

Prevalence, Characteristics, and Associated Risk Factors of Wrist Fractures in Americans Above 50: the Cross-sectional NHANES Study

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Abstract

Background

Wrist fractures, also known as distal radius fractures, are the most common fractures occurred in the upper limb. This study is conducted in the purpose of evaluating the prevalence, characteristics, and associated factors of wrist fractures in Americans that aged 50 and above.

Methods

Data of Americans aged 50 or above from the year 2013 to 2014 and 2017 to 2018 in NHANES was extracted and analyzed. Based on orthopedist's diagnosis, we further conducted surveys to determine the condition of wrist fractures, and collected relevant epidemiological and demographic data. The prevalence of wrist fractures and other statistics were calculated to study population characteristics and analyze potential risk factors associated with wrist fractures.

Results

The prevalence of wrist fractures among Americans whose age was 50 or above was 12%, with similar results between men and women patients (male 12.8 % vs female 11.4 %, $P = 0.267$). Male and female Americans' first wrist fracture occurred at a mean age of 29.4. 17.8% of Americans aged 50 and above had experienced two fractures, while 1.7% of Americans even experienced four or more fractures. The top two causes of the first fracture were falling down from standing height (56%) and violent falls (34.8%). Multivariate analysis showed that osteoporosis (OR = 2.2, 95% CI = 1.7-2.9), excessive drinking (OR = 1.8, 95% CI = 1.3-2.4), smoking (OR = 1.6, 95% CI = 1.2-2.1), prednisolone administration (OR = 1.5, 95% CI = 1.1-2.1) and obesity (OR = 0.8, 95% CI = 0.6-0.9) were independently associated with wrist fractures. Gender was not an independent risk factor associated with wrist fractures.

Conclusions

The prevalence of wrist fractures in Americans aged 50 and above was 12 %. The prevalence was similar between male and female patients. Falling from a standing height was the main cause of the first wrist fracture. Osteoporosis, excessive drinking, smoking and prednisolone administration were risk factors of wrist fractures, while obesity was negatively correlated.

Introduction

Wrist fracture is one of the most common fractures occurred in the United States, accounting for about one-sixth of all fractures treated in emergency departments. The prevalence of wrist fracture increases with age[1–4]. Studies have implied a significantly increased risk of recurrent wrist fractures within 7 years after the incidence of the initial wrist fracture. Risks of hip and vertebral fractures increased as well[5–7]. Fractures are usually followed by acute pain and swelling in the wrist and lead to dysfunction of wrist and even the quality of life if not being treated timely or appropriately [8, 9]. There is also an

increased risk of death following wrist fractures: within 5 years of the occurrence of distal fracture of the forearm, patients age 65 to 74 have a death risk of 13.1%, while patients above 85 years old was 44.8% [10]. It is predicted that by the year 2040, treatment cost for fractures would add up to \$50 billion, which adds the burden of the national health care system[11].

In the US., the incidence rate of wrist fractures were three times higher than that of hip fractures. Therefore, even though the cost for hip fractures treatment per patient is higher, the overall treatment fee for wrist fractures excels hip and other fractures, which is why wrist fractures have drawn more attention from health care[7, 12]. Therefore, it is high time that we design more studies to assess the prevalence, characteristics and associated risk factors of wrist fracture, contributing to their prevention and treatment measures. However, epidemiological studies on that incidence of wrist fractures were limited[5, 13]. There has not been reports on the prevalence of wrist fractures yet. Therefore, this study aimed to comprehensively investigate the prevalence, characteristics and related risk factors of wrist fracture among Americans aged 50 and above according to NHANES data from 2013 to 2014 and 2017 to 2018. To the best of our knowledge, our study conducted the first research on patients with wrist fractures above 50 years of age based on data extracted from the NHANES database, which can enlighten the understanding for the disease as well as lending insight into prevention and improving prognosis.

Methods

Study population

The National Health and Nutrition Examination Survey (NHANES) is a bi-yearly stratified cross-sectional study of the population in the United States conducted by Centers for Disease Prevention and Control (CDC). NHANES was approved by the CDC for written informed consent from each participant. NHANES data are publicly available for use worldwide. The data of 19,429 Americans aged 50 or above from the year 2013 to 2014 and 2017 to 2018 NHANES was extracted to estimate the prevalence of wrist fractures among US civilian population aged ≥ 50 . All study subjects were examined physically and evaluated at medical centers. 13,587 subjects containing missing information on wrist fractures were excluded. The remaining 5,842 subjects, containing 554 wrist fracture cases (male $n = 239$, female $n = 315$), were included into our study cohort.

