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Risk factors for fractures among Japanese-American men: the Honolulu Heart Program and Honolulu-Asia Aging Study

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Abstract

Purpose—The objective of this study was to identify risk factors ascertained at baseline that were associated with prevalence and incidence of fractures at advanced age among Japanese-American men.

Methods—The present study used data from Honolulu Heart Program (HHP) and Honolulu-Asia Aging Study (HAAS). The HHP was a prospective study with primary focus on risk factors for cardiovascular diseases and stroke. A cohort of 8,006 men of Japanese ancestry aged 45–68 residing on Oahu was recruited in 1965, and followed through 1999. The HAAS started in 1991 in conjunction with the HHP with a focus on age-related health conditions. Self-reported cumulative prevalence of hip, spine and forearm fractures was ascertained in 1991–1993 among 3,845 men aged 71–93. Incidence was obtained during the follow-up period (1994–1999) among 2,737 men aged 74–98. Poisson regression models were used to determine multi-variable adjusted prevalence and incidence ratios for fracture.

Results—Baseline age was directly and inversely associated with cumulative incident spine and prevalent forearm fracture, respectively. Education was inversely and directly associated with prevalent spine and forearm fracture, respectively. Body mass index (BMI) was independently and directly, and upper arm girth was inversely associated with incident hip fracture. Height and

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Summary
Baseline risk factors were associated with fractures that developed after 29–31 years among Japanese-American men. One unit increase in BMI, physical activity, and arm girth was associated with a 28%, and 7% increase and a 27% decrease in risk of hip fracture, respectively.

diabetic medication were directly associated with prevalent spine fracture. Physical activity and pack-years of smoking were independently and directly associated with incident and prevalent hip fracture, respectively.

Conclusions—These results indicated that multiple baseline demographic lifestyle and anthropometric characteristics predict fracture risk at advanced age. In addition, associations varied by fracture location.

Keywords

fracture; incidence ratio; men; prevalence ratio; risk factors

Introduction

Worldwide projections estimate that annual fracture cases will reach 2.6 million by 2025 and 4.5 million by the year 2050, compared with 1.66 million cases in 1990 [1]. In the U.S., the number of hip fractures is expected to triple as the aged population is expected to double from 1990 to 2050. Although women have higher risk of fracture than men, men have higher mortality rates following fracture than women [2]. There are limitations to using bone mineral density (BMD) as a single risk predictor of fracture. These include the following issues (1) the threshold of using BMD for fracture diagnosis might vary among men with and without type 2 diabetes mellitus [3]; (2) there does not seem to be a consensus definition of osteoporosis based on BMD in men [4]; and (3) there are ethnic differences in BMD in men [5]. Although the World Health Organization Collaborating Center identified a comprehensive set of modifiable risk factors for hip fracture in 2004, which included BMD at the femoral neck, BMI, a prior fragility fracture, glucocorticoid exposure, a parental history of hip fracture, smoking, excessive intake of alcohol, and rheumatoid arthritis [6], whether these factors identified at middle age are associated with risk of fractures at advanced age or whether risk factors may vary by fracture site is not clear.

The effects of some other factors on fracture risk have also been reported, such as advancing age [7], educational level [8], grip strength [9], standing height [7, 10], dietary calcium intake [11], coffee intake [12], milk consumption [13], blood glucose [14], diabetes mellitus [15], and diabetic medication use [16, 17]. Although many risk factors have been identified for fracture among different populations, little is known about the risk factors for fracture among Japanese-American men. Therefore a comprehensive analysis of associations between a wide variety of variables and several specific fracture sites would be useful for fracture prevention in this specific ethnic group. In this study, multiple variables were examined in a middle aged Japanese-American population in Hawaii, and the follow-up investigations of multiple fractures were conducted after 26, 29, and 31 years from the baseline to identify associations between possible risk factors and the occurrence of hip, spine, and forearm fracture.

Methods

Study population

The data analyzed in this study were obtained from the Honolulu Heart Program/Honolulu-Asia Aging Study. The Honolulu Heart Program was initiated in 1965 as a prospective epidemiologic study to identify risk factors for cardiovascular diseases and stroke in the population of Japanese-American men residing on the island of Oahu, Hawaii. The Honolulu-Asia Aging Study started at examination 4 (1991–93) in conjunction with the Honolulu Heart Program with a focus on various age-related health conditions. The data collection methods of this study were described in a previous publication [18]. Briefly, a sample of 8,006 men of Japanese ancestry who were born during the period 1900–1919 was identified from a roster of the selective service registry for the Hawaiian Islands during the period 1940–1942, and were contacted and recruited for this study. The baseline data collection was completed from 1965 to 1968 (Examination 1) with 8,006 participants aged 45 to 68 years. Participants were re-examined during the periods of 1967–1970 (examination 2, age range: 47–70), 1971–1974 (examination 3, age range: 51–74), 1991–1993 (examination 4, age range: 71–93), 1994–1996 (examination 5, age range: 74–96), and 1997–1999 (examination 6, age range: 77–99).

