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Who is at Risk for a Spinal Fracture? – A Comparative Study of National Health and Nutrition Examination Survey Data

Joy L. He[1], Morgan Y. He[2], and Grace Y. Yi[2]

[1] Waterloo Collegiate Institute, Waterloo, Ontario, Canada

[2] University of Waterloo, Waterloo, Ontario, Canada

Summary

A bone mineral density (BMD) test involves the process of measuring one's bone strength, which helps predict the chances of getting a spinal fracture. In this study, we examined how BMD may be associated with risk factors such as alcohol consumption, body mass index (BMI), milk consumption and age. We were also interested in whether gender is associated with the chances of suffering from a spinal fracture. We analyzed the data from the National Health and Nutrition Examination Survey, 2007-2008 (NHANES 2007-2008). Our studies suggested that the results for men and women were quite similar for BMD and milk consumption but not for age and alcohol consumption. As men aged, the probability of getting a spinal fracture decreased, while for women, it increased considerably. For alcohol consumption, the higher intake of alcohol increased the chance of a spinal fracture for men, while for women, it decreased the chance of a spinal fracture. For both men and women, a higher BMI resulted in a higher BMD, which reduced the risk of a spinal fracture. The same occurred between men and women with milk consumption.

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Introduction

It is estimated that over 200 million people worldwide suffer from osteoporosis (1). Osteoporosis is a condition that causes bones to become thin and porous, decreasing bone strength and increasing the risk of breaking a bone. It causes fractures in many locations, commonly in the hip, vertebrae, and wrist. Among the many consequences of osteoporosis, spinal fractures are one of the most common injuries (2-6). Spinal injuries may appear in various forms, ranging from relatively mild ligament and muscle strains, such as whiplash, to fractures and dislocations of the bony vertebrae and debilitating spinal cord injuries. Spinal fractures and dislocations can pinch, compress, and even tear the spinal cord (7). A vertebral compression fracture occurs when the discs in the spine fracture or collapse (8-9). When external forces are applied to the spine, such as from a fall, the forces may exceed the ability of the bone within the vertebral column to support the load. Many spinal fractures are not serious enough to warrant surgery, but major fractures can result in serious long-term conditions unless treated promptly and properly (10).

Spinal fractures are different from a broken arm or leg. The vertebrae do not break, but they collapse (11). A fracture or dislocation of a vertebra can cause bone fragments to pinch and damage the spinal nerves or spinal cord. Having one spinal fracture significantly increases the chance of another fracture (12). Multiple fractures can disrupt the alignment of one's spine, causing it to tilt forward, which is known as Dowager's Hump. The curvature of one's spine can cause imbalance and make the chest cavity feel compressed, disrupting one's daily life due to difficulties in breathing, sleeping, and eating (13).

Spinal fractures have devastating impacts on a person's day-to-day life. It can lead to back pain, loss of height, deformity, immobility, an increased number of bed days, and reduced pulmonary function. In addition, the negative impacts of spinal fractures also have mental effects. Spinal fractures can result in a loss of self-esteem and development of a distorted body image and depression (14).

Bone mineral density (BMD), a common measurement of bone strength, can be used to identify the likelihood of a fracture. This value is measured using special X-rays or CT scans. Low BMD plays an important role in determining a person's risk of osteoporosis. It has been found that age, gender, race, excessive weight loss, nutritional status, and previous history of fractures all have an effect on BMD; individuals with more risk factors have a higher chance of suffering a fracture (15). Other risk factors include high body mass index (BMI), large weight loss, long-term use of certain medications, smoking, alcohol consumption, and certain chronic diseases. In this study, we specifically examined

