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Normative Values of Bone Mineral Content and Bone Mineral Density Assessed by Double X-ray Absorptiometry in Congolese Urban Women.

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Abstract

Introduction

The World Health Organization (WHO) have validated dual X-ray absorptiometry as the‘‘gold standard’’ densitometric technique for assessing bone mineral density and and the definitions of osteopenia and osteoporosis are based on its results Loss of bone mass with ageing or osteoprosis leads to decline of bone strenght and fragility fractures.

there are racial/ethnic differences in bone mass parameters for populations of different ethnic origines altought living in the same environmental

WHO criteria for the diagnosis of osteoporosis and the associated risks of fractures are based on bone parameters assessed by dual x absorptiometry in postmenopausal Caucasian women

studies have showns the necessity to establish reference data for bone mass measurements for each population according to habit and ethnicity these data are lacking for congolese populations.

This study aims to establish spine and hip normative values in healthy congolese women population and to compare them with those for Caucasian,asian,and others etnical groups ***Materials and methods*** *:*

604 bantoues women were recruited after public media advertising and undergoes DXA of spine and hip.

To be included in the study, women must fulfill the conditions of absence of factor affecting bone metabolism.

Results *: Bone mass parameters shows a growth up to the peak that is reached in the fourth decade followed by a slow decay that causes a loss of nearly 14.2% in BMD and BMC over a period of 20 years and, then a decrease more pronounced towards the sixtieth year (1.5% yearly),higher than among CaucasiansAsians and Arabs .We found that the references curves for the lumbar spine and total hip are significantly differents from the Caucasian,asean or arab*

Keywords :Normative Values ,Bone Mass ,DXA ,Bone Mineral Density,Bone Mineral Content,Black women,Congolese

1. Introduction

The World Health Organization (WHO) has established dual X-ray absorptiometry (DXA) as the‘‘gold standard’’ densitometric technique for assessing bone mineral density (BMD) and the definitions of osteopenia and osteoporosis are based on its results (Cummings SR et al. ,2002 ; IOF ,2011 ; Kanis JA et al. ,1996 ; Kanis JA et al. ,1997 ; WHO, 1994).

Bone is composed of collagen I as main organic phase and of hydroxyapatite crystals as the main inorganic phase, and a cellular component of osteoblasts and osteoclasts (Jager PL et al. ,2010. ;

Every year, the human body replaces not less than 10% of its bone mass by a resorption and formation process due to osteoclasts and osteoblasts. Formation of new bone is also related to synthesis of the organic matrix followed by deposition of calcium crystals, and a gradual maturation process (Kanis JA et al. ,1997) . Bone mass is a major determinant of bone strength and, after reaching peak values in the third decade of life, bone mass and density begins to decline until age 60-65 wich results in low bone mass with ageing and osteoporosis(Kroger H et al.,1992 ; Pretley GW et al. ,1996 ;WHO ,1995).
Low bone mass has been found to be a major cause of decline of bone stenght and a risk factor for fragility fractures that occures in osteoporosis (Genant HK et al. ,1999 ; Simmons A et al. ,1995).

Osteoporosis predisposes individuals to fragility (low trauma) fractures, defined as fractures relating to a fall from the standing position and laboratory studies have shown a high correlation between bone mineral content and the force needed to break a bone (Chami G et al., 2006)

The peak of bone mass and rate of decline seems related to etnicity, environnement and income level of nutritional habits. (Wulan SN, 2010 ; Luckey MM at al. ,2013)

Dual-energy x-ray absorptiometry (DXA) accurately provides information on bone mass and related indices of the the axial and appendicular bone (Chami g et al. , 2006 ; Wulan SN et al. ,2010 ; Borrud LG et al., 2010).

WHO criteria for the diagnosis of osteoporosis and the associated risks of fractures are based on DXA assessed BMD in postmenopausal Caucasian women (Genant HK et al. ,1999 ; Cipriani C et al., 2017 ; WHO ,1994 ; WHO ,1995 , Genant HK et al. ,1999).