Among the 8,006 participants who were initially recruited, 3,845, 2,698 and 1,987 completed examination 4, 5 and 6 respectively. Because of the small number of cumulative incident fractures identified at examination 5 and 6, the two examinations were combined to calculate 6-year cumulative incidence during the period between each participant's clinic visit for examinations 4 and 6. Therefore the population at risk included three groups: men who only completed examination 5, those who only completed examination 6, and those who completed both examination 5 and 6 for a total of 2,737 participants (age range: 74–98). Informed consent was obtained from the study participants. This study was approved by the Institutional Review Board of the Kuakini Medical Center.

Fracture ascertainment

At examination 4, the participants were asked by an interviewer if they ever had fractures of the hip, spine, or forearm. At examination 5 and 6, the participants were asked "Since last exam, has a doctor told you that you had a fracture of the hip, spine, or forearm?" Each fracture case was counted separately to calculate the prevalence or incidence for examinations 4, 5 and 6, except for the combined follow-up (1994–1999). At exam 4, seven men reported both hip and spine, three men reported both hip and forearm, and four men reported both spine and forearm fracture at the same time. At exam 5, one man reported both hip and spine fracture at the same time. At exam 6, one man reported both hip and spine, and one man reported both spine and forearm fracture at the same time. When calculating the cumulative incidence for the 6-year period after combining examinations of 5 and 6, only the first fracture occurrence was counted. For example, one man developed hip fracture and two men developed spine fracture at both examination 5 and 6, respectively, only the first occurrence was counted. Traumatic fractures were not identified from questionnaires.

Cumulative incidence of forearm fracture was not analyzed because of the very small number (n = 7) of cases identified from examinations 5 and 6.

Ascertainment of potential risk factors

Demographic, anthropometric, life style, dietary, and metabolic data were accessed from baseline questionnaires and have been described elsewhere [19]. Educational level was recorded as the highest number of years of school attended. BMI was calculated by dividing weight in kilograms by the square of height in meters. Biacromial diameter, grip strength, girth at the midpoint of the left upper arm, and standing height were measured by trained research staff. Grip strength was tested using a dynamometer in both right and left arms, but the dominant one was used for present analyses. Data collected on alcohol intake was based on the usual monthly intake of wine, beer, and liquor, and was expressed as ounces per month of ethanol using conversion factors for wine, beer, and liquor as specified in the United States Department of Agricultural Handbook #8: 10% ethanol for wine, 3.7% for beer, and 38% for liquor [20]. Dietary calcium intake was calculated from the food and drink intake assessed from a 24-hour dietary recall [19]. A physical activity index was similar to that used in the Framingham Heart Study and has been described in detail previously [21]. Pack-years of smoking cigarettes was calculated as a summary measurement based on the amount and duration of cigarette smoking [22]. Also, smoking status was classified into three categories: never, former, and current smoker at baseline. Blood glucose was measured 1 hour after a 50-g glucose load. Coffee and milk intake were obtained from the questionnaire and were categorized as follows: almost never, less than two times a week, 2–4 times a week, almost daily, more than once a day. In addition, use of diabetic medication was self-reported at baseline since the standard glucose tolerance criteria employed by the World Health Organization (WHO) to define diabetes were unavailable at that time [23].

Statistical analysis

The cumulative prevalence of fracture at exam 4 for various sites was computed by dividing the number of participants who ever had fracture by the number at risk. The cumulative incidence of fracture (at exam 5, exam 6, exam 5 or 6) was defined as the number of new cases of fracture occurring during the respective follow-up period divided by the number of participants at risk of developing fractures during the same period. Age-adjusted mean levels of selected baseline (1965–1968) continuous variables and age-adjusted frequencies of selected baseline categorical variables were compared by cumulative prevalent fracture status (yes, no) at examination 4 and incident fracture status at examination 5 or 6 (yes, no). To determine the independent association of potential baseline risk factors with fracture, a multivariate Poisson regression model for a binary response variable was fit separately for each fracture site. The response variables used were cumulative prevalent fracture ascertained at exam 4 (yes, no) and incident fracture from examination 5 or 6 (yes, no). The Poisson regression model was used to estimate the prevalence ratios (PRs) for cumulative prevalent fracture and incidence ratios (IRs) for cumulative incident fracture.