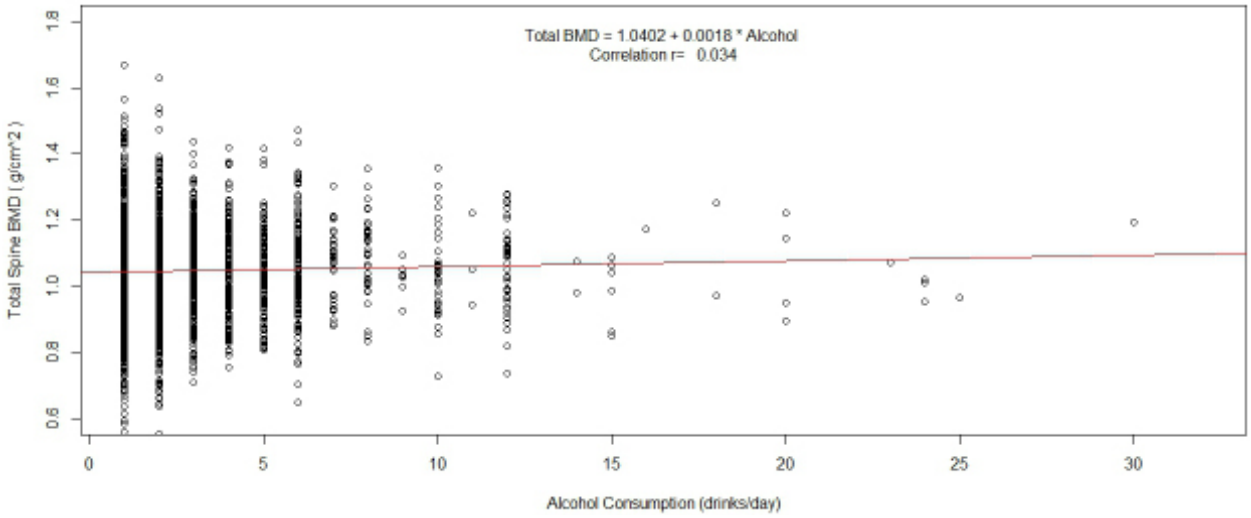

Figure 1: Relationship of Alcohol Consumption and BMD.

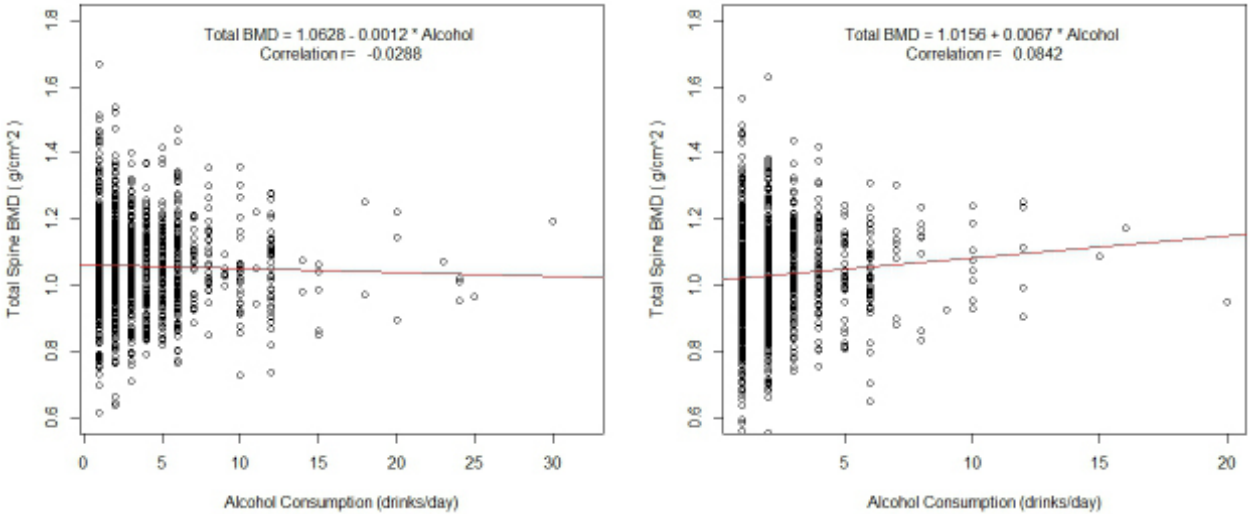

Figure 2: Relationship of Alcohol Consumption and BMD by gender. Left: male. Right: female.

how BMD may be associated with risk factors such as gender, alcohol consumption, BMI, milk consumption , and age. Our studies suggested that the indicated risk factors have different effects on BMD.