Previous studies have investigated bio-anthropometrics (age, gender, heigh, weight and ethnic group-specific differences in whole body and regional bone mineral density (BMD) have showns the necessity to establish reference data for bone mass measurements for each population according to habit and ethnicity (WHO, 1994 ; Lewiecki EM et al. ,2006 ; Ardawi MS et al. ,2005 ;Kudlacek S et al. ,2003).

Thus, several authors reported values of bone mass parameters related to theirs country or regions (Sangmo H et al. ,2011 ;Looker AC et al. ,2013 ; Iki M et al. ,2001 ;El Maghraoui a et al. ,2006

These studies ,conducted in Europeans and overseas Caucasians,in Aseans ,in South African Black and White populations in Middle-Eastern and Arab populations showed that there are racial/ethnic differences in BMD and BMC values of populations of different ethnic origines altought living in the same environmental (Kelly TL et al. , 2009 ; Kanis JA et al. ;1997 ; Sangmo H et al.,2011 ; Alacreu E et al.,2017 ;Tracy JK et al. ;Luckey MM et al. ,1996 ; Conradie M et al. ,2015 ; Muhamad MA et al.,2014 ;Aspray TJ et al.,1995 ;Conradie M et al., 2015) .

WHO has also defined osteoporosis on the basis of the T-score, which is the difference between the measured BMD and the mean value of young adults expressed in standard deviations (SDs) ; the interpretation of the BMD data generated by DXA systems raises also many problems in clinical practice because these criteria define osteoporosis as a standard deviations from a normative population of the same ethnicity (WHO ,1994).

Dxa machine manufacturers uses reference values based on a United States (U.S.) and/or northern European adult population, altough some times providing data for some specifics ethnical groups.

If the reference values are not the ethnical one, there will be obvious consequences on the classification of subjects, what may lead in discrepancy of results.

This littérature review show the necessity to establish reference data for bone mass measurements and patterns of bone loss for each particular population.

Such data are lacking for the Congolese population.

Thus, this study aims to establish reference values of spine and hip normatives values in healthy congolese female population and to compare them with those for Caucasian,asian,and others etnical groups .

2. Materials and Methods

2.1 Subjects

A cross-sectional study of 604 women, selected in the urban area of kinshasa, aged to 18 and 92 yearsof age) was carried out to establish reference values of BMD. Measurements were taken at the lumbar spine and proximal femurs using a densitometer from hologic : Hologic QDR Discovery Densitometer **.**The first DXA machine installed in our country (1 DXA for at least 80 millions people) , installed in a private hospital of Kinshasa :The Harish Jagtani Hospital.

After a public media advertising call for check up, a total of 802 subjects were respondant from june 2016 to june 2017 ,whom 713 women and 89 men and our study group is constitued of 604 consecutives Black Bantoues women of congolese origine who agreed to participate in the survey .

All the 802 subjects undergoes clinical examination by a physician, DXA, abdominal ultrasound,chest radio,head ct scanner and blood and urines samples were preleved.

Results were given back to physician and Women were eligible for the study if they:

- were black Congolese from origine, living Kinshasa for, at least, 5 years.

-Had no previous high energy vertebral fractures.

-had no history of any fracture

- had No diseases nor medications known to affect bone metabolism (cancer, diabetes, ss,prolonged diseases of the liver, kidney, thyroid gland, etc. or treatment using corticosteroids greater than or equal to 3 months, anticonvulsants, thyroid hormones, etc.)

- have a non perturbed menstrual and reproductive histories. (amenorrhea, anorexia nervosa, premature ovarian failure). Also excluded were women who had experienced an early menopause (before 40 years of age).

-Subjects from the postmenopausal group who had taken estrogens earlier (at least during the 2 years after menopause) or who still were taking estrogens were excluded, as well as those who had taken oral corticosteroids for more than 6 months

-Women using medications affecting calcium metabolism and those with medical conditions known to affect bone metabolism were excluded.

