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Importance of bone mineral density and comorbidity index for functionality

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Abstract

Background: Assessing elderly ambulatory patients at risk of osteoporotic fractures is crucial for achieving appropriate functioning, including daily activities, rehabilitation, lifestyle improvements, and dietary optimization.

Aim: This study focuses on evaluating bone health and comorbidities in patients to predict osteoporotic fracture functionality, using multiple logistic regression and comparing cohorts for optimal operating points.

Methods: A retrospective study was conducted at Prince Rashid bin Al-Hasan Military Hospital, Jordan, to examine the correlations and quality of patients' functionality statuses based on Age-adjusted Charlson Co-Morbidity Index (AACCI) and femoral hip bone mineral density (fH_BMD). The study categorized patients into two cohorts, with functional grades ranging from III-IV to I-II. The results were analyzed using statistical tests and confidence intervals.

Results: A Multiple Logistic Regression model was developed to simulate the relationship between patients' Age-adjusted Charlson Co-Morbidity Index (AACCI) and femoral hip bone mineral density (fH_BMD) and their functionality statuses. The model was statistically significant, explaining variation in the dependent variable from 30%-40.2% depending on the reference method. It correctly classified 78.2% of cases, with the explained variation ranging from 30%-40.2% depending on the method used.

Conclusion: A small, non-sponsored study found an exponential association between patients' femoral bone mineral density and their functionality status, with this correlation shifting to the right when the Age-adjusted Charlson Co-Morbidity Index is ≥4.

Keywords: Co-morbidity burden; Bone mineral density; Functionality status; Osteoporotic fracture

1. Introduction

In order to achieve a sufficient level of functioning that enables elderly ambulatory patients who are at risk of osteoporotic fractures to carry out daily activities, participate in rehabilitation therapies, plan improvements to their lifestyle, and optimise their dietary intake, it is essential to conduct an assessment of the overall functional status of these patients. When it comes to patients who are at risk of osteoporotic fracture, the degree to which the overall functional statuses can be affected varies for each individual patient. Patients who are older and have developed age-related comorbidities as well as sarcopenia at the same time are particularly affected by this. [1-6]

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In particular, sarcopenia is associated with decreased bone mineral density (BMD) and osteoporosis, and this is especially true for people who are older. Additionally, the presence of co-morbidities can sometimes create opportunities for the development of osteoporosis that are not immediately obvious. For example, individuals with specific medical conditions such as kidney and liver diseases, rheumatoid arthritis, diabetes mellitus, inflammatory bowel disease, cancer, and celiac disease are at a greater risk of developing osteoporosis. According to research, having a lower bone mineral density can in fact make functional disabilities more complicated. As was mentioned earlier, the functionality of the patient is closely connected to both the burden of co-morbidity and the bone mineral density of the patient. Utilising these two independent predictors, it is therefore possible to make a prediction regarding the patient's functionality. [7-11]

The Charlson Co-Morbidity Index, also known as the CCI, is a comorbidity index that is widely used and is extremely prevalent on the market. There are 19 different conditions included in the dataset, each of which is differentiated according to hazard ratios and weighted on a scale that ranges from one to six points. The sum of these scores, each of which has been given a weight, is what is used to calculate the overall score. For the purpose of predicting mortality over the long term, this is a tool for assessment that has been specifically designed. For the purpose of determining the validity, reliability, and sensitivity of the instrument, it is utilised. When calculating the final score, the age-adjusted Charlson Comorbidity Index (ACCI) takes into account age as a correction factor. This is accomplished by deducting one point for every decade that comes after the age of 40. The CCI and ACCI have both been subjected to extensive validation in a variety of settings, including surgical and nonsurgical ones. Low (≤2), medium (≤3), and high (≥4) were the three categories that were used to classify the grading distributions of ACCI. [12-16]

Limited knowledge exists regarding the process of evaluating the functional prognosis of patients who have been attended to and who are at risk of osteoporotic fracture. The primary objective of this study was to investigate the relationship between femoral bone mineral density and the burden of co-morbidities, as well as the impact that these factors collectively have on patients' overall functional characteristics. The creation of a Multiple Logistic Regression Model was the means by which this was accomplished.

