which is unable to effectively offset the harmful stress. This phenomenon also explains that when the hip joint is subjected to the external stress, fractures can be caused without obvious trauma. Thus, active anti-osteoporosis treatment and several kinds of effective measures to prevent the tumble, such as wearing anti-skid shoes, strengthening physical exercise and avoiding water on the ground, are the key to prevent the hip fractures in the elderly.

In addition to the factors of age and osteoporosis, race (mainly non-Hispanic white), smoking, drinking alcohol, living alone, and combined with diabetes are also vital risk factors of the elderly with hip fractures. Therein, common risk factors, such as age, gender, smoking, drinking alcohol, and osteoporosis, are basically consistent with the current international hip fracture assessment tools (such as the FRAX, Garvan Fracture Risk Calculator, and Qfracture) or the factors contained.[21,22] However, this current study has observed that the risk factors of race and living alone are also the significant risk factors for the geriatric hip fractures. Compared with other races included in the NHANES database, the non-Hispanic white exhibits a higher incidence of hip fractures in the elderly (75.6%, $P<0.001$), which may be associated with the factors such as the specific race genes, dietary characteristics, and lifestyle habits. Furthermore, similar to the previous reports by Shen et al[23] and Ward and Klesges,[24] smoking ($\chi^2=36.914$, $P<0.001$) is another significant risk factor for

elderly with hip fractures. According to a previous study performed by Marques et al,[25] smoking can promote the occurrence of fractures by affecting the bone mineral density, and the influence of smoking on the risk of fractures is dose-dependent. When the smoking index reaches more than 200 cigarettes per year, the incidence of fractures is significantly increased.[26] Meanwhile, in a large-scale cohort study, Gerdhem and Obrant[27] also found that the risk of hip fractures in the elderly can be significantly reduced after 10-years of smoking cessation. Similarly, drinking alcohol (χ^2=8.292, P=0.004) can also trigger the elderly towards hip fractures by affecting the bone mineral density. A previous study performed by Kim et al[28] revealed that the bone mineral density of the femur and lumbar vertebrae will decrease in varying degrees in individuals who drink 40–100 g per day and have a history of drinking alcohol for more than 3 years. Hence, this study further reveals the significance of standardized smoking and alcohol cessation for the prevention of hip fractures in the elderly.

Interestingly, we have also unexpectedly observed that living alone is a vital risk factor of the elderly with hip fractures in this current study. In multivariate analysis, the factor of living alone (including the widowed, divorced, separated, and never married) showed asignificant statistical difference (OR=0.458, 95% CI=0.300–0.700, P<0.001), which may be related to the fact that this type of individual is mostly living alone. Due to the lack of care from their spouse and children, hip fractures are frequent in these individuals, which needs more attention from the medical and healthcare personnel, so as to strengthen the regular prevention and education of this group of individuals.

As a common concomitant disease in the elderly with hip fractures, diabetes has also been reported as a common risk factor in previous studies.[29,30] However, in this study, the elderly with diabetes in the hip fracture group (21.3%) were similar to the non-hip fracture group (21.8%) and showed no significant difference in the univariate analysis (P=0.892). However, after the inclusion of multivariate analysis, there was a significant statistical difference (OR=1.636, 95% CI=1.081–2.475, P=0.020). This result may be related to the data loss of partial individuals in the NHANES database, which needs to be further included, analyzed, and verified in the future. However, it is certain that previous studies have indicated that glucose metabolites can affect the activity and function of the osteoblasts and osteoclasts,[31,32] and the degradation and reconstruction of the bone matrix will also increase the bone fragility. Moreover, diabetes-related complications will also affect the activity and balance ability of individuals, thereby increasing the risk of tumble.[33] Hence, it is still essential to pay attention to the risk factors of diabetes and its related complications in the elderly.

Currently, the research conclusions regarding the relationship between hip fracture and cardiovascular disease in the elderly are not consistent. Bagger et al[34] suggested that elderly females with cardiovascular diseases have an increased risk of hip fracture. However, Sinnott et al[35] pointed out that osteoporosis and atherosclerosis were two independent processes in postmenopausal females. In addition to cardiovascular diseases, the elderly individuals were often accompanied with various kinds of chronic diseases, which jointly affect the physical and mental health and result in the decreased motor function and increased risk of tumble. In this current study, the result shows that the hip fracture group with hypertension (61.6%) is similar to the non-hip fracture group (62.2%), and there is no significant statistical significance in the univariate or multivariate analysis. However, it is still necessary for us to recognize that the incidence of hip fractures in the elderly may be related to dizziness caused by hypertension and increased risk of tumble due to cardiovascular and cerebrovascular diseases.[36,37]

Ultimately, it is still essential to recognize and point out certain shortcomings in this current study. On one hand, this study is restricted by the self-reported nature of partial variables, such as history and factors of hip fractures and medication history of the prednisone or cortisone, and the inevitable report bias and recall bias might exist in this process. Despite this restriction, the overall data collection procedures in the NHANES database are reliable, and have been well validated for capturing accurate individuals sampling on which to ascertain the prevalence estimates. On the other hand, the sample size with reported hip fractures was relatively small, and only 127 individuals aged 65 years and older were ultimately included in the final analysis, which needs to include more years and a larger sample size for further analysis and validation in the future. In addition, limited by the updating mode of population information in NHANES database, the next cycle of geriatric hip fracture cases/controls will be planned to be conducted after the data in the NHANES database is completely updated in the future.

Conclusions

To sum up, based on the data extracted from the existing NHANES database from 2005 to 2010, the prevalence of hip fractures in the elderly is generally on the rise, and females occupy a higher proportion. Moreover, tumbling is the primary factor of hip fractures in elderly, and five is the highest number of occurrences among the included individuals. Compared with the non-hip fracture group, the hip fracture group in the elderly revealed a higher age characteristic, especially for the individuals aged 80 years and older. In addition to the common risk factors related to hip fractures in elderly (age, smoking, drinking alcohol, combined with diabetes and osteoporosis), race (mainly the Non-Hispanic white) and living alone are also significant risk factors for hip fractures in elderly, although these variables still need to be verified in further prospective investigations.

Ethical Statement

This study was conducted in accordance with the principles of the Declaration of Helsinki. The NHANES database used in this study did not contain identifiable nor protected the health information and is publicly available for download. Moreover, this is an exempt study due to the fact that the current study only involved secondary data analysis of the existing NHANES database, which is publicly available and has been de-identified, thus there is no need to apply an IRB approval from our own institution.

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Disclosure

The authors have no conflict of interest to disclose in relation to this article.

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