Different Tools for the Assessment of Bone Mass among Egyptian Adults

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Abstract

BACKGROUND: Several tools such as, dual X-ray absorptiometry (DXA), quantitative computed tomography (QCT) and self-assessment tool (OST), are being used for diagnosis of osteoporosis.

OBJECTIVE: to compare the sensitivity and specify detection rate of bone mineral density (BMD) changes for DXA versus QCT and OST among a sample of Egyptian adults of both sexes.

SUBJECTS AND METHODS: This study is a cross sectional one, which included 62 Egyptians, aged 20-65 years. Each individual was assessed for BMD using DXA at femur and spine sites; QCT and OST which take into account body weight and age. Accordingly they were diagnosed as either osteoporotic/osteopenic or normal.

RESULTS: The highest prevalence of osteopenia or osteoporosis was diagnosed among menopause women. DXA at femur has diagnosed more cases of osteoporosis (both osteopenic and osteoporotic) as compared to spine DXA or QCT, but OST is out of rang; as it failed to diagnose any case.

CONCLUSION: DXA has been found to be more efficacious than QCT scan in the diagnosis of osteoporosis. DXA in femur is better than DXA-spine and QCT. Generally, DXA is the "gold standard" when assessing osteoporosis. Further studies are needed to modify the equation of OST and confirm its efficiency in Egyptians population.

Introduction

Bone is a highly metabolic tissue, incorporating multiple functions such as stabilization of the body, protection of the inner organs and calcium storage [1]. Osteoporosis is the most common metabolic bone disorder. It is defined as "a skeletal disease, characterized by low bone mass and micro-architectural deterioration of bone tissue, with a consequent increase in bone fragility and susceptibility to fracture [2].

Several tools have been developed to identify patients with high risk of osteoporosis, in whom actual bone mineral density (BMD) testing would be most useful in terms of diagnosis, treatment, and follow up [3].

Dual-energy X-ray absorptiometry (DXA) is the most widely used bone densitometry technique. It is versatile in the sense that it can be used to assess bone mineral content of the whole skeleton as well as of specific sites, including those most vulnerable to fracture [4].

Before the advent of DXA, several researchers reported using computed tomography (CT) scanners to obtain bone density measurements. This technique is called quantitative CT (QCT) to differentiate it from imaging CT. However, more advanced procedures were developed to improve the accuracy and precision of the measurement [5].

One of the simplest clinical tools is the Osteoporosis Self-assessment Tool (OST) which only takes into account body weight and age, which in

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adult populations are, respectively, related inversely and directly to the risk of osteoporosis [6].

Since, assessment technique differs between the three modalities, therefore, the purpose of this study was to analyze and compare the sensitivity and specify detection rate of BMD changes for DXA versus the QCT and OST among a sample of Egyptian adults of both sexes.

Subjects and Methods

The current study is a cross sectional one, which included 62 participants (women and men), aged 20 through 65 years, during the period from January to March 2014. The participants were recruited from those attending the outpatient clinic of BMD unit, which is a part of the "The Medical Service Unit" of the "National Research Centre" Egypt. All participants had sedentary life (practicing less than 2 hrs of physical activity per week and not involved in impact sports), with no diagnosis of co-morbidities, no history of fracture and no history of major orthopedic problems or other disorders known to affect bone metabolism. An informed written consent was obtained from every participant. This study was approved by the Ethical Committee of "National Research Centre".

Anthropometric measurements

Anthropometric evaluation was performed. Height and weight were measured following the recommendations of the International Biological Program [7]. Height was measured to the nearest 0.1 cm using a Holtain portable anthropometer, and weight was determined to the nearest 0.01 kg using a Seca Scale Balance, with the subject wearing minimal clothing and no shoes. Body mass index (BMI) was calculated as weight divided by height squared (Kg/m²).

The Osteoporosis Self assessment (OST) scores: was calculated as 0.2 (weight in kg – age in years) and rounded up to the closest integer [8]. The cutoff points for low BMD is 2 [9].