Thus, we excluded subjects with gastrectomy, intestinal resection, recent hyperthyroidism or hyperparathyroidism, treatment with corticosteroids, or recent severe immobilization.
We did not exclude individuals using inhalation steroids. We did not exclude subjects with certain lifestyle habits, such as heavy smoking, being sedentary, being athletic which are examples of voluntary factors that may have some impact on bone metabolism.

2.2 Measurements

-Anthropometric parameters (age, height, and weight) were collected according to standardized procedures. Weight was measured (kg) using portable digital scales to the nearest 0.1 kg (seca ,Vivadia,Valbonne,France)and height was measured (cm) using a vertical stadiometer to the nearest 0.1 cm(seca ,Vivadia,Valbonne,France) -BMI were calculated as follows: Body mass index (BMI) was calculated by dividing weight in kilograms by height in meters squared [BMI in $Kg/m^2 = w (Kg)/T^2 (m)$].
A BMI $\geq$ 25Kg / m² defined the overweight and a BMI$\geq$30Kg / m² the obesity.

-The DXA exams of the lumbar spine and proximal femurs were conducted with a QDR Discovery fan beam densitometer (Hologic, Inc., Bedford, MA, USA), in accordance with the procedures recommended by the manufacturer.

All subjects changed into light clothing and removed all jewelry and other things that could interfere.

The DXA Analysis was performed using Hologic Discovery software in its default configuration.

Scans were obtained by standard procedures recommended by the manufacturer for scanning and analysis. The examinations that revealed items with the ability to affect the accuracy of DXA results, such as prosthetic devices, implants, or other extraneous objects, were excluded.

All BMD measurements were carried out by 2 trained technicians.

The DXA instruments used in survey were calibrated according to the methods proposed by the manufacturer.At the time of the study, phantom measurements showed stable results.

Patient BMD was measured at the lumbar spine (anteroposterior projection at L1 to L4 and L2 to L4) but only L2 to L4 results were used in the current study and at the hip (total hip).

The data sets include spine and hip DXA measurements of bone mineral content (BMC, g), bone mineral density (BMD, g/cm2)).

In total, from 713 women received, 109 individuals were excluded from the study according to predetermined exclusion criteria, whereas 604 meets all inclusion criteria and were included in the study to constuate the reference population sample (220 premenopausal [36.42%] and 384 postmenopausal [63.57%] women).

All subjects were fully ambulatory.

Data from men are not included in the present study.

2.3 Statistical Analysis

The statistical analysis was performed using commercially available software (SPSS version 21).

The results were expressed as mean, standard deviation (mean ± SD), range (minimum and maximum values) and absolute (n) and relative (%) frequencies.

The differences in bmd,bmc and surfaces values between subgroups were analyzed using the Student's *t*-test The threshold of significance was set at 0.05

2.4 Ethics statement

The study design was approved by the local ethics committee and the study was conducted in accordance with the declaration of Helsinki for human studies.

3. Results

3.1 Anthropometric and biological parameters

the anthropometric and biological characteristics of the 604 females studied are listed inTable 1

Table 1 anthropometrics and biological features of our subjects

	N	Minimum	Maximum	mean	Standard deviation
Age (years)	604	18	92	49,97	12,53
Weight(Kg)	604	31,00	133,99	79,93	16,79
Height(m)	604	1,46	1,83	1,65	0,065
BMI (Kg/m²)	604	11,53	51,02	29,35	5,78
OHvitamine D (ng/ml)	604	13,30	59,20	29,53	8,96
Calcium (mg/dl)	604	8,1	11,0	9,35	,3980
Tsh3rd gen (µIU/ml)	604	0,32	8,93	1,77	1,12
Cholestérol (mg/dl)	604	101	393	201,70	42,26

The mean weight was 79.93+- 16.79 kg, the mean height was 1.65+-0.065 cm, and their mean body mass index 29.35+- 5.78 kg/m2.

Weight : From 16-25years of age (mean 62.64 +- 15.99) to more than 75 years of age (mean 73.74 +- 13.96 Kg) a increase of +11.1 kg ($p<0.001$) is observed.

