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Analysis of Osteoporosis Risk Factors in 148 Retired Employees Based on Physical Examination Results

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Abstract: *Objective:* To investigate and thoroughly understand the physical examination results of retired employees from a certain unit in Beijing, analyze their bone mineral density (BMD), and identify risk factors that may indicate osteoporosis. This provides a reference for the individualized prevention, identification, and control of osteoporosis among retired employees. *Methods:* The bone mineral density and potential factors of 148 retired employees from a unit in 2023 were analyzed and categorized into osteoporosis and non-osteoporosis groups. Key factors from the physical examinations of the two groups were compared. Spearman's correlation analysis was used to determine the correlation between key factors and osteoporosis. Significant key factors were included in a regression analysis. A multivariate binary logistics regression was employed to identify risk factors indicative of osteoporosis. *Results:* Correlation analysis revealed that gender, age, and ECG ST-segment length were significantly associated with osteoporosis. Regression analysis showed that for each additional year of age, the likelihood of developing osteoporosis increased by 1.058 times; females were 2.865 times more likely to develop osteoporosis compared to males; the longer the ECG ST-segment, the higher the likelihood of osteoporosis. *Conclusion:* Gender, age, and ECG ST-segment length are significantly associated with osteoporosis. These indicators can provide reference points for early identification, early intervention, and reducing the incidence of osteoporosis in clinical settings.

Keywords: Osteoporosis; Gender; Age; ECG ST-segment; Correlation analysis

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1. Introduction

Osteoporosis is a systemic disease characterized by reduced bone mass and decreased bone density, leading to increased bone fragility and a higher likelihood of fractures [1]. In elderly patients, the presence of multiple comorbidities means that fractures can exacerbate the risk of other systemic diseases, a concern that warrants significant attention. Large-scale epidemiological surveys in China have shown that the age-standardized prevalence of osteoporosis in the population over 50 years old is 6.46% for men and 29.13% for women [2]. This highlights the importance of addressing this disease due to its high prevalence. Osteoporotic fractures often involve decreased bone mass and poor bone stability, commonly occurring in weight-bearing areas such as the spine, hips, and wrists, and are associated with high disability and mortality rates, imposing a significant social and healthcare burden.

With the increasing aging population in China and the rising average lifespan of the elderly in Beijing, the health status of retired employees has become a growing concern. Clinical experience suggests that certain electrocardiogram (ECG) features may have indicative significance for osteoporosis. However, previous studies on osteoporosis risk factors have rarely mentioned blood indicators and ECG results from physical examinations. Therefore, this study commences from the health examination results of 148 retired workers, adhering to the guidelines [3] and under the premise of common risk factors such as gender and age. To achieve a more comprehensive analysis, this study incorporates previously overlooked ECG characteristics and common blood indicators, in addition to other methods of reference. The goal is to provide a comprehensive analysis of osteoporosis risk factors based on physical examination results, categorize and classify patients, and offer a basis for clinical prevention education, identification of high-risk groups, and individualized patient management.

2. Materials and methods

2.1. Study subjects

This case-control study retrospectively selected 148 retired employees aged 55 and above (42 with normal bone mass, 47 with reduced bone mass, and 59 with osteoporosis) who underwent physical examinations at the Civil Aviation General Hospital in Chaoyang District, Beijing, from January to December 2023. Inclusion criteria: completed ultrasound bone density examinations. Exclusion criteria: patients with bone metastases from malignant tumors; those with secondary bone loss due to various causes and bone metabolism-related diseases; patients with major illnesses or bedridden for over 3 months in the past year; those requiring long-term corticosteroid use in the past six months; incomplete ultrasound bone density examination; incomplete blood indicator checks; no ECG examination; incomplete basic information such as age.