Materials and Methods

Although numerous risk factors have previously been linked to osteoporosis, this study looked at certain conditions to see how much they affect a person's BMD, which is correlated with one's risk of osteoporosis (16). Specifically, we analyzed the data from the National Health and Nutrition Examination Survey, 2007-2008 (NHNES 2007-2008), provided by Dr. Lisa Lix from the School of Public Health at the University of Saskatchewan (17). The data was collected from 2,549 people, of which 1,370 were males and 1,179 were females. The response variable was "Total Spine BMD (g/cm^2)".

We considered four main variables: alcohol consumption, BMI, milk consumption, and age; each was individually assessed relative to the outcome BMD. The first set of data included alcohol consumption that is measured as the average number of alcoholic drinks consumed by a subject per day in the last 12 months. The second set of data used BMI, a measurement of the relative percentages of fat and muscle mass in the human body defined as the weight in kilograms divided by height in meters squared. The measurement was used as an index of obesity. The third set of data looked at how milk consumption corresponds to a subject's BMD. This was measured by the subject's milk consumption in the past 30 days. The last variable used was the subject's age.

We conducted two analyses for each of the four data sets: with or without gender distinguished. The first analysis was performed with every subject, while the second analysis split males and females to control potential effects caused by gender. The four risk factors were each placed on a scatter plot on the x-axis, while

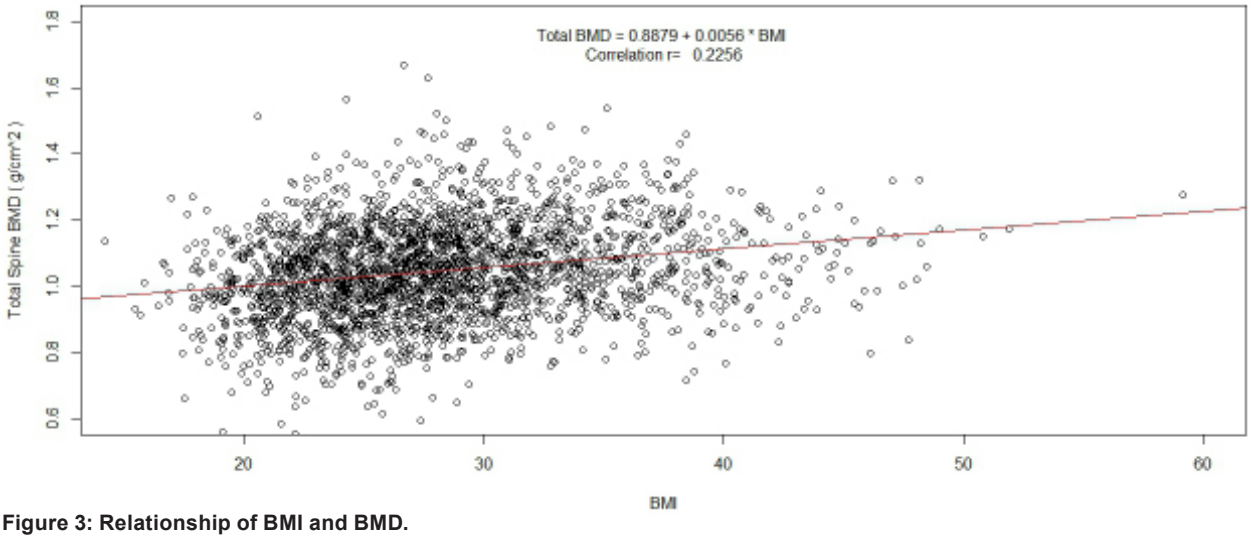

Figure 3: Relationship of BMI and BMD.