2. Methods

A study that was conducted at Prince Rashid bin Al-Hasan Military Hospital, Royal Medical Services, in Irbid, Jordan, was a retrospective study that was conducted at a single centre. The participants in the study were all patients who were suspected of having osteoporosis and who had visited the rheumatology and rehabilitation clinic between the months of September and November 2021. This was an observational study that was neither sponsored nor funded in any way.

In this study, multiple logistic regression (MLgR) tests were carried out in order to investigate the relationship between two factors that could potentially have a significant impact on the outcome: the Age-adjusted Charlson Co-Morbidity Index (AACCI) of the patients, the femoral hip bone mineral density (fH_BMD) of the patients, and the functionality statuses of the patients. The statuses of the functionality were classified as either having a higher functionality status (1) or a lower functionality status (0).

The tests were designed to ascertain the degree of correlation, the predictive quality of the dependent variable, the range of total variations in functionality among the patients, and the percentage of cases that can be explained by the two independent variables. All of these outcomes were intended to be determined.

Taking into account the impact of the patients' co-morbidity burden, the purpose of this study was to investigate the relationship between the functional health-related body mass index (fH-BMD) of patients and their functionality status. MLgR analysis was utilised in the research project in order to ascertain the coefficients that were required for the development of a predictive model for the functionality status of the patients. F

H_BMDs and AACCIs (whether they were lower or higher than 4) of the patients were taken into consideration by the model. For the purpose of this investigation, we decided to make use of a machine learning model in order to investigate the probability and odds of patients being in higher or lower functionality statuses based on their fH_BMDs. Separate analyses were carried out for patients who had AACCI scores that were lower than four and for those who had scores that were four or higher.

On the basis of their functional grades, the patients who were the subject of the study were separated into two distinct groups: Cohort I, which included patients with functionality grades ranging from III to IV, and Cohort II, which included patients with functionality grades weighing between I and II. The Chi-Square Test was employed to analyse the variables that were the subject of comparison between the two cohorts. The significance level for this test was set at p-value less than 0.05. The findings were documented in the form of numerical values (percentages).

In order to administer the Chi-Square Test, it was necessary to compute the Pearson chi-square statistic (χ 2), which is a statistical measure that quantifies the difference between the observed and expected frequencies squared. In addition to this, the Goodness of Fit (G-Test of independence) was utilised in order to evaluate the degree to which the observed frequencies corresponded to the values that were anticipated.

During this test, you will be required to compute the logarithm of the ratio of two likelihoods. In addition, odds ratios (OR) were used as a measure of the statistical significance of the associations that were found. The representation of the correlations, which included both interval by interval (Pearson, r) and ordinal by ordinal (Spearman, ρ), was of the value plus or minus the standard error of the value. If the p-value was less than 0.05, then the data was considered to be statistically significant. Intervals of confidence with a 95% level were computed. When conducting the analyses, SPSS (SPSS Statistics Version 25 IBM) was the software that was utilised.

3. Results

For the purpose of analysing the relationship between the patients' functionality statuses (the probability of having higher versus lower functionality statuses) and their Age-adjusted Charlson Co-Morbidity Index (AACCI) and femoral hip bone mineral density (fH_BMD), a logistic regression model was developed. Patients who visited our rehabilitation and rheumatology clinic between September 2021 and November 2021 were included in the study. The research was carried out at Prince Rashid bin Al-Hasan Military Hospital, which is part of Royal Medical Services in Irbid, Jordan.

The equation that represents the model is as follows: [e (-45.740 + 2.526 × AACCI + 60.218 × fH_BMD) /1+ e (-45.740 + 2.526 × AACCI + 60.218 × fH_BMD)]. With a chi-square value of 48.837 and a p-value that was lower than 0.0005, the logistic-based model was able to demonstrate statistical significance. The amount of variance that our model takes into account in the dependent variable can range anywhere from thirty percent to forty two percent, depending on whether the Cox and Snell R2 method or the Nagelkerke R2 method is utilised, respectively. The cases were correctly classified in 78.2 percent of the cases, which is an additional positive finding.