DXA measurements

DXA scans of the lumbar spine (L1–L4) and left hip were performed using a pencil beam Norland (XR-46) densitometry with host software version: 3.9.6 in the medical unit of the National Research Centre. Average BMD is expressed in grams per square centimeter. The DXA T-score was calculated on the basis of the reference database. The diagnostic criteria established by the World Health Organization (WHO) in adults were used. Osteoporosis and osteopenia were defined as a BMD t-score of -2.5 and between -1 < -2.5 respectively [2, 10].

Quantitative Computerized Tomography (QCT)

QCT measurements were obtained with Philips 16- lice CT scanner with Software. Vertebrae from L1 to L5 were scanned in the supine position. Images were analyzed using the software. Elliptical regions of interest were put in the mid plane of the vertebral body of interest (L4) in the trabecular bone automatically, avoiding the cortical bone of the vertebrae. Fractured vertebrae were excluded from measurement. Average BMD is expressed in milligrams per cubic centimeter of calcium hydroxyapatite. For the BMD of spinal trabecular bone, thresholds of 120 mg/cm^3 for osteopenia (equivalent to a DXA T-score of−1.0 SD) and 80 mg/cm^3 for osteoporosis.

Statistical analysis

Data were analyzed using the Statistical Package for Social Sciences (SPSS/Windows Version 16, SPSS Inc., Chicago, IL, USA). Statistical significance was set at $P < 0.05$. Normality of the data was verified with the Kolmogorov-Smirnov test. All the variables showed normal distribution. Parametric data were expressed as mean $\pm$ SD. Comparisons between the different variables were analyzed by Student's t test for independent groups. Number of participants; who suffer from osteopenia / or osteoporosis; according to different diagnostic tools; was calculated. The validity of QCT in the diagnosis of osteopenia/or osteoporosis; using DXA as standard tool; was examined by calculation of sensitivity, specificity, positive and negative predictive values. Sensitivity was calculated as true-positives/ (true-positives + false-negatives); specificity as true-negatives/ (true-negatives + false-positives). True-positive subjects were those with low BMD by DXA and QCT. True-negative subjects were those with normal BMD by DXA and QCT. False-positive subjects were those with low BMD by QCT and normal BMD by DXA. False-negative subjects were those with normal BMD by QCT and low BMD by DXA. Positive predictive value (PPV) was defined as the percentage of subjects with low BMD by DXA and QCT. Negative predictive value (NPV) was defined as the percentage of subjects with normal BMD by DXA and QCT.

Results

The present study included 62 participants of both sexes, with mean age of 49.4 $\pm$ 14.36 years. Females were; statistically; significant older than males, while males were significantly heavier and taller than females (Table 1). However, there was statistical insignificant sex difference in their BMI. Regarding the bone mass, females had significantly lower values of BMD and its t-score measured by

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DXA; at lumbar and femur sites; and QCT; at lumbar site; than males. Also, females had significantly lower values of OST than males.

Table 1: Characteristics of the sample by sex (using t-test).

Variable	Males (N=18)		Females (N=44)		t-value	p
	Mean	+ SD	Mean	+ SD		
Age (years)	39.33	14.05	53.55	12.43	-3.934	0.000
Weight (Kg)	95.84	14.50	84.55	12.84	2.804	0.007
Height (cm)	173.10	4.17	155.31	6.14	10.335	0.000
BMI (Kg/m²)	32.14	5.70	35.08	4.98	-1.877	0.066
OST	11.20	0.77	6.15	2.85	10.239	0.000
DXA:						
Lumbar BMD(gm/cm²)	1.06	0.22	0.95	0.16	2.204	0.031
Lumbar BMD T-score	- 0.58	1.19	-1.26	0.94	2.371	0.021
Femur BMD(gm/cm²)	0.96	0.07	0.79	0.12	6.777	0.000
Femur BMD T-score	-1.03	0.58	-1.77	0.90	3.873	0.000
CT data:						
Lumbar BMD(gm/cm²)	130.73	26.34	117.81	37.98	1.316	0.193
Lumbar BMD T-score	-0.37	1.10	- 0.70	1.56	0.815	0.419

N.B.: P<0.05= Significant differences; P<0.01= highly significant differences.