The criteria for entry of a variable into the multivariate models were two sided P values of at least 0.10 for comparisons of age-adjusted mean levels or proportions among groups with and without fractures in the present study and a report of significant association with fracture in at least one published epidemiologic study. Based on these criteria, biacromial diameter was not eligible for entry into these models. Coffee consumption was collapsed into two categories due to insufficient cell sizes. Multicollinearity analysis was conducted. The variance inflation factor for each independent variable was less than 2.7. Missing data for each variable was less than 5%. The analyses were performed using the SAS software package 9. 2 (SAS Institute, Cary, NC).

Results

Among men who participated in examination 4 (1991–1993), their mean age at baseline was 52.7 years and mean height was 64.5 inches (Table1). The average educational attainment among this cohort was 10.6 years, and 65% of the men were former or current smokers. The men who participated in examinations 5 or 6 (1994–1999) had similar baseline characteristics to those who participated in examination 4.

Self-reported cumulative prevalence of hip, spine, and forearm fracture as of examination 4 in 1991–1993 was 1.65%, 3.07%, and 4.29% respectively (with 63, 117, and 164 hip, spine, and forearm fractures occurring, respectively) (Table 2). During the approximate three-year follow-up period from examination 4 to 5, a total of 18, 17, and 3 men developed hip, spine, and forearm fracture respectively, corresponding to an incidence of 0.67%, 0.63, and 0.11%, respectively. During the subsequent three-year follow-up period, 16 hip, 28 spine, and 4 forearm fractures developed, and the corresponding incidence was slightly higher at 0.81%, 1.43%, and 0.2%, respectively. Over the combined approximate six years of follow-up from examination 4 (1991–1993) to examination 6 (1997–1999), there were 33, 43, and 7 cumulative incident hip, spine, and forearm fractures, respectively, and the corresponding incidence was 1.21%, 1.57%, and 0.26%, respectively.

To identify potential risk factors for fracture, age-adjusted mean levels of candidate variables among men who developed fracture were compared with those who remained free of fracture (Table 3). Among Japanese-American men who had cumulative prevalent hip fracture, mean BMI, hand grip strength, and girth of left upper arm values were significantly smaller and pack-years of smoking was significantly higher than those without fracture. Similarly, age-adjusted mean levels of education and BMI were significantly lower, pack-years of smoking were significantly higher, and the proportions who were taking diabetic medication were marginally higher for the Japanese men with cumulative prevalent spine fracture than for those without fracture. The group with cumulative prevalent forearm fracture had a significantly higher level of education and significantly lower grip strength compared to the group without fracture. Over the approximate six-year follow-up period from examination 4 to 6, girth of left upper arm was marginally smaller and alcohol intake was about two-fold higher for men who developed hip fracture compared to those who were free of fracture. The age-adjusted distribution of smoking status for the group who developed hip fracture was marginally different from those free of fracture. The proportion of men who took diabetic medication was more than two-fold higher in those who developed a spine fracture than in those who did not.

After adjusting for the effects of each selected variable in the model, PR and IR analyses (Table 4) illustrated that age at baseline was significantly and inversely associated with cumulative prevalent forearm fracture, and was significantly and directly associated with risk of incident spine fracture. A 10-year increase in age was associated with a 50% decrease (PR = 0.50, 95% CI: 0.34 – 0.73) in cumulative prevalence of forearm fracture, and a 133% increase (IR =2.33, 95% CI: 1.18 – 4.62) in cumulative incidence of spine fracture, respectively. Education showed a significant independent inverse association with cumulative prevalent spine (PR = 0.92, 95% CI: 0.86 – 0.99) and positive association with incident forearm fracture (IR = 1.06, 95% CI: 1.00 – 1.13), respectively. BMI had a significant direct association with incident hip fracture (IR = 1.28, 95% CI: 1.09 – 1.52). Girth of left arm was independently and inversely associated with the risk of incident hip fracture (IR = 0.73, 95% CI: 0.57 – 0.93). Standing height was positively associated with cumulative prevalent spine (PR = 1.12, 95% CI: 1.03 – 1.22). Physical activity index was independently and directly associated with incident hip fracture (IR = 1.07, 95% CI: 1.01 – 1.13). A 10 - pack-years increase in smoking was associated with 24% increase in hip fracture prevalence (PR = 1.24, 95% CI: 1.08 – 1.42). Current smoking status at baseline was inversely associated with prevalent hip fracture (PR = 0.34, 95% CI: 0.14 – 0.79). Diabetic medication use was independently associated with cumulative prevalence of spine fracture (PR = 2.31, 95% CI: 1.08 – 4.97).