In this particular study, the gender ratio that was examined was 5.87 females to 1 male. The cohort with a lower functionality status (Cohort I) and the cohort with a higher functionality status (Cohort II), which had ratios of 6:1 and 5.76:1, respectively, did not differ significantly from one another in terms of the distribution of gender ratios. The statistical analysis revealed a ratio of 1.041, with a 95% confidence interval ranging from 0.477 to 2.273, a range of 0.007 to 0.070, a chi-square value of 0.010, and a p-value of 0.920.

When it came to the age groups of the patients who were examined, the proportion of patients who fell within the age range of 50-59 years was significantly higher than the proportion of patients who fell within the age range of 60-69 years. To be more specific, 110 patients, or 53.4%, fell into the age range of 50-59 years old, while 96 patients, or 46.6%, represented the age range of 60-69 years old.

A comparison of these proportions between Cohort I and Cohort II revealed a significant difference between the two groups. In the first cohort, there were 19 patients who fell within the age range of 50 to 59 years old, while 72 patients (79.1%) were in the age range of 60 to 69 years old. Twenty-nine patients, or 79.1%, were in the age range of 50-59 years old in Cohort II, while twenty-nine patients, or 20.9%, were in the age range of 60-69 years old. According to the findings of the statistical analysis, the p-value was 0.000, which indicates that there is a significant difference between the two time periods.

When compared to Cohort II, the proportion of individuals in Cohort I who had body mass indexes that fell into the obese category was significantly higher (64.8%), as was the proportion of individuals who were overweight (28.6%). Cohort II had a greater proportion of individuals who fell into the category of being obese (80.9%) and those who were considered to be of normal weight (8.7%). Both the Pearson correlation (r) and the Pearson chi-square statistic (χ 2) were statistically significant (p-value = 0.001). The Pearson correlation (r) was 0.151±0.070, and the Pearson chi-square statistic reached 17.301.

Both the femoral head bone mineral density (fH_BMD) and the lumbar bone mineral density (LBMD) of the patients were found to be significantly distributed across the two cohorts that were tested. Over the course of the first cohort, 86.8% of the patients had a fH_BMD that was lower than 0.755 g/cm2, while 12.2% of the patients had a fH_BMD that was higher than 0.755 g/cm2. In a similar manner, in cohort 2, twenty-nine patients (20.9%) had a fH_BMD that was lower than 0.755 g/cm2, while ninety-one patients (79.1%) had a fH_BMD that was higher than 0.755 g/cm2. With a value of 24.962 (95% confidence interval; 11.725-53.144), a mean of 0.655±0.052, a chi-square value of 88.364, and a p-value of 0.000, the difference between the two cohorts was found to be statistically significant.

When it came to the lower body mass index (LBMD), 31 patients in cohort 1 (34.1%) had LBMD that was lower than 0.835 g/cm2, while 60 patients (65.9%) had LBMD that was higher than 0.835 g/cm2. Eighty-six percent of the patients in cohort 2 had LBMDs that were higher than 0.835 g/cm2, while twenty patients, or 17.4 percent, had LBMDs that were lower than 0.835 g/cm2. With a value of 2.454 (95% confidence interval; 1.283-4.694), a mean of 0.192±0.069, a chi-square value of 7.561, and a p-value of 0.006, the difference between the two cohorts was found to be statistically significant.

On the other hand, the findings of the FRAX analysis, which evaluates the risk of hip fracture and overall major osteoporotic fracture over a period of ten years, were found to be significantly different between the two groups that were being compared. From the findings of the analysis, it was determined that the risk scores, which are inversely related to bone mineral density (BMD), were distributed as follows: 19 (20.9%) and 72 (79.1%) in one group, and 91 (79.1%) and 24 (20.9%) in the other group.

Statistical analysis produced a p-value of 0.000, which indicates that there is a significant difference between the two groups. In a different comparison, the risk scores were distributed as follows: they were 62 (68.1%) and 29 (31.9%) in one group, and they were 95 (82.6%) and 20 (17.4%) in the other group. The p-value that was obtained from the statistical analysis was 0.015, which also indicates that there is a significant difference. In **Table** 1-4 and **Figure** 1-4, the results of the analysis and illustrations for all of the patients who were tested were presented in a manner that was both clear and comprehensive regarding the information.