2.2. Detection methods and diagnostic criteria

2.2.1. Detection methods

Data for this study were collected from the medical examination management information system of the Civil Aviation General Hospital (T-PES2005 medical examination management information system by Beijing Tongfang Weikang Technology Co., Ltd.). All participants underwent relevant examinations at least 8 hours after fasting, starting the following morning. The following examinations were completed by trained nurses, technicians, and physicians in our department, with participants having the right to choose or decline specific examination items. The relevant items in this study include:

(1) Laboratory tests: Biochemical tests (detected using Beckman Coulter AU5800 automatic biochemical analyzer);

(2) Electrocardiogram (ECG): detected using GE MAC2000 electrocardiograph analyzer;

(3) Bone density: detected using the BMD-9M3 ultrasound bone densitometer by Beijing Yueqi Chuangtong Technology Co., Ltd., which evaluates bone mineral density (BMD) and bone strength by measuring the speed of sound (SOS) and broadband ultrasound attenuation (BUA) in bones. The built-

in processor compares the measured BMD results with the reference database to generate a T-score. The bone density of both forearm radial and ulnar bones at the 1/3 distal end of the non-weight-bearing side was measured, obtaining the mean BMD and T-score, and comparing the measured bone density with the peak bone density of the same gender, noting the standard deviation [1].

2.2.2. Diagnostic criteria

(1) Lipid levels: In biochemical tests, lipid levels are considered appropriate when total cholesterol (TC) < 5.2 mmol/L, triglycerides (TG) < 1.7 mmol/L, low-density lipoprotein cholesterol (LDL-C) < 3.4 mmol/L, and high-density lipoprotein cholesterol (HDL-C) ≥ 1.0; otherwise, they are considered dyslipidemia [4].

(2) Blood glucose: According to the diagnostic criteria proposed by the WHO Expert Committee on Diabetes (1999), this study uses fasting venous blood glucose as the judgment standard, with hyperglycemia diagnosed when fasting blood glucose > 6.1 mmol/L.

(3) Liver function: According to the reference values in the reagent instructions provided with the instruments, liver function is normal when alanine aminotransferase is 9–50 mmol/L and aspartate aminotransferase is 15–40 mmol/L; otherwise, liver function is abnormal.

(4) Uric acid: According to the reference values in the reagent instructions provided with the instruments, hyperuricemia is diagnosed when UA > 422 μmol/L in men and UA > 387 μmol/L in women.

(5) Heart rate: Adults' normal resting heart rate typically ranges between 60 and 100 beats per minute [5]; rates outside this range are considered abnormal.

(6) ST-segment length [6]: The ST segment in an ECG is located between the end of the QRS complex (J point) and the beginning of the T wave, reflecting the early repolarization process of the ventricles. Measured using the DELIXI plastic digital caliper 20220325.

(7) TP-segment length [7]: The TP segment in an ECG refers to the time interval from the end of the T wave of one heartbeat to the start of the P wave of the next heartbeat. Measured using the DELIXI plastic digital caliper 20220325.

(8) Bone density: A T-score > -1 is considered normal; -2.5 < T-score ≤ -1 indicates reduced bone mass; and a T-score ≤ -2.5 at one or more sites indicates osteoporosis. Normal bone mass is considered normal, while reduced bone mass and osteoporosis are considered abnormal [1].

2.4. Data processing and analysis

Data entry and processing were performed using EXCEL, and statistical analysis was conducted using SPSS 29.0 statistical software. Quantitative data not normally distributed were described as $M(Q_1 - Q_3)$. Differences in factors among the normal bone mass, reduced bone mass, and osteoporosis groups were analyzed using chi-squared tests for binary variables and Kruskal-Wallis rank-sum tests for continuous variables. Correlation analysis involved using Spearman correlation to analyze the relationship between key factors and the binary variable of osteoporosis. Multivariate binary logistic regression analysis was employed to examine the relationship between risk factors and osteoporosis. A P-value of < 0.05 was considered statistically significant.

3. Results

3.1. Basic information of examinees

Among the 148 samples, there were 43 males (29.1%) and 105 females (70.9%); the age range was 55–92 years, with a median age of 68 (62–72) years. Specifically, there were 15 people aged 55–59 (10.1%), 78 people aged 60–69 (52.7%), 41 people aged 70–79 (27.7%), and 14 people aged 80 and above (9.5%). For more details, see **Table 1**.