Height : the size declined with age by 0.04 m ($p = 0.218$).from 16-25 years of age (mean 1.65+- 0.08 m) to more than 75y age group (mean 1.61 +- 0.06) .this decrease were not significant.

BMI : A significant increases ($p=0.002$) is seen from 16-25 years of age (mean 22.92 +-4.96 kg /m²) to more than 75 years of age (mean 28.57+-5.12 kg /m²) the BMI in women increased steadily until 65 years of age and then, remain stable.

Mean weight and BMI of our patients shows hights values and a great proportion of our subjects are quoted over weigth altough the cholesterol mean level is in borderline.

The TSH mean value seems normal.

The CA++ level values wich range from 8.1 to 11 mg/dl with mean value of 9.35mg/dl in our study group are surimposable to world wide accepted values (8.6 to 10 mg/dl for ca++)

The OHvitamine D mean level of 29.53 ng/ml is at the lower limite of world wide normatives values.

3.2 Spine BMC and BMD

Mean and standard deviation values of spine bone mass parameters according to age are presented in table 2

Table 2 Age-related variations of values for spine’s Surface, BMC and BMD (L2 To L4) in urban Congolese female adult

Age group		BMC		BMD	
	n	Mean	SD	Mean	SD
16-25	13	16,3490	5,70132	1,2155	0,26178
26-35	58	15,2566	2,76725	1,1199	0,19198
36-45	149	15,8508	2,96214	1,1353	0,15190
46-55	177	14,6251	2,97765	1,0521	0,16538
56-65	146	14,0314	3,79215	0,9749	0,19350
66-75	46	13,9308	3,59765	0,9713	0,19474
>75	15	11,1988	3,39455	0,8217	0,2062
total	604				

The mean values of BMC and BMD on L2 to L4 vertebral spine shows a light increase to peak wich is reached in the 36 to 45 years age group and then a decrease appears with age wich is significative for BMD ($p=0.012$) and BMC ($p=0.008$).

for surface, statistically significative differences ($p=0.006$) are disclosed only between the first(16-25 age group) and the last (> 75 years)age group.

These data showed that mean BMD value of the spine of Congolese females was declining with age, especially in their post-menopausal period with accelerated decline after age 65 years. The peak BMD of the spine and proximal femurs was reached in the fourth decade of life

The spine BMD values between 36-45 years were defined as the peak bone mass values. Between 46 and 65 years, there was a linear decline of BMD (equivalent to a decrease of approximately 14.2% or 0.71% per yr). The apparent decrease was higher between 66 and more than 75 years (15.7% or-1.57% per year).

Congolese women exhibited a similar pattern of decrease in BMD that was also described for U.S., European, Lebanese, Saudi, and Kuwaiti reference values

3.3 Total HIP BMC and BMD

Means and standard deviation values of bone mass parameters on the hip according to age are presented in table 3

Table 3 the age-related variations of total hip bone mass indices and standard deviation

TOTAL HIP BONE MASS						
AGE GROUP		N	Minimum	Maximum	mean	Std dev.
15 - 25 years	Surface (cm²)	16	3,43	6,29	4,7766	1,09906
	BMC (gr)	16	3,72	5,69	4,6716	,83848
	BMD (gr/cm²)	16	,71	1,63	1,0517	,33638
26 - 35 years	Surface (cm²)	45	2,22	6,66	4,5694	,96549
	BMC (gr)	45	2,35	5,83	4,3526	,93905
	BMD (gr/cm²)	45	,49	1,65	,9859	,27183
36 - 45 years	Surface (cm²)	96	2,22	7,47	4,6127	,77295
	BMC (gr)	96	1,89	6,23	4,4255	,77171
	BMD (gr/cm²)	96	,43	1,63	0,9593	,19557
46 - 55 years	Surface (cm²)	92	3,48	17,94	4,8526	1,45178
	BMC (gr)	92	2,38	21,10	4,4700	1,87561
	BMD (gr/cm²)	92	,46	1,65	0,9300	,17786
56 - 65 years	Surface (cm²)	86	2,25	5,77	4,7500	,51324
	BMC (gr)	86	1,71	6,03	3,8500	,77981
	BMD (gr/cm²)	86	,38	1,14	0,8100	,15443
66 - 75 years	Surface (cm²)	25	2,00	5,65	4,6700	,69017
	BMC (gr)	25	1,36	6,84	3,4600	1,07408
	BMD (gr/cm²)	25	0,34	1,45	0,7200	,20692
over 75 years	Surface (cm²)	7	4,25	6,64	4,3900	,75659
	BMC (gr)	7	2,00	6,72	3,5800	1,49646
	BMD (gr/cm²)	7	0,40	1,01	0,6900	,18356
total		367				