4. Discussion

Using multidimensional Likert scales, which are generally considered to be valid, it is possible to evaluate the functional statuses of patients. We made use of the functional grading system I-IV, which was derived from the grading system that was proposed by Lowe C et al through their research. comes from the user's text. In general, when the functional status of a patient is classified as Grade III or Grade IV, we can anticipate a decrease in productivity, an increase in the intensity of pain, a restriction in activity, and more obvious objective findings. Examples of patients who fall into the Grade I category include those who experience pain that goes away shortly after resting after engaging in physical activity.

The majority of the time, these patients have normal levels of productivity and workflow capacity, and there are typically no objective findings present. In the same way that Grade I patients do, Grade II patients experience pain that is self-limiting after they exercise. Nevertheless, there is a slight decrease in their productivity, and there may be some difficulty in determining the findings for objective purposes. When compared to patients with Grade I-II, those with Grade III-IV, on the other hand, experience a significant decline in terms of productivity, pain during and after workouts, limitations in daily activities, and objective observations.

The functionality of the patients who underwent testing at the rehabilitation clinic was assessed using a grading system. The participants were assigned to either Cohort I, representing a lower functionality status (Grade III-IV), or Cohort II, representing a higher functionality status (Grade I-II), based on the results. Cohort I had 91 participants, accounting for 44.17% of the total, while Cohort II had 115 participants, accounting for 55.83%. In this study, we allocated the functional grades I-IV to delineate distinct levels of functionality. The grades can also be denoted as Grade I, Grade II, Grade III, and Grade IV, corresponding to relatively functional, partially functional, partially non-functional, and relatively non-functional, respectively.

The distribution of the four mentioned functionality statuses varied significantly between the two cohorts. The distribution in the initial cohort was as follows: zero (0.0%), zero (0.0%), fifty-eight (63.7%), and thirty-three (36.3%). The distribution in the second cohort was as follows: 50 individuals (43.5%), 65 individuals (56.5%), 0 individuals (0.0%), and 0 individuals (0.0%). The p-value of 0.000 indicates a statistically significant difference. The Pearson correlation coefficient (r) was determined to be 0.877 with a standard error of 0.005. Additionally, the chi-square statistic (χ 2) was calculated to be 206.0.

The results of our research have revealed a number of important findings that have important repercussions. Patients in the age range of 50-59 years were found to have a higher likelihood of being in the higher functionality cohort (Cohort II) and a lower likelihood of being in the lower functionality cohort (Cohort I) when compared to patients in the age range of 60-69 years. This was the conclusion reached by our research findings. For Cohort II, the proportions were 91

(79.1%) versus 24 (20.9%), and for Cohort I, the proportions were 19 (20.9%) versus 72 (79.1%). The p-value for this difference was 0.000, which indicates that it was statistically significant.

The Pearson correlation coefficient (r) measured the relationship between the age ranges of the patients and the functionality cohorts. It was found to be -0.580±0.057. 69.271 was the value of the chi-square statistic (χ^2) for this particular relationship. Ageing is associated with a significant inverse relationship between bone mineral quantity and quality, which ultimately results in functional impairments. This finding is consistent with the findings of a large number of other studies. Ageing is a natural process that is characterised by a decrease in both the strength and frequency of growth hormone secretions. This decrease occurs as a result of the natural process of ageing. This decrease occurs at a rate of approximately 14% per decade in the population that is getting older. Consequently, the liver produces less insulin-like growth factors (IGF-1 and 2), which leads to a decrease in the amount of these growth factors. It was highly indicative of lower bone mineral density (BMD) when serum IGF levels were lower or when IGF binding proteins were higher. [17-23]

Furthermore, we demonstrated a clear and significant positive correlation between the body mass indexes (BMIs) of the patients who were being examined and their functionality statuses. This correlation was discovered through our research. Furthermore, the person (r) and spearman (ρ) correlations exhibited significantly positive values, as indicated by their respective standard errors of values [0.151±0.070, χ^2=17.301] and [0.205±0.068, G-Test=18.654]. These correlations were found across the two functional statuses that were tested, and they were found among the four BMI ranges that were investigated. This was mentioned earlier in the section that discussed the results. Positive correlations have been found between body mass index (BMI), body mass index (BMD), and functionality statuses, and these findings are in line with the findings of a large number of other authors who have also observed positive inter-relationships between these three variables. It is believed that these relationships are influenced by a variety of intricate mechanisms that lie beneath the surface, primarily involving mechanical, hormonal, and nutritional factors. [23-27]