According to the different diagnostic tools, the number of participants diagnosed as having osteopenia or osteoporosis, were as follows: 48/62 (77.5%) by DEAX at femur site, 32/62 (51.6%) by DXA at lumbar site and 28/62 (45.2%) by QCT at lumbar site. The highest no. of those suffering from osteopenia or osteoporosis; was diagnosed by DXA at femur site, while the lowest no. was diagnosed by CT at lumbar site. The percentages within females were higher than those within males by the different methods. Unfortunately, nobody was diagnosed as having osteopenia or osteoporosis by using OST, whose range in our participants was 2 up to 14, which was higher than the cutoff point (< 2). This means that the equation; which used for calculating OST for Asian; is not suitable for African; especially Egyptians (Table 2).

Table 2: Number of participants with osteopenia or osteoporosis according to different diagnostic tools.

	Total (N=62)	Males (N=18)	Females (N=44)
	N (%)	N (%)	N (%)
DXA:			
Lumbar BMD T-score	32 (51.6%)	6 (33.3%)	26 (59.1%)
Femur BMD T-score	48 (77.5%)	12 (66.7%)	36 (81.8%)
CT Lumbar BMD T-score	28 (45.2%)	6 (33.3%)	22 (50%)
OST	0 (0.0%)	0 (0.0%)	0 (0.0%)

Comparing subjects suffering from osteopenia or osteoporosis with those with normal BMD; using DXA at lumbar site; there were highly statistical significant differences were found in BMD and its t-score by using DXA, QCT or even OST, in spite of presence of insignificant differences in their BMI (Table 3).

The validity of QCT in diagnosing of osteopenia or osteoporosis; using DXA as standard tool; was evaluated in table (4). QCT showed high sensitivity (81.1%) and specificity (93.3%) with BMD t-score at lumbar site by DXA. While with BMD t-score at femur site by DXA, CT had high specificity (100%), but low sensitivity (58.3%).

Table 3: Characteristics of the participants according to their bone mineral density by DXA at lumbar site.

	Normal BMD (N=30)		Osteopenia or osteoporosis (N=32)		t-value	p
	Mean	+ SD	Mean	+ SD		
Age (years)	40.80	14.52	57.50	8.33	-5.506	0.000
Weight (Kg)	84.71	16.69	90.06	11.27	-1.412	0.164
Height (cm)	160.64	11.28	159.77	8.51	0.325	0.746
BMI (Kg/m²)	32.99	6.15	35.35	4.28	-1.624	0.112
OST	8.48	3.78	6.73	2.75	1.925	0.061
DXA:						
Lumbar BMD(gm/cm²)	1.11	0.16	0.85	0.09	7.764	0.000
Lumbar BMD T-score	- 0.21	0.77	-1.86	0.53	9.754	0.000
Femur BMD(gm/cm²)	0.93	0.10	0.76	0.10	6.720	0.000
Femur BMD T-score	-0.97	0.59	-2.11	0.74	6.660	0.000
CT data:						
Lumbar BMD(mg/cm³)	146.93	25.98	97.79	24.76	7.626	0.000
Lumbar BMD T-score	0.43	1.06	-1.57	1.02	7.569	0.000

N.B.: P<0.05= Significant differences; P<0.01= highly significant differences.

Discussion

The increasing trends for osteoporosis seemed to have been on steady rise since early twenty-first century, not only in old age but also in young age. The noninvasive techniques for measuring bone mineral density (BMD) play an important role in the clinical diagnosis of osteoporosis and in monitoring its progression [11]. Several studies have compared the various osteoporosis risk tools [12- 14].

Table 4: Sensitivity and specificity of Ct in diagnosis of osteopenia or osteoporosis using DXA as standard tool.