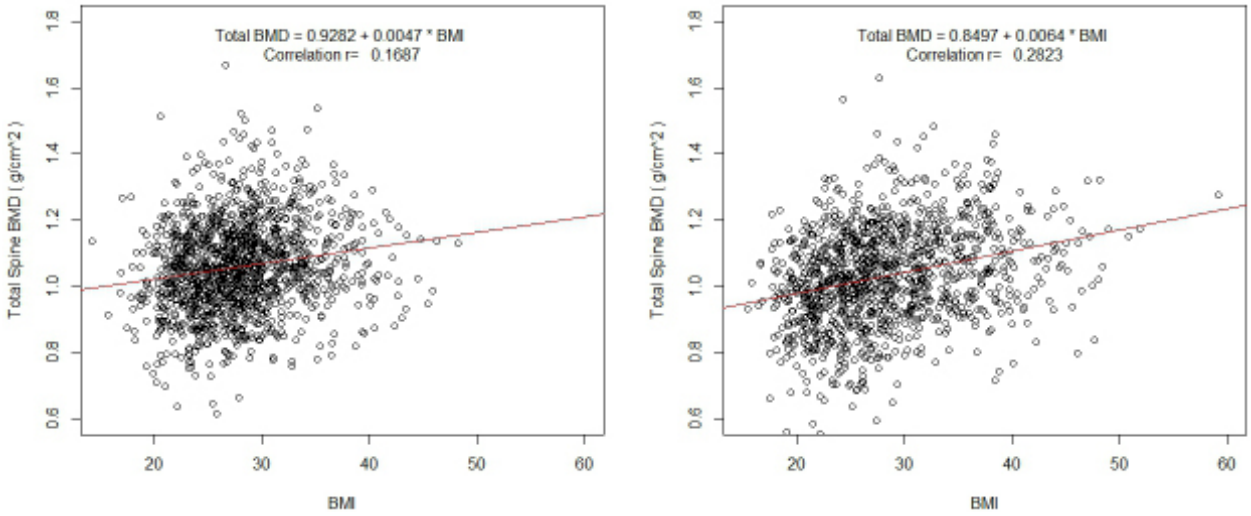

Figure 2: Relationship of BMI and BMD by gender. Left: male. Right: female.

the response variable BMD was placed on the y-axis. A best fit line was used to describe how a subject's total spine BMD is associated with each of the variables we considered; Using the least squares regression method, a line was fit to the data using the statistics software package R (18).

Analysis and Results

Osteoporosis is becoming an increasingly prevalent disease affecting the lives of many people. Examining the risk factors associated with BMD helps us to better understand the causes of osteoporosis, decreasing the chances of a spinal fracture. The data set from the National Health and Nutrition Survey was obtained using biomedical equipment, questionnaires, and administrative exams (17).

As alcohol consumption increased, BMD for all study subjects did not change dramatically (**Figure 1**). This suggested that alcohol consumption is not a huge risk factor when it comes to the chances of getting a spine fracture. This result was observed when we ignored possible differences between men and women.

When we separated the results between men and women, we obtained different results. As more alcohol was consumed, the chance of getting a spinal fracture for males increased, while for females, it decreased (**Figure 2**). Outside sources (4) suggest that the average drink contains around 14 g of pure alcohol. Women who drink 11-29 g (1-2 drinks) of alcohol per day have higher BMD levels, while women who drink 1-10 g (less than 1 drink) of alcohol or more than 30 g (more than 2 drinks) of alcohol per day do not have much change in their BMD levels (4). The different patterns revealed in **Figure 2** uncover that alcohol consumption between genders had an effect on the BMD.

We found that there is a relationship between the BMI and BMD values. As BMI increased, BMD increased as well (**Figure 3**). This indicated that the