Table 1. Basic information of the examined population [*n* (%)]

Age group	Male		Female		Total	
	n	%	*n*	%	*n*	%
55–59	0	0.0%	15	14.3%	15	10.1%
60–69	25	58.1%	53	50.5%	78	52.7%
70–79	12	27.9%	29	27.6%	41	27.7%
80 years and over	6	14.0%	8	7.6%	14	9.5%

3.2. Overview of common blood indicators and ECG results in normal bone mass, reduced bone mass, and osteoporosis groups

Bone density was categorized into normal bone mass, reduced bone mass (31.08% total: 8.11% male, 22.97% female), and osteoporosis (40.54% total: 7.43% male, 33.11% female). The proportion of the examined population with abnormal bone mass (including reduced bone mass and osteoporosis) was 71.62% of the total. Differences in the risk factors analyzed among these three groups were tested, and the results are shown in **Table 2**. Among these, the differences in ST-segment length between the groups were significant, with $P < 0.001$. Other factors did not show significant differences.

Table 2. Analysis of blood indicators and ECG results in normal bone mass, reduced bone mass, and osteoporosis groups [*n* (%)]

Factor	Normal bone mass group	Reduced bone mass group	Osteoporosis group	χ^2-value	*P*-value
Dyslipidemia	18 (32.73)	16 (29.09)	21 (38.18)	0.657	0.720
Hyperglycemia	31 (29.52)	34 (32.38)	40 (38.10)	0.495	0.781
Elevated liver transaminase levels	39 (27.86)	45 (32.14)	56 (40.00)	0.381	0.826
Increased uric acid	40 (31.01)	41 (31.78)	48 (37.21)	4.226	0.121
Abnormal heart rate	40 (27.97)	46 (32.17)	57 (39.86)	0.472	0.790
ST-segment length	52.63*	77.50*	87.68*	16.77	< 0.001
TP-segment length	67.50*	79.91*	74.02*	1.867	0.393

Note: * indicates the rank mean value. The ST-segment length and TP-segment length were tested using rank-sum tests, with the second-to-last column representing the H value.

3.3. Correlation analysis between various factors and osteoporosis

The normal bone mass and reduced bone mass groups were combined into a non-osteoporosis group, thus classifying the data into osteoporosis and non-osteoporosis. Factors potentially related to osteoporosis were then analyzed, with the results of the Spearman correlation analysis shown in **Table 3**. It can be seen that gender, age, and ST segment length are significantly correlated with osteoporosis, and these factors were included in the subsequent regression analysis.

Table 3. Correlation analysis between various factors and osteoporosis

Factor	*r*	*P*
Gender	-0.217	0.008
Age	0.164	0.047
Dyslipidemia	0.062	0.471
Hyperglycemia	0.056	0.495
Elevated liver transaminase levels	-0.012	0.889
Increased uric acid	0.141	0.087
Abnormal heart rate	0.001	0.995
ST-segment length	0.251	0.002
TP-segment length	0.000	0.997

3.4. Multivariate regression analysis of osteoporosis

The factors found to be correlated in the analysis (age, gender, ST segment length) were included in a multivariate binary logistic regression analysis, with the results shown in **Table 4**. As seen in **Table 4**, age is a significant risk factor for osteoporosis ($P = 0.013 < 0.05$), with a further impact coefficient of 0.585 > 0, indicating that the likelihood of osteoporosis increases with age. For each age group increase, the likelihood of developing osteoporosis is 1.795 times the previous group. Gender is also a significant risk factor for osteoporosis ($P = 0.017 < 0.05$), with a further impact coefficient of 1.053 > 0, indicating that women are more likely to develop osteoporosis than men. The likelihood of women developing osteoporosis is 2.865 times that of men. The ST-segment length is another significant risk factor for osteoporosis ($P = 0.026 < 0.05$), with a further impact coefficient of 0.472 > 0, indicating that the likelihood of osteoporosis increases with the length of the ST segment. For every 1 mm increase in ST-segment length, the likelihood of developing osteoporosis is 1.604 times the previous value.

Table 4. Binary logistics regression analysis results for various factors and osteoporosis

	B	*P*	OR	95% confidence interval for OR	
				Lower limit	Upper limit
Age group	0.585	0.013	1.795	1.129	2.854
Gender	1.053	0.017	2.865	1.203	6.826
ST-segment length	0.472	0.026	1.604	1.057	2.434
Constant	-3.379	< 0.001	0.034		

Furthermore, if age was analyzed in finer detail, using each year as a unit rather than grouping by age ranges, further regression results shown in **Table 5** were obtained. It is evident that age is a significant risk factor for osteoporosis ($P = 0.019 < 0.05$), with a further impact coefficient of 0.056 > 0, indicating that the likelihood of osteoporosis increases with age. For each additional year of age, the likelihood of developing osteoporosis increases by a factor of 1.058.