Study variables

NHANES data were collected through standardized questionnaires and medical evaluation at medical centers. In combination with the epidemiological characteristics of previous wrist fractures and NHANES data variables, we collected the following variables of Americans aged 50 and above: age, gender, number of fractures onsets, the specific age and cause of the first wrist fracture; race (Mexican-American, Other Hispanic, Non-Hispanic White, Non-Hispanic Black, other race-including multi-racial), education (less than high school, high school or than), marital status, smoking history, drinking history, obesity,

hypertension, diabetes, osteoporosis, medication history of prednisone or cortisone, and hip fracture history of parents. Participants were defined as high blood pressure patients if he complied at least one following condition: 1. currently taking antihypertensive medications, 2. previously diagnosed by a physician, 3. four blood pressure measurements indicated a mean systolic blood pressure ≥ 130 mmHg, 4. diastolic blood pressure ≥ 80 mmHg[14]. Obesity was defined if body mass index (BMI) ≥ 30 [15]. Diabetes was defined if the participant complied with at least one of the following conditions: 1. diagnosed by a physician, 2. currently taking hypoglycemic drugs, 3. fasting blood glucose ≥ 130 mg/dl, 4. glycated hemoglobin $\geq 6.5\%$ [16]. Kidney conditions were estimated based on the glomerular filtration rate in serum creatinine, $eGFR (mL/min/1.73m^2) = 175 \times \text{standardized Scr} - 1.154 \times \text{age} - 0.203 \times 1.212$ [if black] $\times 0.742$ [if female][17]. $eGFR < 60mL/min/1.73 m^2$ were defined as chronic kidney disease (CKD), indicated by the Modification of Diet in Renal Disease (MDRD) Study [18]. Marital status included living alone (unmarried, separated, divorced, and widowed) and not living alone (living with a partner, married). All details of study variables in this study could be accessed in www.cdc.gov/nchs/nhanes.

Statistical Analysis

Considering the complex design of study of NHANES, we applied the survey package in R 4.0.5 to calculate sample-weighted prevalence and other statistics to study the population characteristics of American wrist fracture patients. Continuous variables were expressed as mean standard, enumeration data were expressed as percentage (%), t-test was used for continuous variables, and chi-square test was used for categorical variables. In addition, variables such as age, gender, race, education, marital status, smoking, alcohol consumption, medication history of prednisone or cortisone, disease, and history of wrist fractures in the parents were applied in univariate analysis. The covariate with P value < 0.20 in univariate analysis was included in the multivariate logistic regression analysis to study risk factors related to wrist fracture. Statistical analysis was performed using R (R package, version 4.0.5). P < 0.05 (two-sided) were considered as statistically significant.

Results

1. Clinical characteristics

Clinical characteristics of the study population was displayed in Table 1. Men took up 46.5% of the total cases while women took up 53.5%. The weighted mean age was 63.7. Races included Mexican American, Other Hispanic, Non-Hispanic White, Non-Hispanic Black, Other Races - Including Multi-Racial. Other characteristics included frequent drinking, non-smokers, current smoker, obesity, daily uptake of prednisone or cortisone, combination of osteoporosis, and parent history of wrist fractures.