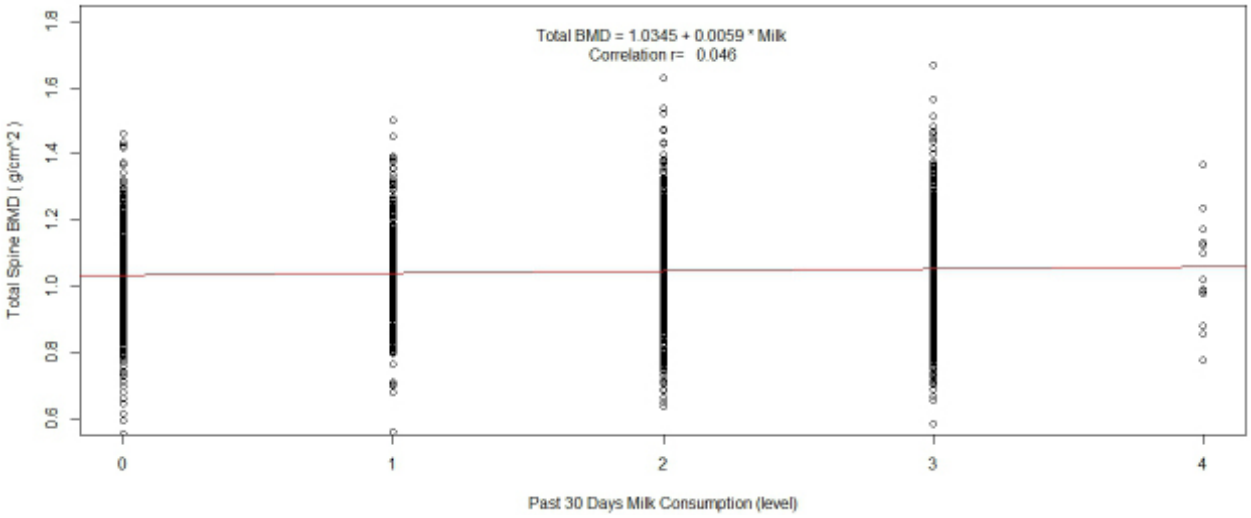

Figure 5: Relationship of Milk Consumption and BMD.

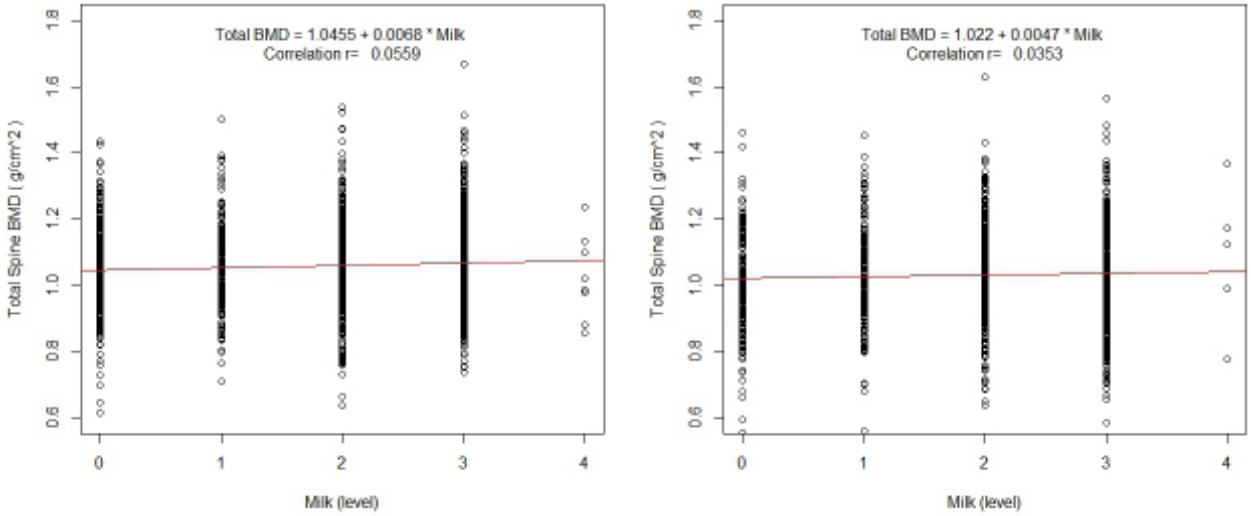

Figure 6: Relationship of Milk Consumption and BMD by gender. Left: male. Right: female.

smaller the BMI, the more susceptible one is to getting a spine fracture. With smaller bodies, the bones are often smaller and thinner, which increases the risk of a spinal fracture. Furthermore, when genders were separated, we found the effects of BMI on BMD were of a different magnitude (**Figure 4**). The effect of BMI on BMD was stronger for females than for males. Overall, one is more likely to get a spine fracture if their BMI is lower.

We found that milk consumption had a small effect on the total spine BMD. The more milk consumed, the less likely one was to get a spine fracture, regardless of including or excluding gender as a variable (**Figures 5 and 6**). This result is supported by the fact that bones contain calcium phosphate and calcium carbonate. The body continuously removes calcium from the bones while replacing it with new calcium, like a bone "remodelling" process (19). The high levels of calcium in milk help replenish and strengthen bones, thus increasing BMD.