Discussion

The present study assessed the associations of demographic, anthropometric, life style, dietary, and metabolic factors at baseline (1965–1968) with cumulative prevalence identified after 26 years and with cumulative incidence of fractures that occurred during a subsequent 6-year follow-up among middle-aged Japanese-American men. Multi-variable adjusted PR and IR indicated that those factors collected from baseline were independently associated with cumulative prevalence and cumulative incidence of fractures identified at advanced age, respectively. These associations varied by fracture location. Age had an independent inverse association with cumulative prevalent arm fracture, but an independent and direct association with incident spine fracture. Education was inversely associated with cumulative prevalence of spine fracture and directly associated with prevalence of forearm fracture.

BMI had a strong direct association with risk of incident hip fracture. Arm girth had an inverse association with incidence of hip fracture. Height, physical activity, and pack-years of smoking were independently and directly associated with cumulative prevalence of spine, incidence of hip, and prevalence of hip fracture, respectively. The cumulative prevalence of forearm fracture was higher than that of hip and spine fracture in this cohort. Cumulative prevalence of fracture would include fractures that may have occurred a number of years ago when the participants were younger. In contrast, incidence of fractures was ascertained only when they were much older.

It has been widely recognized that age is associated with an increase in risk of hip fracture [7, 24]. However, in the present study, age at baseline was not associated with either cumulative prevalence or incidence of hip fracture. Although these results did not indicate that age at baseline was a risk factor for hip fracture, bone mineral content was found to be inversely associated with age at assessment in a previous HHP study [25]. The non-significant associations could be explained by residual confounders such as dietary protein and mental health which were considered as risk factors in two previous prospective studies [26, 27]. The associations of age with fracture for other sites are understudied to our knowledge. Baseline age was independently associated with the incidence of spine fracture in the present study, which was consistent with the result from White et al [24], but was inconsistent with findings from the Framingham Heart Study [28]. This might be due to a smaller sample size (n = 252) in the Framingham Study. A strong inverse association between baseline age and cumulative prevalence of forearm fracture was also observed in the present study (PR = 0.50, 95% CI: 0.34 – 0.73), which was inconsistent with two previous studies [24, 26]. In the previous studies, the majority of participants were office workers, whereas approximately 58.8% of the men in the current study had been laborers working at sugarcane or pineapple plantations. The different occupations could account for these inconsistent findings. These findings may indicate that age might be a stronger contributor to risk of spine than hip fracture. Future studies that compare the attributable fraction of age to the risk of hip and spine fracture are needed.

A limited number of studies have assessed the effects of education on fracture by site among men. Wilson et al reported that lower educational level was a contributor to hip fracture risk in their prospective study with 64.9% of participants being female. However this inverse association was not observed for both prevalent and incident hip fracture in the present study. The different association might be explained by the hormone replacement therapy used among women which was associated with a 33% reduced hip fracture risk, since women with a higher educational level in general were more likely to use hormone replacement therapy [8]. The inverse association of educational level with cumulative prevalent spine (PR = 0.92, 95% CI: 0.86 – 0.99) and positive association with cumulative prevalent forearm fracture (PR = 1.06, 95% CI: 1.00 – 1.13) in the present analysis might be explained by the participants' occupations. Overall lower educational attainment of this cohort compared with American men of similar age in 1965 (percentages with less than 9 years and greater than or equal to 16 years of education were 45.2% and 1.2% vs. 20.1% and 20.6%, respectively) [29] might have restricted their choices to less safe jobs. Additional epidemiologic studies need to be conducted in different populations to explore how occupational exposures are associated with fracture and whether the extent of these associations varies by fracture location.