Table 1
Clinical characteristics of the study population

Parameters	Total	Nonfracture	Fracture	p-value
	Mean or % [95% CI]	Mean or % [95% CI]	Mean or % [95% CI]	
N*	5842	5288	554	-
Age(mean,years)	63.7[63.2,64.2]	63.7[63.2,64.2]	63.8[62.7,64.9]	0.8709
Sex (%)				
Male	46.5[45.1,48]	46.1[44.7,47.5]	46.1[44.7,47.5]	0.2676
Female	53.5[52,54.9]	53.9[52.5,55.3]	50.7[45,56.3]	0.2676
Race (%)				
Mexican American	5.4[3.9,7.4]	5.7[4.1,7.8]	3.4[1.8,6.3]	0.0699
Other Hispanic	4.7[3.8,5.8]	4.9[4.0,6.1]	2.8[2.0,4.0]	0.0014
Non-Hispanic White	72[67.9,75.8]	70.4[66,74.5]	83.6[79.4,87]	< 0.0001
Non-Hispanic Black	10.2[8.2,12.5]	10.7[8.6,13.3]	5.9[4.5,7.7]	0.0001
Other Race - Including Multi-Racial	7.7[6.3,9.5]	10.7[8.6,13.3]	5.9[4.5,7.7]	0.0042
Marital status (%)				
Living alone	33.9[31.9,35.9]	35.3[32.9,37.7]	35[30.7,39.5]	0.9011
Not living alone	36.7[34.9,38.5]	64.7[62.3,67.1]	65[60.5,69.3]	0.9011
Level of education (%)				
Less than high school	13.9[17.8,16.2]	14.2[12,16.8]	11.4[8.4,15.3]	0.1985
High school or than	86.1[80.7,91.6]	85.8[79.7,91.9]	88.6[78.0,99.5]	0.1225
Drinking (%)				
Never	32.3[29.7,35]	32.7[30.2,35.3]	29.5[23.6,36.1]	0.2763
Occasional drink	55.6[52.6,58.5]	56.3[53.4,59.1]	50.5[43.9,57.1]	0.0607
Frequent drink	12.1[10.7,13.7]	11[9.8,12.4]	20[15,26.3]	0.0003
Smoking status (%)				
Never smoker	53.5[50.7,56.3]	54.9[52.3,57.5]	43.3[35.7,51.1]	0.003
Past smoker	32.2[30.1,34.3]	31.6[29.5,33.8]	36.2[29.5,43.5]	0.1823
*Unweighted calculation				

Parameters	Total	Nonfracture	Fracture	p-value
	Mean or % [95% CI]	Mean or % [95% CI]	Mean or % [95% CI]	
Current smoker	14.3[12.6,16.3]	13.5[11.8,15.3]	20.5[15.9,26.1]	0.0016
Obesity (%)	42[39.6,44.4]	41.3[39,43.6]	46.8[40.8,52.9]	0.049
Combined with chronic kidney disease (%)	50.5[48.9,52.2]	50.5[48.9,52.2]	50.6[44.9,56.2]	0.989
Combined with hypertension (%)	72.6[70.6,74.6]	72.6[70.3,74.7]	72.9[66.7,78.3]	0.9277
Combined with diabetes mellitus(%)	22[20.8,23.3]	21.7[20.4,23.1]	23.9[19.8,28.5]	0.334
Combined with heart failure (%)	4.6[3.9,5.5]	4.5[3.8,5.4]	5.6[3.6,8.4]	0.3034
Combined with stroke (%)	5.9[5.2,6.8]	5.8[5,6.7]	6.7[4.5,10]	0.5205
Every taken prednisone or cortisone daily (%)	7.5[6.5,8.5]	6.9[5.9,8.1]	11.3[7.7,16.4]	0.0345
Combined with osteoporosis (%)	10.4[9.1,11.8]	9.3[8.2,10.5]	18.4[13.6,24.5]	< 0.0001
History of Parents wrist fractures (%)	17.2[15.7,18.7]	83.5[81.7,85.2]	77.6[73.3,81.4]	0.0123
*Unweighted calculation				

2. Population characteristics of wrist fractures from NHANES, 2013–2014 and 2017–2018

Among the total 5,842 US participants ≥ 50 years of age, 554 patients with wrist fractures were identified via standard questionnaire described above. The prevalence of wrist fractures was 12%, with similarities in men and women (male 12.8% vs female 11.4%, $P = 0.267$) (Fig. 1). Non-Hispanic White had the highest prevalence of 14% and there was significant difference in prevalence between Non-Hispanic White and other ethnic groups (Fig. 2). Male patients usually experienced a higher prevalence of the first wrist fractures under the age of 25 than women, while women had a higher prevalence than men once they reached the age of 50 (Fig. 3). Among the studied cases, the first fracture incidence occurred at a mean age of 29.4, which was mostly caused by falling from standing height (56%) or a violent fall (34.8%). 17.8% of the studied population experienced a second wrist fracture, while 1.7% experienced four or more. However, there was no gender difference in the cause and frequency (Table 2).