Within the scope of this investigation, we discovered that there were substantial positive correlations between the protein densities and vitamin D levels of the patients who were examined in relation to their functional statuses. An odd ratio of 14.253 (95% confidence interval; 7.083-28.680) was found for the protein density, and the corresponding χ^2 value was 65.864. On the other hand, the vitamin D levels had an odd ratio of 0.364 (95% confidence interval; 0.293-0.452) and a χ^2 value of 71.815. The group of patients who had higher functionality (Cohort II) had a significantly higher proportion of individuals who had higher protein density (≥2.5 g/100 Cal) and vitamin D level (≥30 ng/ml) compared to the group of patients who had lower functionality (Cohort I) [100 (87.0%) and 63 (54.8%) versus 29 (31.9%) and 0 (0.0%), respectively, with a p-value of 0.000].

There have been a number of studies that have reached the same conclusion: the risk of developing osteoporosis and age-related sarcopenia can be decreased by consuming adequate quantities of protein and calcium/vitamin D, in addition to engaging in regular physical activity or exercise, as the case may be. Individuals should consume an optimal amount of dietary protein, which is recommended by the European Society for Clinical and Economic Aspects of Osteoporosis and Osteoarthritis (ESCEO). This amount of protein should range from 1.0 to 1.2 grammes per kilogramme of body weight per day. At a minimum, twenty to twenty-five grammes of high-quality protein should be incorporated into each of the primary meals that you consume. Additionally, it is essential to ensure that an adequate intake of vitamin D is achieved, with a daily intake of 800 International Units (IU), in order to keep serum 25-hydroxyvitamin D levels at or above 30 to 50 nanograms per millilitre. In addition, it is recommended that one consume a daily calcium intake of one thousand milligrammes. To prevent the age-related decline in musculoskeletal health, it is recommended that individuals engage in regular physical activity or exercise, which should be performed three to five times per week. Additionally, protein consumption should be performed in close proximity to exercise. [27-30]

The MLgR model that is depicted in figure 1 demonstrates that there is a clear exponential relationship between the fBMDs of the patients who are being investigated and the probabilities that they have a higher functionality status. The MLgR illustrated model was displaced to the right when the patients' co-morbidity burden (AACCI) reached or surpassed 4. Through the course of this research, the relationship between the Age-Adjusted Charlson Comorbidity Index (AACCI) and the femoral bone mineral density (fBMD) was investigated. According to the results of our research, once the AACCI reaches a value of four or higher, an additional fBMD of at least 0.05 g/cm2 is required in order to have an equivalent likelihood of having a higher functionality status with the same level of functionality. According to the findings of previous research, patients who suffer from osteoporosis may experience improved functionality if they refrain from smoking and consume fruits and vegetables on a regular basis. In spite of this, our research did not uncover any significant associations between the aforementioned factors and the functional statuses of the patients [1.167 (95% CI; 0.473-2.883) and 0.742 (95% CI; 0.380-1.447), respectively]. [31-32]

5. Conclusion

The purpose of this retrospective study, which was carried out at a single centre and was neither sponsored nor funded, was to investigate the relationship between femoral bone mineral density (fBMD) and overall functionality status in patients who were suffering from co-morbidities. fBMD was found to have a significant positive correlation with the likelihood of having a higher functionality status, at least according to the findings of the study. To be more specific, the correlation moved to the right by a minimum of 0.05 g/cm2 whenever the Age-adjusted Charlson Co-Morbidity Index was four or higher. Despite this, there was a possibility of subjectivity in this study due to recall and selection bias. Nevertheless, it has the potential to offer supplementary assistance to other prospective studies that are conducted across multiple sites and investigate the connection between the bone mineral densities of patients and their functional statuses, particularly in Jordanian or Mediterranean cohorts. Furthermore, it is essential to take into account other potential confounding factors in addition to their co-morbidity burdens.

Compliance with ethical standards

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Disclosure of conflict of interest

There is no conflict of interest in this manuscript

Statement of ethical approval

There is no animal/human subject involvement in this manuscript

Statement of informed consent

Owing to the retrospective design of this study, the informed consent form was waived.

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