A strong positive association was found between midlife BMI and the risk of hip fracture at advanced age in the present study. One unit increase in BMI was associated with a 28% increase in the incidence ratio of hip fracture. This finding was consistent with Nielson el [30] who reported that obesity (BMI ≥ 30 kg/m^2) was associated with the risk of hip fracture among men with mean age of 73.6 years, having obesity prevalence of 21.0%. In the present study, the prevalence of obesity was 34.7% when the BMI cut-off point for obesity (BMI ≥ 25 kg/m^2) was used [31] among this younger cohort (mean age: 52.7±4.7 years). Although increased BMI may be associated with an increase of BMD [30] which is a primary determinant for fracture [32], Asian populations may have a high percentage of body fat at a relatively low BMI [33]. In addition, cross-sectional associations of C- reactive protein (CRP) concentration with BMI have been seen among Japanese [34]. Elevated plasma CRP seems to be a marker of the early stages of osteopenia [35]. A marginally significant inverse association (PR = 0.97, 95% CI: 0.94 – 1.00, P = 0.076) was observed between grip strength and cumulative prevalent forearm fracture in the present study which was consistent with previous findings. For example, a previous HHP study reported that strenuous exercise was positively related to bone mineral content of the os calcis and the distal ulna [25], and grip strength has been reported as a marker of forearm bone mineral density (BMD) [36]. This association was not observed for hip fracture which was consistent with the findings from Lan et al [13] and for spine fracture which was consistent with the Framingham Study [28]. To our knowledge, the present study was the first to investigate the association between upper arm girth and fractures. The independent and strong inverse association of this variable with the risk of hip fracture might be explained by the exposure to excessive workloads [37] early in life.

Tall stature has been reported to be a risk factor for hip fracture among relatively tall populations. Men taller than 68 or 72 inches had increased risk of hip fracture [10]. Although the cohort in the present study was relatively short (mean height = 64 inches, only one man was taller than 72 inches), increased height was also associated with cumulative prevalence of spine fracture. Therefore, these associations might not be explained only by the greater force when falls occurred from greater height [10]. There may be other undiscovered underlying mechanisms related to the effects of increased body height on the factors affecting bone strength, as Turner suggested that bone strength could be affected by bone mass, bone tissue properties, or bone architecture [38]. However, the relationship between body height and bone strength has not been reported to our knowledge.

In general, physical activity has been reported to decrease bone loss [39] and thus reduce the risk of hip fracture [7]. However, in the present study, physical activity was independently and positively associated with cumulative incidence of hip fracture. Men who were physically active in middle age were more likely to maintain their physically active lifestyle until advanced age. Household activities might be a major component of daily activity when this cohort reached advanced age, and such activities have been reported to increase the risk of fall among the elderly [40]. The lack of significant inverse associations in the present study was consistent with results from the Framingham study [28]. These differences might be due to the method of physical activity assessment. Physical activity was measured for all activities combined in the present and the previous study. Different types of physical activity have been reported to have different effects on fracture. High degrees of leisure-time physical activity protected against hip fracture, but work-related physical activity was not protective [7]. If the type of physical activity were available, it would be possible to evaluate the differential effects on fracture risk.

The effect of smoking on fracture risk remains controversial in the literature and inconsistent results have been reported for different fracture sites [7, 24, 28, 41]. There were few studies with relatively large sample size that explored the association of pack-years of smoking with cumulative prevalent fracture among men. Pack-years of smoking was independently associated with cumulative prevalent hip fracture (PR = 1.24, 95% CI: 1.08 – 1.42) but was not associated with incident hip fracture in the present study. Ward and Klesges reported a significant inverse correlation of pack-years of smoking with hip and spine BMD after adjustment for age and BMI [42]. The positive effects of smoking cessation or reducing the amount of smoking cigarettes on BMD [43] that could have occurred during a long period of follow-up, might have diminished the association of pack-years of smoking with fracture in the present study. The independent inverse association of current smoking status with prevalent hip fracture needs to be interpreted with caution. Maybe current smokers at baseline who had a prevalent hip fracture were more likely to give up smoking. In addition, smoking status might be changed over the long period of follow-up. Therefore, the association might be underestimated in this situation. Positive though not significant associations of former and current smoking with incident hip and spine fracture were observed in the present study. These results are consistent with findings from Ward et al that smoking cessation might have a positive effect on BMD [42].

The association of diabetic medication use with fractures was investigated in the present study. The direct association of diabetic medication with cumulative prevalence of spine fracture was consistent with the previous studies [44, 45]. If these medications are involved in bone metabolism, they would be expected to be also associated with prevalent fracture or incident fracture at the other sites. However, these associations were not observed in the present study.

Some limitations of the present study need to be considered. First, since traumatic fractures could not be distinguished from low energy fractures (caused by a fall from standing), misclassification bias might have occurred. Second, physical activity was not recorded separately by different activity types, such as leisure time, occupational and household activity. Therefore the influence of each type of activity on fracture could not be assessed. In addition, those findings in Japanese-American men may not be generalizable to other populations.