Table 2
Epidemiological characteristics of wrist fractures in the population aged 50 years or older

Parameters	Total	Male	Female	P value
	Mean or % [95% CI]	Mean or % [95% CI]	Mean or % [95% CI]	
N*	554	239	315	0.029
Age when 1st time wrist fracture occurred (years)	29.4[27.7,31.1]	24.3[22.1,26.5]	34.5[31.5,37.6]	< 0.0001
Factors of 1st time wrist fracture (%)				0.1028
A fall from standing height or less	56[46.2,65.4]	42.5[24.4,63]	60[47.9,71.1]	
A hard fall**	34.8[26.7,43.8]	38.1[24.7,53.5]	33.8[23,46.7]	
A car accident or other severe trauma	8.5[4.6,15.3]	17.6[7.2,36.9]	5.8[2.9,11.2]	
Don't know	0.7[0.2,2.8]	1.8[0.2,13.2]	0.3[0,2.5]	
Frequency of wrist fractures (%)				0.3687
Twice	17.8[11.2,27.3]	15.7[8.6,32.6]	19.9[12.1,33.1]	
Three times	5.5[3.4,11.2]	5.6[1.9,17.8]	5.4[2.2,12.4]	
Four times or more	2.2[0.9,5.2]	2.5[0.6,10.3]	1.9[0.8,4.1]	
*Unweighted calculation				
**A hard fall such as falling off a ladder or step stool, down stairs;A fall from standing height or less, for example, tripped, slipped, fell out of bed.				

3. The relationship between each variable and wrist fracture

Univariate analysis of the wrist fractures and demographic characteristics of American men and women aged ≥ 50 were showed (Table 3): There was no significant correlation between gender and wrist fracture ($P = 0.914$). Surprisingly, ethnic factors were correlated with the incidence of wrist fractures: compared to Mexican American, non-Hispanic Black were more likely to suffer from wrist fractures. Other correlated risk factors included frequent drinking, smoking, oral administration of glucocorticoids, concomitant osteoporosis, and fractures in family history and obesity.

Table 3
univariate and multivariate analysis of Wrist Fracture

Parameters	Univariate analysis	Multivariate analysis
Age	1.0 (1.0, 1.0) 0.098	1.0 (1.0, 1.0) 0.662
Female	1.0 (0.8, 1.2) 0.914	-
Not living	1.1 (0.9, 1.3) 0.538	-
More than high school	1.2 (0.8, 1.7) 0.310	-
Occasional drink	1.1 (0.9, 1.3) 0.413	1.1 (0.8, 1.3) 0.656
Frequent drink	2.1 (1.6, 2.7) < 0.001	1.8 (1.3, 2.4) < 0.001
Past smoker	1.4 (1.2, 1.8) < 0.001	1.2 (1.0, 1.5) 0.089
Current smoker	1.9 (1.5, 2.4) < 0.001	1.6 (1.2, 2.1) < 0.001
Combined with hypertension	1.1 (0.9, 1.3) 0.525	-
Combined with diabetes diabetes mellitus	0.9 (0.8, 1.1) 0.529	-
Combined with heart failure	1.1 (0.8, 1.6) 0.509	-
Combined with stroke	1.2 (0.9, 1.7) 0.165	-
Every taken prednisone or cortisone daily	1.9 (1.5, 2.5) < 0.001	1.5 (1.1, 2.1) 0.011
Combined with osteoporosis	2.4 (1.9, 3.0) < 0.001	2.2 (1.7, 2.9) < 0.001
History of Parents wrist fractures	1.4 (1.1, 1.8) 0.004	1.1 (0.8, 1.4) 0.652
Obesity	1.3 (1.1, 1.5) 0.010	0.8 (0.6, 0.9) 0.006
Combined with chronic kidney diseases	1.2 (1.0, 1.4) 0.071	1.0 (0.8, 1.3) 0.886

Multivariate analysis of the wrist fractures and demographic characteristics of American men and women aged ≥ 50 were showed (Table 3): frequent drinking (OR = 1.8, 95% CI = 1.3–2.4, $P < 0.001$), smoking (OR = 1.6, 95% CI = 1.2–2.1, $P < 0.001$), prednisolone administration (OR = 1.5, 95% CI = 1.1–2.1, $P = 0.011$), osteoporosis (OR = 2.2, 95% CI = 1.7–2.9, $P < 0.001$) were independent risk factors associated wrist fractures. However, obesity was not considered as a risk factor and obesity (OR = 0.8, 95% CI = 0.6–0.9, $P = 0.006$) in American men and women aged ≥ 50 (Table 3).

Discussion

In the present cross-sectional study of 5,842 Americans ≥ 50 years of age, the prevalence of wrist fractures was 12%, without gender difference. Non-Hispanic whites had a higher risk of fractures than other races. Under the age of 25, male patients usually experienced a higher prevalence of the first wrist

fractures than women, while women had a higher prevalence than men after the age of 50. It was discovered that falling from standing height was the main factor for wrist and forearm fracture. The population of patients with wrist fracture were found with frequent smoking, drinking history. The majority was also had a history of osteoporosis, prednisolone treatment, which accounted for a higher prevalence. However, obesity was not a positively related risk factor.