	CT at lumbar site				
	Sensitivity (%)	Specificity (%)	PPV	NPV	PPV/NPV
DXA:					
Lumbar BMD T-score	81.3	93.3	0.92	0.83	1.11
Femur BMD T-score	58.3	100	1.0	0.70	1.43

Current results showed that, in spite of insignificant sex difference in their BMI, males had significantly higher values of BMD than females; using different diagnostic tools (DXA, QCT and OST). The prevalence of osteoporosis or low bone mass in this study at either the femur or lumbar spine using DXA and QCT was higher in females than in males. This finding can be attributed due to the fact that the females in this study were going through menopause where rapid bone loss occurred. The lifetime risk of suffering a fragility fracture is estimated to be 30–40% for 50-year-old females [15]. Also, Hassan et al. [16], stated that among Egyptian adolescent girls, there is a positive effect of obesity on BMD due to body weight. This explains our findings of female sample due to hormonal changes with ageing.

In this study, the detection of osteoporosis at femoral site by DXA was better than DXA spinal, followed by QCT at spine. However, OST was out of range. The low sensitivity indicates that BMD tests should be undertaken in femur. The tools offer comparable performance characteristics in that they have high sensitivity with high specificity in lumber site, as it is shown from the comparisons of DXA with

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QCT. The high sensitivity provides opportunities that the findings can be influenced by degenerative changes, leading to a decrease in the ability to detect osteoporosis in spine especially in old age. Schneider et al. [17] found that, under the WHO classification, females with spinal osteoarthritis were more likely to be given a diagnosis of osteoporosis of the femoral neck and hip than those without spinal osteoarthritis.

QCT and DXA have been applied to assess osteoporosis since the 1990s and after considerable review it is generally agreed that DXA is the "gold standard" when assessing osteoporosis [14]. Because DXA is best related to relative fracture risk, as it exposes the subject to a lower radiation dose, delivers the specific study swiftly and efficiently and can assess a number of sites in the body (spine, hip, forearm or whole body) [4]. The major government advisory boards have consistently depended to recommending that the osteoporosis assessment be by DXA rather than QCT. DXA is very sensitive [18]. Clinicians and researchers favor DXA because scanners are readily available and relatively inexpensive [5].

Overall, there are a few longitudinal studies on QCT in predicting fracture and no evidence it is better than DXA. QCT results should not be used as the preferred results when trying to decide if treatment should be initiated. Also, the dose of radiation in case of QCT is significantly higher than that of DXA and providers should justify exposing patients to a higher dose for no demonstrated benefit [19].

Koh et al. [8] developed the OST using linear regression, with femur neck BMD T-score as the dependent variable in Asian. The easiest to use in clinical practice is certainly the osteoporosis self-assessment tool (OST). It was developed and validated in several studies in Asian and from eight countries [19]. Saraví [20] concluded that the OST is useful for selecting patients for DXA testing in the studied population of Mendoza, Argentine. Wehren and Siris, [21] also stated that OST "the simplest of the instruments, performs as well as more complex tools". But as with most studies, our finding has some limitations, our data; collected from Egyptian; may differ; in some ways; from the other population, hence the results may not be generalized.

In Summary, BMD is significantly higher among Egyptian males than females. The highest no. of those suffering from osteopenia or osteoporosis; was diagnosed by DXA at femur site, while the lowest no. was diagnosed by QCT at lumbar site. The percentages within females (suffering from osteopenia or osteoporosis) were higher than those within males by the different methods used. Although QCt had high sensitivity and specificity in the diagnosis of osteopenia or osteoporosis; using DXA at lumbar site as standard tool; DXA is preferable as it is more accurate and also due to the high cost and the greater radiation exposure of QCT. Unfortunately, nobody was diagnosed as having osteopenia or osteoporosis by using OST, whose range in our participants was 2 up to 14, which was higher than the cutoff point (< 2). This means that the equation used to calculate OST in Asians; is not suitable for Africans; especially Egyptians.

Recommendation: DXA is the recommended technique to diagnose and monitor bone density in the management of osteoporosis. The DXA of the hip is the best predictor. QCT technology may be used when an osteoporosis assessment is called for, while DXA is unavailable, or when there is a specific research need to do the study using QCT. Further studies are recommended to modify and confirm the efficiency of OST in Egyptian populations.

*Conclusion:*DXA is superior to QCT for diagnosing of osteopenia or osteoporosis. The equation for OST in Asians cannot be used for Africans. It should be modified and re-evaluated.

Acknowledgments

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