In conclusion, a number of risk factors assessed in middle age were associated with fracture risk in advanced age. In addition, the risk factors varied by fracture location. Age was directly associated with 6-year cumulative incident hip and spine fracture, but was independently and inversely associated with cumulative prevalence of forearm fracture. Education was inversely and positively associated with cumulative prevalence of spine and forearm fracture, respectively. BMI and physical activity had positive associations with incident hip fracture. Upper arm girth was independently and inversely associated with the incidence of hip fracture. Pack-years of smoking was independently and directly associated with cumulative prevalent hip fracture. Current smoking status at baseline was inversely associated with prevalent hip fracture. Some selected candidate variables such as blood glucose level, alcohol intake, dietary calcium, coffee, and milk consumption were not statistically independently associated with fractures for all sites in the present analysis. The mechanisms underlying the associations need to be explored in future studies.

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Tab1e 1

Baseline Characteristics (1965–1968) of Participants Who Were Examined in 1991 to 1993 and from 1994 to 1999, Honolulu Heart Program and Honolulu-Asia Aging Study (1965–1999).

	Men participated in Exam 4 (1991–93) (N = 3,845)		**Men participated in Exam 5 and 6 (1994–99) (N = 2,737)**	
Variable	**n**	**Mean (SD)**	**n**	**Mean (SD)**
Age (years)	3,845	52.7 (4.8)	2,737	52.1 (4.3)
Education (years)	3,843	10.6 (2.8)	2,735	10.8 (2.8)
BMI (kg/m^2)	3,843	23.9 (2.9)	2,736	24.0 (2.8)
Biacromial diameter (cm)	3,842	38.1 (1.9)	2,736	38.2 (1.9)
Grip strength (kg)	3,842	39.5 (6.1)	2,735	39.9 (6.0)
Upper arm girth (cm)	3,844	28.1 (2.7)	2,736	28.3 (2.6)
Standing height (inches)	3,844	64.3 (2.3)	2,737	64.4 (2.2)
Alcohol (oz/month)	3,841	12.1 (21.2)	2,735	11.6 (20.5)
Dietary calcium (mg)	3,845	513.9 (310.4)	2,737	518.4 (311.0)
Physical activity index	3,827	32.9 (4.6)	2,722	32.7 (4.6)
Blood glucose (mg/dL)	3,832	151.9 (48.3)	2,730	149.5 (45.5)
Diabetic medication (%)	110	2.9	78	2.9
Smoking (pack-years)[†]	2,446	30.0 (20.0)	1,707	29.0 (19.9)
Smoking (%)				
Never	1,344	35.0	993	36.3
Former	1,101	28.6	783	28.6
Current	1,399	36.4	960	35.1
Coffee (%)				
Never	305	7.9	224	8.2
≤ twice a week	162	4.2	101	3.7
2–4 times a week	123	3.2	86	3.1
Almost daily	1,566	40.7	1,122	41.0
> once a day	1,689	43.9	1,204	44.0
Milk (%)				
Never	840	21.9	584	21.3
≤ twice a week	1,398	36.4	985	36.0
2–4 times a week	355	9.2	264	9.7
Almost daily	986	25.6	714	26.1
> once a day	266	6.9	190	6.9

Note: values are means and standard deviations for continuous variables and percentages for categorical variables.

[†] pack-years of smoking was calculated only for former and current smokers.

Table 2

Cumulative Prevalence and Cumulative Incidence of Fracture by Site in Japanese-American Men, Honolulu Heart Program and Honolulu-Asia Aging Study (1965–1999)

	Hip				Spine				Forearm			
Time period[†]	**Number at risk**	**Number of cases**	**Prevalence per 100**	**Incidence per 100**	**Number at risk**	**Number of cases**	**Prevalence per 100**	**Incidence per 100**	**Number at risk**	**Number of cases**	**Prevalence per 100**	**Incidence per 100**
Exam 4	3,822	63	1.65		3,805	117	3.07		3,820	164	4.29	
Exam 4 to 5	2,687	18		0.67	2,686	17		0.63	2,688	3		0.11
Exam 5 to 6	1,968	16		0.81	1,955	28		1.43	1,981	4		0.20
Exam 4 to 6	2,737[a]	33[b]		1.21	2,737	43[c]		1.57	2,737	7		0.26

[†] Exam 4 (1991–1993); Exam 5 (1994–1996); Exam 6 (1997–1999).

[a] Men at risk included those who completed examination 5, examination 6, and those who completed both 5 and 6.

[b] One man developed hip fracture at both exam 5 and exam 6, only first occurrence was included.

[c] Two men developed spine fracture at both exam 5 and 6, only first occurrence was counted.