In 2000, WHO reported that the prevalence of wrist fracture in population age ≥ 50 was 18.5%[19]. Hye-Young Kwon et al. suggested that the prevalence in Korea was 4.52% with no gender difference[20]. In a retrospective study of pediatric anterior wall fractures, the prevalence of forearm fractures in children aged 0 to 17 years was 24.1% in Washington, D.C[21]. In the Oslo Health Study conducted on 5,976 participants, the prevalence of anterior wall fractures 7.2% in men and 10.1% in women between the age of 59 and 60, and men 9.1% and women 34.5% between the age of 75 and 76[22]. The Study of Women's Health Across the Nation suggested that the prevalence of forearm fractures in postmenopausal women was 15%[23]. The reason why these results differed from our result (prevalence of 12%) might due to the different parameters included of the studied cases, such as ages, regions, and the initial occurrence time. Furthermore, we discovered that non-Hispanic whites had a higher risk of fracture, which was consistent with the results of a study of fracture risk in the diabetic population[24]. The higher risk that non-Hispanic whites experienced might be related to race-specific genes and dietary characteristics[25]. We also found that the incidence of the first wrist fracture after the age of 50 was higher in women than in men, which was supported by the Oslo Health Study[22]. Women ages above 50 are usually in or about to enter their menopause, who are at higher risk of osteoporosis that may lead to brittle fractures[6, 13, 26–28].

In addition, this study also showed that falling from standing height was a major contributing factor to forearm fractures (56.0%), which was in line with the results reported by Norma J Mac Intyre and K C Chung[29, 30]. People in their adolescence (under the age of 25) are more exposed to various activities and movements that have potential danger of causing physical injuries, which included falling from the standing height[31–33]. Therefore, active anti-osteoporosis treatment and various effective measures for preventing falls, such as wearing non-slip shoes, avoiding slippery road surface and strengthening physical exercise, are vital for preventing forearm fracture.

Obesity, smoking, drinking alcohol, osteoporosis and usage of adrenal cortex hormones are common factors associated with fractures[4, 34, 35]. In our study, we have verified the positive correlation of wrist fractures with smoking, drinking, osteoporosis and prednisolone treatment. Smoking was an important risk factor for non-vertebral fracture in diabetic women, and the risk of non-vertebral fracture in diabetic women who have smoked is 3.47 times higher than that in non-smoking diabetic women[36]. Smoking can promote fracture by reducing bone mineral density in a dose-dependent manner[37]. Our study revealed that drinking alcohol also caused wrist fractures by affecting bone mineral density. Drinking alcohol was independently associated with an increased risk of forearm fractures and a dose-response relationship. Compared with non-drinkers, the RR for forearm fractures was 1.38 for women who drank greater than or equal to 25 g daily[38]. We further revealed the importance of smoking cessation and alcohol restriction for the prevention of hip fracture in the elderly.

In a study conducted by Jason Lacombe et al. showed that a higher BMI was associated with a reduced risk of forearm and wrist neck fractures compared to women with an ideal BMI of 20.0 to 24.9 kg/m² [39]. The fact that a high BMI is protective and that weight loss appears to increase the risk of fractures may indicate an interaction between bone and fat[40]. However, the results in our study showed that obesity was negatively associated with wrist fractures: our results showed a 12% prevalence of wrist fractures in Americans aged 50 and above, without gender differences. Non-Hispanic whites were presented with a greater risk of bone fractures than other races. The incidence of the first wrist fracture after the age of 50 was higher in women than in men. Obesity, occasional smoking, frequent smoking, excessive drinking, osteoporosis, and prednisolone accounted for a higher proportion in the population with wrist fractures, which was positively correlated with wrist fractures. As far as we know, this is the first study to evaluate the prevalence of wrist fractures using NHANES data, which can provide the basis for the Ministry of Health to formulate measures for the prevention and treatment of wrist fractures.

Some limitations in this study should be addressed. First, this study could not avoid the parameters being associated with reporting bias and memory bias, such as the history of wrist fractures, medication history of prednisone or cortisone, smoking and drinking history. Second, due to the design of cross-sectional study, relative conclusion of causality couldn't be obtained. Finally, some variates which were closely related to fracture, such as exercise, BMD, and vitamin D, were not considered as covariates because they contained too much missing values. Despite of the discussed limitations, the overall data collected from the NHANES database were reliable and had undergone sufficient validation to filter accurate individual samples to determine the prevalence.