Table 5. Binary logistics regression analysis results for various factors and osteoporosis (detailed age analysis)

	B	*P*	OR	95% confidence interval for OR	
				Lower limit	Upper limit
Age	0.056	0.019	1.058	1.009	1.109
Gender	1.051	0.018	2.860	1.195	6.846
ST segment length	0.454	0.032	1.575	1.040	2.383
Constant	-6.367	< 0.001	0.002		

4. Discussion and conclusion

The prevention and treatment of osteoporosis in China face prominent issues, such as high prevalence and low awareness, diagnosis, and treatment rates, often referred to as the "one high and three lows" situation. This presents significant challenges for healthcare professionals involved in wellness and related care [8,9]. The prevalence of osteoporosis and reduced bone mass is increasing annually [10]. If pathological fractures occur, serious cases can lead to bedridden status, require home care, cause disability, or even result in death. The costs associated with treatment and care can impose a significant burden on families and society.

This study, based on the results measured by an ultrasonic bone density scanner, suggests that post-55-year-old females exhibit significantly higher levels of bone density abnormalities compared to males, consistent with domestic literature [1]. The prevalence of osteoporosis in women is significantly higher than the average level in Western countries but is similar to data from other Asian countries like Japan and Korea [11]. Previous studies have suggested that osteoporosis is an age-related skeletal disease, characterized by an increasing incidence with advancing age [12]. However, data from this study suggest that among retirees and elderly examinees in different age groups, there was no observed increase in the prevalence of reduced bone mass with age. This might be attributed to high medication compliance among retired workers in this particular unit, timely disease prevention, and effective treatment following annual physical examinations, which may have slowed the progression of bone loss. The data indicate that increased screening and education regarding bone density among retirees could enable timely intervention for those with abnormal bone density, effectively mitigating risks associated with further bone loss. This strategic approach could delay the progression from reduced bone mass to osteoporosis (including moderate and severe osteoporosis). The ultrasonic bone density scanner offers advantages such as being radiation-free, simple, and fast for screening high-risk populations for osteoporosis, although guideline recommendations [13] caution that measurement biases may impact results.

When pathological changes occur in blood electrolytes, especially a significant decrease in calcium ion concentration, the direct result can be a prolonged phase 2 action potential in cardiac electrophysiological activity, leading to an extended ST segment on an ECG. From the perspective of myocardial action potentials, the duration of phase 2 is determined by the time required for the action potential to transition into phase 3. The necessary condition for this transition is a significant change in intracellular electrolytes, particularly a sufficient decrease in potassium ions, which allows for the rapid outward flow of potassium ions, facilitating the transition to phase 3 [14]. However, during electrolyte disturbances, especially hypocalcemia, the reduced influx of calcium ions and corresponding changes in potassium ion outflow lead to decreased potassium content, extending the time for rapid potassium outflow. Consequently, the duration of phase 2 in the action potential is significantly prolonged, manifesting as an extended ST segment on the ECG. Therefore, a negative correlation can be observed between serum calcium concentration and ST segment length during electrolyte disturbances.

Correspondingly, when the body lacks calcium, physiological changes occur to compensate for the deficiency, leading to decreased calcium ion levels in the blood. This can result in increased bone resorption and decreased bone density, triggering secondary hyperparathyroidism, which further releases calcium from bone tissue into the bloodstream, ultimately leading to osteoporosis [15,16].

This study aims to explore the potential risk factors for osteoporosis through physical examination results. It innovatively conducted a multi-indicator correlation study, associating blood biochemical indicators, ECG indicators (ST segment length), and bone density data to explore their correlation with osteoporosis. This research provides valuable insights into the clinical prevention of osteoporosis, offering new perspectives and reference points for early detection. Monitoring these common and easily accessible examination indicators, utilizing multidimensional examination data, can help early identification of high-risk groups. Clinicians can then detect osteoporosis risk in middle-aged and elderly patients early, allowing for timely preventive measures, interventions, and treatment plans.

In summary, the analysis of the physical examination results of retirees from a particular unit suggests the need for increased education and active intervention regarding osteoporosis among retirees (middle-aged and elderly patients). This can improve the health status and quality of life of retirees.

Disclosure statement

The authors declare no conflict of interest.

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