Table 3

Age-adjusted mean (SE) levels of continuous variables and prevalence of categorical variables at baseline (1965–1968) by subsequent fracture status, Honolulu Heart Program and Honolulu-Asia Aging Study (1965–1999).

	Prevalent fracture ascertained in 1991–1993				Incident fracture, incurred in 1994 – 1999		
Baseline variable (1965–68)	**Hip (n = 63)**	**Spine (n = 117)**	**Forearm (n= 164)**	**No (n = 3,467)**	**Hip (n = 33)**	**Spine (n = 43)**	**No (n = 2,657)**
Age (years)	53.9 (0.6)*	52.8 (0.4)	51.5 (0.4)**	52.8 (0.1)	53.8 (0.8)	53.9 (0.7)	52.7 (0.1)
Education (years)	10.3 (0.4)	10.1 (0.3)**	11.1 (0.2)**	10.6 (0.0)	10.5 (0.1)	10.7 (0.4)	10.8 (0.5)
BMI (kg/m^2)	23.2 (0.4) **	23.5 (0.3)*	23.6 (0.2)	23.9 (0.0)	24.2 (0.5)	23.1 (0.4)**	24.0 (0.1)
Biacromial diameter (cm)	37.8 (0.2)	38.1 (0.2)	38.1 (0.2)	38.1 (0.0)	38.1 (0.3)	38.1 (0.3)	38.2 (0.0)
Grip strength (kg)	38.4 (0.7)*	39.0 (0.9)	38.7 (0.5)**	39.6 (0.1)	39.3 (1.0)	39.3 (0.9)	40.0 (0.1)
Upper arm girth (cm)	27.4 (0.3)**	27.8 (0.2)	27.9 (0.2)	28.2 (0.0)	27.4 (0.5)*	27.8 (0.4)	28.3 (0.5)
Standing height (inches)	64.0 (0.3)	64.2 (0.2)	64.3 (0.2)	64.3 (0.0)	64.4 (0.4)	64.7 (0.3)	64.4 (0.0)
Alcohol (oz/month)	11.5 (2.7)	14.0 (0.2)	12.4 (1.7)	11.9 (0.4)	22.1 (3.6) **	7.9 (3.1)	11.6 (0.4)
Dietary calcium (mg)	523.7 (39.0)	515.2 (28.5)	532.8 (24.3)	512.7 (5.3)	480.3 (54.1)	514.6 (47.4)	519.1 (6.0)
Physical activity index	33.4 (0.6)	33.1 (0.4)	32.7 (0.4)	32.9 (0.1)	33.9 (0.8)	32.0 (0.7)	32.7 (0.1)
Blood glucose (mg/dL)	150.6 (6.1)	151.1 (4.5)	148.5 (3.8)	152.0 (0.8)	157.1(8.0)	140.6 (6.9)	149.6 (0.9
Diabetic medication (%)	1.5	6.0*	1.3	2.8	3.0	6.7*	2.8
Smoking (pack-years)	25.3 (2.7)**	23.3 (2.0)**	21.1 (1.7)	18.9 (0.4)	24.2 (3.7)	18.3 (3.2)	18.3 (0.4)
Smoking (%)							
Never	36.5	30.8	32.5	35.5	23.8*	32.8	36.1
Former	29.1	28.9	28.8	28.9	27.0	28.9	29.0
Current	34.5	40.4	38.6	35.5	49.2	38.3	34.9
Coffee (%)							
Never	7.1	7.2	7.6	7.8	9.3	10.2	8.1
≤ twice a week	4.0	4.0	4.2	4.3	4.1	4.4	3.7
2–4 times a week	3.0	3.0	3.2	3.3	3.5	3.7	3.1
Almost daily	39.8	39.9	40.6	41.0	42.6	43.4	40.8
> once a day	46.0	45.9	44.4	43.6	40.5	38.8	44.4
Milk (%)							

Baseline variable (1965–68)	**Prevalent fracture ascertained in 1991–1993**				**Incident fracture, incurred in 1994 – 1999**		
	Hip (n = 63)	**Spine (n = 117)**	**Forearm (n= 164)**	**No (n = 3,467)**	**Hip (n = 33)**	**Spine (n = 43)**	**No (n = 2,657)**
Never	25.5	23.5	22.6	21.8	27.6	19.0	21.4
≤ twice a week	37.7	37.0	36.6	36.3	37.8	34.5	35.8
2–4 times a week	8.5	8.8	9.0	9.1	8.6	9.9	9.6
Almost daily	22.4	24.2	25.0	25.8	20.9	28.6	26.2
> once a day	5.8	6.4	6.7	7.0	5.1	8.0	7.0

[**] $P < 0.05$;

[*] $P < 0.10$ (P values are two sided).