Conclusions

In conclusion, our study demonstrated that the prevalence of wrist fractures in Americans aged 50 and above was 12 %. The prevalence was similar between male and female patients. Moreover, falling from a standing height was the main cause of the first wrist fracture. Osteoporosis, excessive drinking, smoking and prednisolone administration were risk factors, while obesity was negatively correlated with the prevalence of wrist fractures.

Abbreviations

NHANES: National Health and Nutrition Examination Survey; CI: Confidence interval; OR: Odds ratio; BMI: Body mass index; EGFR: Estimate the glomerular filtration rate; CKD: Chronic kidney disease.

Declarations

Acknowledgements

We thank the NHANES data for being publicly available on the Internet for use by researchers worldwide.

Authors' contributions

This study was designed by Jing Nie. Juncai Ye extracted the associated data from NHANES. Qiao Li performed statistical analysis. Juncai Ye and Qiao Li completed the composition of the manuscript. helped supervised the analysis, as well as revised and approved of the manuscript.

Consent for publication

All authors have agreed to publish the work on Journal of Orthopaedic Surgery and Research.

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Availability of data and materials

This research is a secondary analysis. Research data can be obtained from <https://www.cdc.gov/nchs/nhanes/>.

Ethics approval and consent to participate

This study does not contain any studies with human participants or animals performed by any of the authors. This 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.

Competing interests

The authors declare that they have no competing interests.