As age increased, average spine BMD went down slightly (**Figure 7**), suggesting that as one ages, the risk of getting a spinal fracture increases. This reflects the condition known as osteopenia; naturally as one ages, bone density will start to decrease since the body may reabsorb calcium and phosphate from bones causing them to become lighter, less dense, and more porous (20). This observation was obtained without considering possible interacting effects between gender and age. When the subjects were separated by gender, we found that the trend of BMD was different for males and females as they aged (**Figure 8**). As males get older, the risk of spine fracture was reduced slightly, while females were much more likely to get a spine fracture as they aged. These findings were consistent with previous literature (21).

Concluding Remarks

Our analyses showed that the spine BMD is associated with multiple risk factors including alcohol

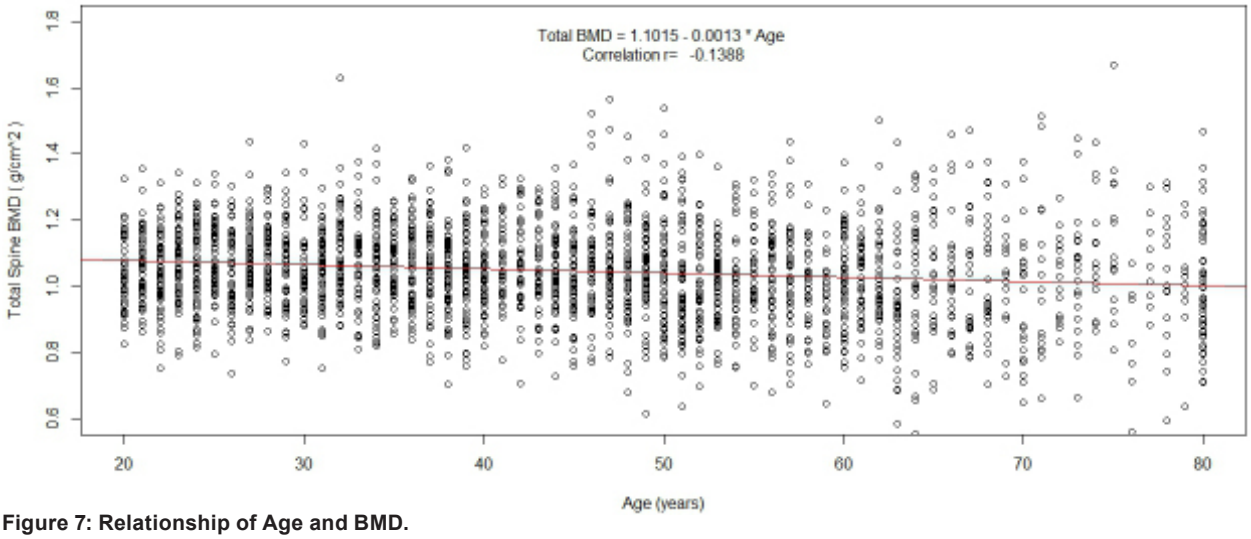

Figure 7: Relationship of Age and BMD.