Table 4

Multivariate Cumulative Prevalence Ratios and Cumulative Incidence Ratios for Fracture by Site in Japanese-American Men, Honolulu Heart Program and Honolulu-Asia Aging Study (1965–1999)

	Prevalent lifetime fracture ascertained in1991–1993 (N = 3,845)						**Incident fracture, 1994–1999 (N = 2,737)**			
	Hip (n = 63)		**Spine (n = 117)**		**Forearm (n = 164)**		**Hip (n = 33)**		**Spine (n = 43)**	
Variable	**PR**	**95% CI**	**PR**	**95% CI**	**PR**	**95% CI**	**IR**	**95% CI**	**IR**	**95% CI**
Age (10 years)	1.21	0.72– 2.02	0.94	0.62–1.44	0.50**	0.34–0.73	2.05	0.87–4.81	2.33**	1.18– 4.62
Education (years)	0.97	0.88– 1.07	0.92*	0.86–0.99	1.06*	1.00–1.13	1.01	0.89–1.15	0.99	0.88–1.11
BMI (kg/m^2)	0.93	0.83–1.05	0.98	0.89–1.07	0.98	0.91–1.06	1.28**	1.09–1.52	0.91	0.78–1.05
Grip strength (kg)	0.98	0.94–1.03	0.97	0.94–1.01	0.97	0.94–1.00	0.98	0.93–1.03	0.98	0.92–1.04
Upper arm girth (cm)	0.96	0.84–1.09	0.98	0.89–1.08	1.01	0.93–1.09	0.73*	0.57–0.93	1.01	0.84–1.20
Standing height (inches)	0.97	0.85–1.11	1.12**	1.03–1.22	1.01	0.93–1.10	1.11	0.98–1.27	1.09	0.94–1.27
Alcohol (10 oz/month)	0.96	0.86–1.08	1.02	0.95–1.11	1.00	0.94–1.06	1.06	0.94–1.19	0.86	0.67–1.09
Dietary calcium (mg/day)	1.02	0.98–1.06	1.00	0.97–1.03	1.01	0.99–1.04	1.00	0.94–1.07	0.99	0.93–1.05
Physical activity index	1.01	0.95–1.08	1.00	0.97–1.04	1.00	0.96–1.04	1.07*	1.01–1.13	1.01	0.95–1.08
Glucose (10 mg/dL)	1.00	0.95–1.06	0.99	0.96–1.03	0.99	0.96–1.02	1.03	0.97–1.10	0.95	0.88–1.03
Diabetic medication (%)	0.62	0.08–4.74	2.33*	1.08–4.97	0.52	0.13–2.10	1.37	0.21–8.91	3.07	0.97–9.70
Smoking (10 pack-years)	1.24**	1.08–1.42	1.08	0.98–1.20	1.06	0.97–1.15	0.95	0.79–1.14	0.99	0.74–1.34
Smoking (%)										
Former vs. Never	0.52	0.25–1.10	0.95	0.56–1.63	0.80	0.50–1.27	1.79	0.60–5.36	1.06	0.39–2.89
Current vs. Never	0.34*	0.14–0.79	0.84	0.46–1.53	0.98	0.61–1.56	2.79	0.91–7.99	1.40	0.41–4.76
Coffee (%)										
≥1 cup/day vs. < 1 cup/day†	1.11	0.67–1.82	1.04	0.71–1.53	0.93	0.67–1.28	0.53	0.24–1.18	0.62	0.32–1.22
Milk (%)										
≤ twice a week vs. Never	0.82	0.44–1.53	0.80	0.49–1.29	0.90	0.59–1.36	1.74	0.70–4.33	0.92	0.38–2.23
2–4 times a week vs. Never	1.05	0.43–2.52	0.78	0.37–1.65	1.26	0.74–2.14	1.23	0.31–4.87	1.30	0.41–4.17
Almost daily vs. Never	0.69	0.34–1.41	0.96	0.56–1.64	0.82	0.50–1.34	0.84	0.26–2.74	1.23	0.51–3.03
> once a day vs. Never	0.42	0.11–1.60	0.62	0.25–1.58	0.78	0.36–1.67	0.50	0.06–4.08	0.60	0.12–3.06

[*] $P < 0.05$;

[**] $P < 0.01$ (P values are two sided).

[†] Coffee consumption was re-categorized due to smaller cell frequencies.

Abbreviation: BMI, body mass index; PR, prevalence ratio; IR: Incidence ratio; CI: Confidence interval.