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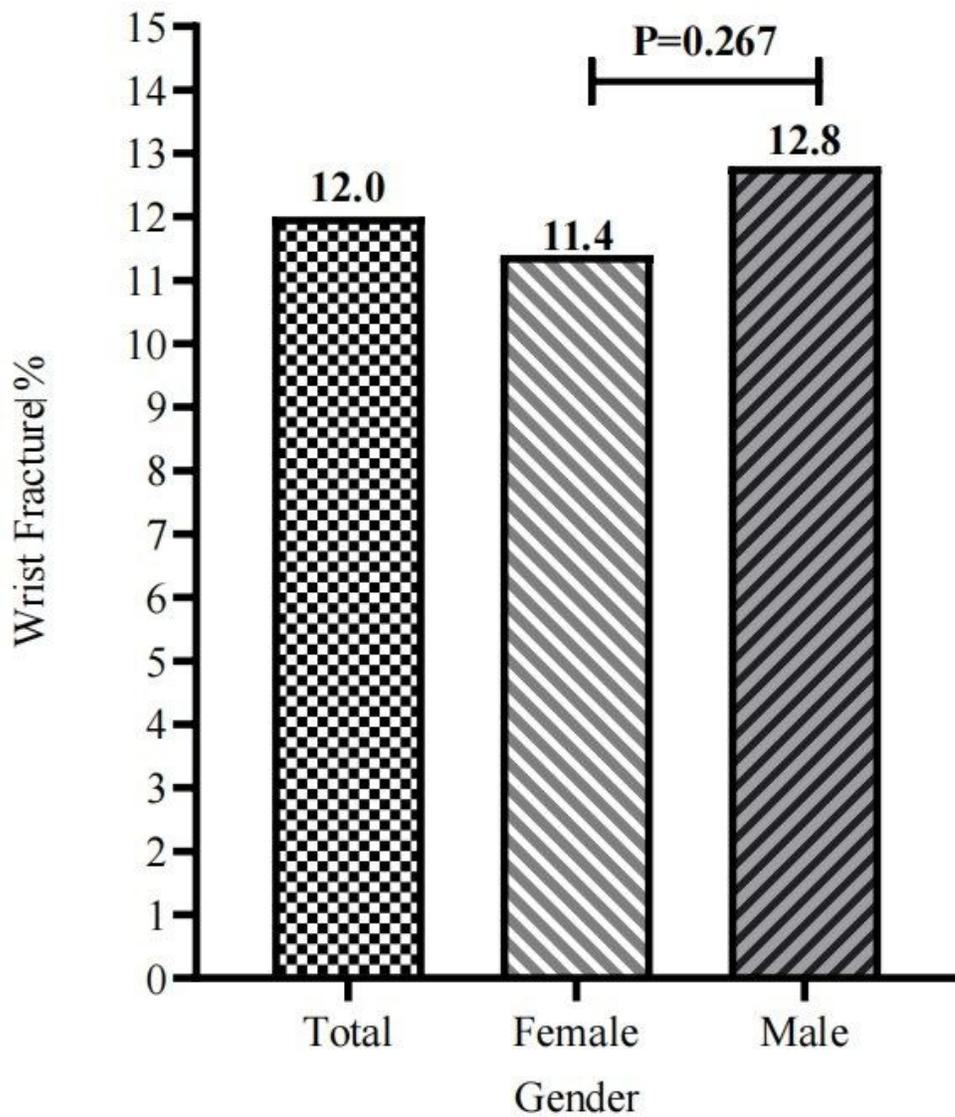
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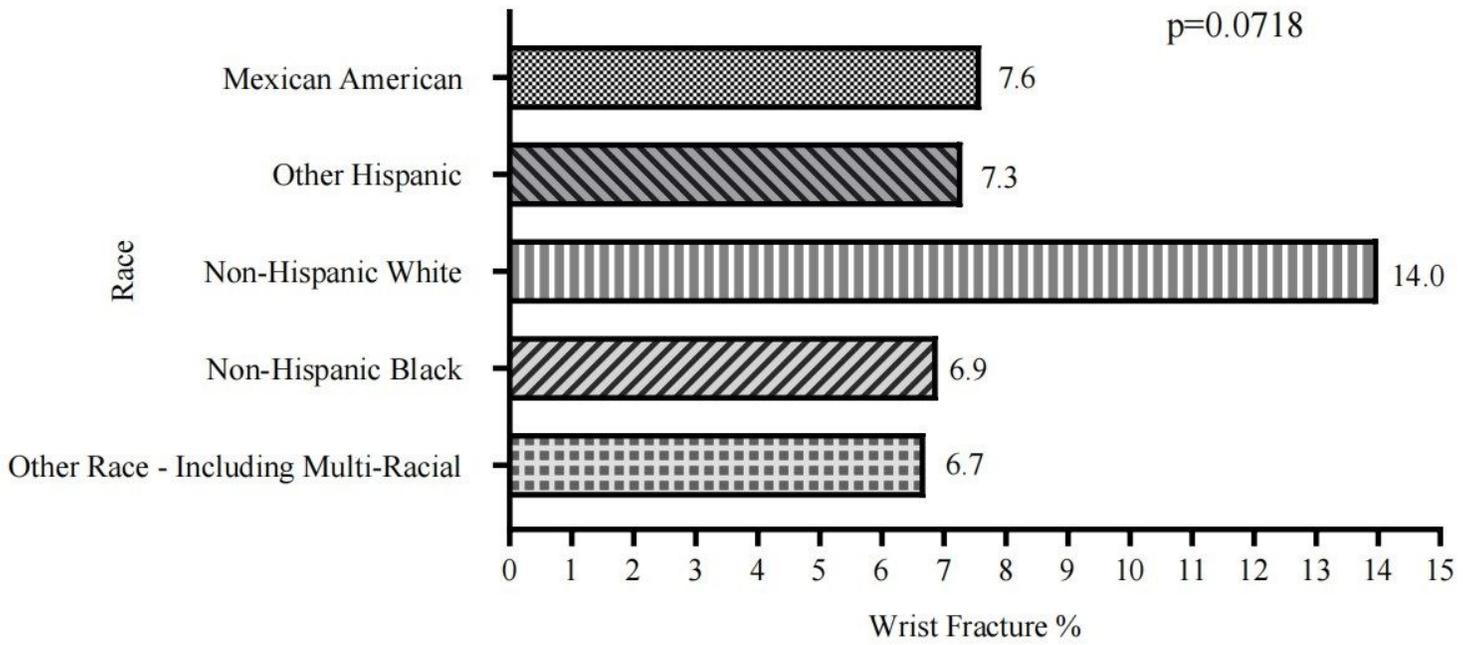
Figures



Sex	Total	Male	Female	P value
Wrist Fracture % [95% CI]	12.0[10.7,13.5]	12.8[10.8,15.0]	11.4[9.9,13.2]	0.267