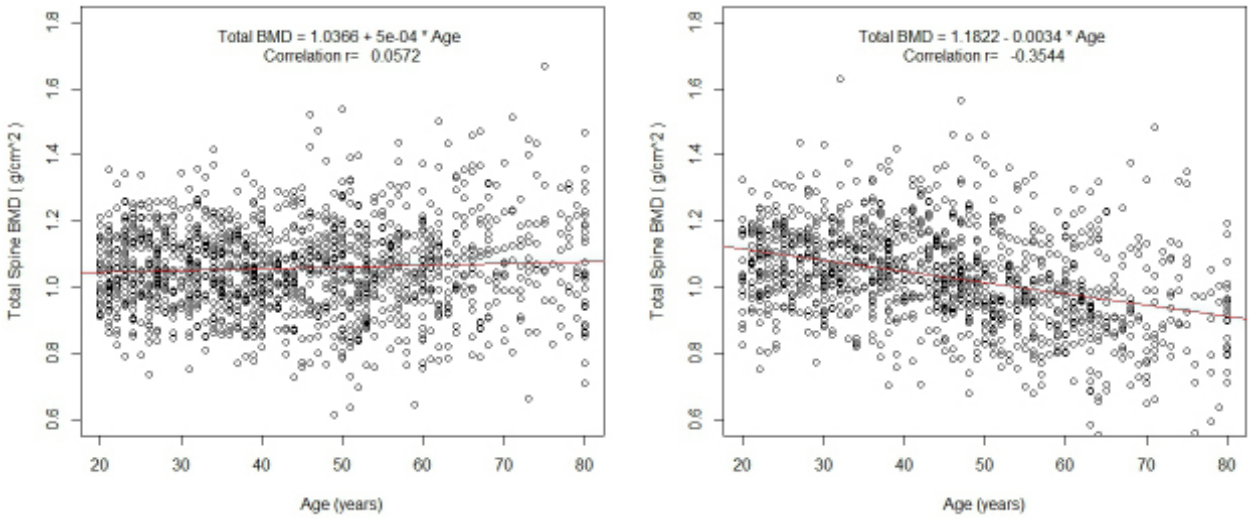

Figure 8: Relationship of Age and BMD by gender. Left: male. Right: female.

consumption, BMI, milk consumption, and age, as well as gender. We conducted marginal analysis on each variable using a widely recognized statistical method – the least squares regression approach. We performed two types of analysis by both evaluating the entire population and separating the data by gender. For BMI and milk consumption, the two analyses revealed the same patterns. Individuals with lower BMI tend to have a lower total spine BMD, which is in agreement with a previous study (22). When separated by gender, the overall results were the same, but the effect size of BMI on BMD was greater in females than males. Regarding milk consumption, drinking more milk slightly increased the total spine BMD, which was confirmed by both analyses with or without gender being considered. This finding agrees with the fact that milk contains calcium (23), which strengthens the bones.

Our analysis suggested that gender is an important variable in describing the risk factor effects on the spine BMD. Some risk effects may be obscured if gender is not also considered as a variable. For alcohol consumption and age, the analyses with gender ignored or incorporated suggested different findings. Among all individuals who were not distinguished by gender, alcohol consumption did not seem to drastically affect the total spine BMD; as one aged, the risk of getting a spinal fracture increased, which is explained by the fact that bone mass density should go down naturally (24).

However, when gender was included in the analysis, the findings were quite different. With increasing alcohol consumption, males tended to have a higher chance of getting a spine fracture, whereas females seemed to have a reduced chance of getting a spine fracture. Furthermore, a female's BMD drastically decreased, while a male's BMD tended to increase slightly with age. These results showed that aging causes females to have a very high chance of getting spine fractures, but caused males to have a slightly reduced chance of getting spine

fractures.

Among the variables that we considered, for the pooled population where the genders were not distinguished, the variable most correlated with BMD was BMI (r-value = 0.2256 in **Figure 3**). Within the male subpopulation, the most correlated risk factor with BMD was still BMI (r-value = 0.1687 in **Figure 4**); but for the female subpopulation, the most correlated variable with BMD was age (r-value = 0.3544 in **Figure 8**).

While our analyses provided some insight into understanding the risk factors of a spinal fracture, they have several limitations. Our analyses focused on pairwise association studies between total spine BMD and one of the risk factors. Although these analyses can offer us an intuitive display of the relationships by graphics, they do not accommodate joint effects from multiple risk factors simultaneously. To perform a more advanced statistical analysis, one may carry out a multiple regression analysis by simultaneously including all the variables (25). The second shortcoming is that our analyses considered only a limited number of variables and did not include all relevant risk factors; a more comprehensive study is warranted to fully reflect the complex nature of conditions that cause a spinal fracture. Finally, we noted that the data collected for this survey was restricted to the health and nutritional information from the individuals within the United States; the findings may not apply to patients of different ethnicities and backgrounds.

In summary, osteoporosis is a common condition that has the potential to cause drastic and life-changing injuries on the spine. Adopting a healthy lifestyle is the best way to reduce the risk of a spinal fracture and maintain a high BMD (26), in which our analysis shed light on.

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