Figure 1

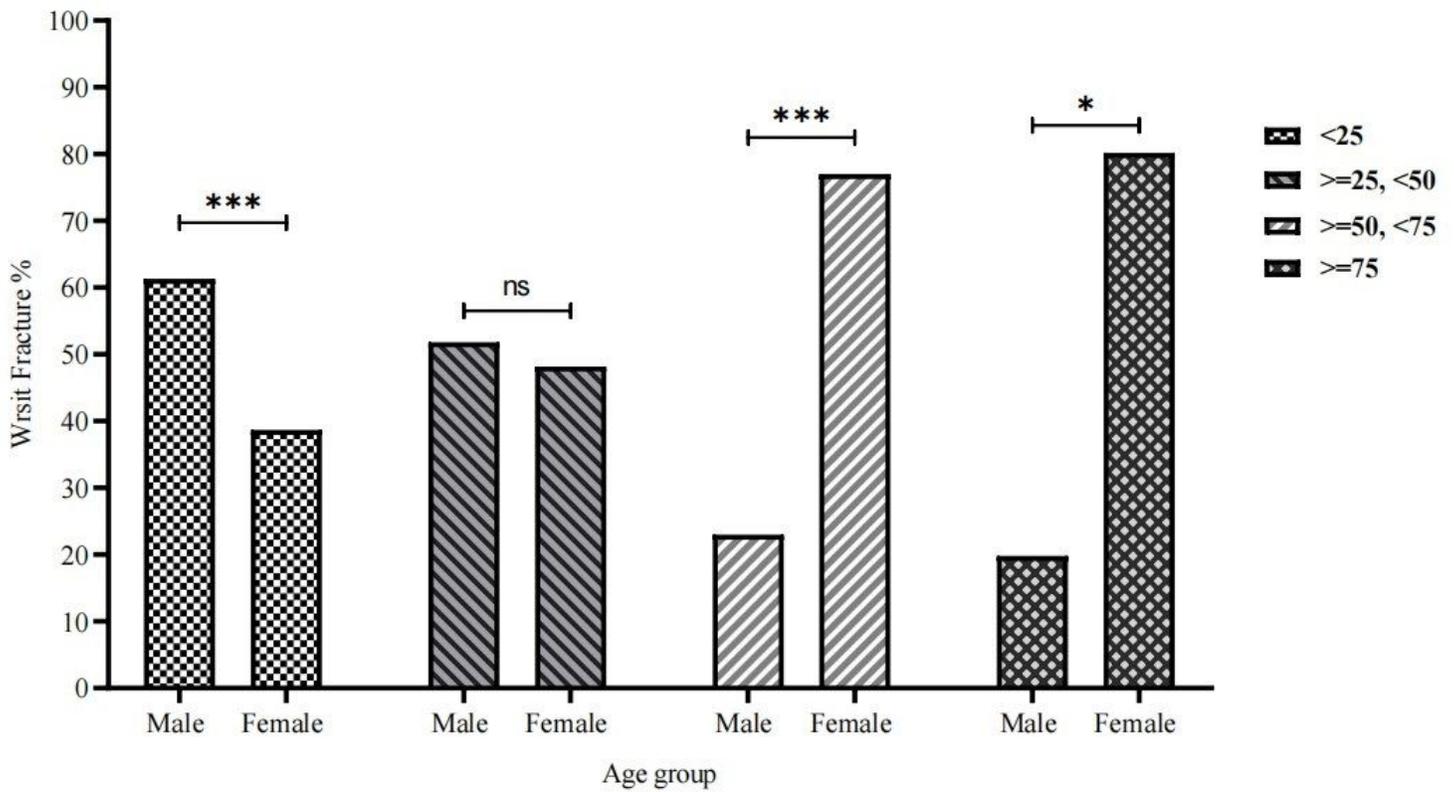
Relationship between gender and prevalence of wrist fractures.



Race	Mexican-American	Other Hispanic	Non-Hispanic White	Non-Hispanic Black	Other Race-Including Multi-Racial	P value
Wrist Fracture % [95% CI]	7.6[4.5,12.7]	7.3[5.7,9.3]	14.0[12.2,16.0]	6.9[5.4,8.8]	6.7[4.3,10.3]	0.0718

Figure 2

Relationship between race and prevalence of wrist fractures.



Age group, years	<25	>=25, <50	>=50, <75	>=75	p for trend
Male % [95% CI]	61.3 [52.4, 69.5]	51.8 [40.2, 63.3]	23.0 [15.8, 32.2]	19.8 [2.0, 49.9]	<0.0001
Female % [95% CI]	38.7 [30.5, 47.6]	48.2 [36.7, 59.8]	77.0 [67.8, 84.2]	80.2 [25.1, 98.0]	<0.0001
p-value	0.0001	0.603	<0.0001	0.0255	

Figure 3

Relationship between gender and first occurrence of wrist fracture in different age groups.