the means values of surface, BMD and BMC of hip show very small differences between neighboring age groups ,without significant statistical differences (p>0.5)
The differences become significant when young adult subjects are compared with persons aged over 65 years of age (p=0.001) where the loss became important

3.4 Z- score

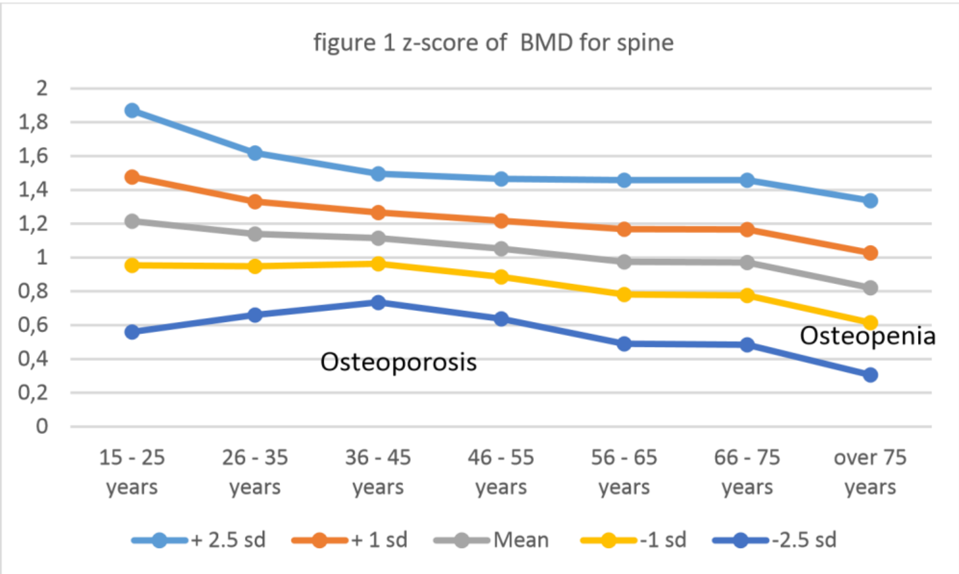
The age-related variations of means and standards deviation (means + 1s.d ,+ 2.5 s.d and minus 1 s.d and minus 2.5 s.d) of BMD assessed on L2 to L4 spine vertebrae in congolese urban females are presented in table 4 wich enables to generate curves of Z-score

Table 4 :Age-related variations of means BMD and s.d in Congolese female subjects

Age group	15 - 25 years	26 - 35 years	36 - 45 years	46 - 55 years	56 - 65 years	66 - 75 years	over 75 years
+ 2.5 sd	1.86995	1.61985	1,49505	1,46555	1,45865	1,45815	1,3372
+ 1 sd	1,47728	1,33188	1,2672	1,21748	1,1684	1,16604	1,0279
Mean	1,2155	1,1399	1,1153	1,0521	0,9749	0,9713	0,8217
-1 sd	0,95372	0,94792	0,9634	0,88672	0,7814	0,77656	0,6155
-2.5 sd	0,56105	0,65995	0,73555	0,63865	0,49115	0,48445	0,3062

Profile of parameters includes an increase ,a peak and a decrease,

Figure 1 is a normogram for BMD showing the curves of the mean plus or minus 1 and 2.5 standard deviation. deviations



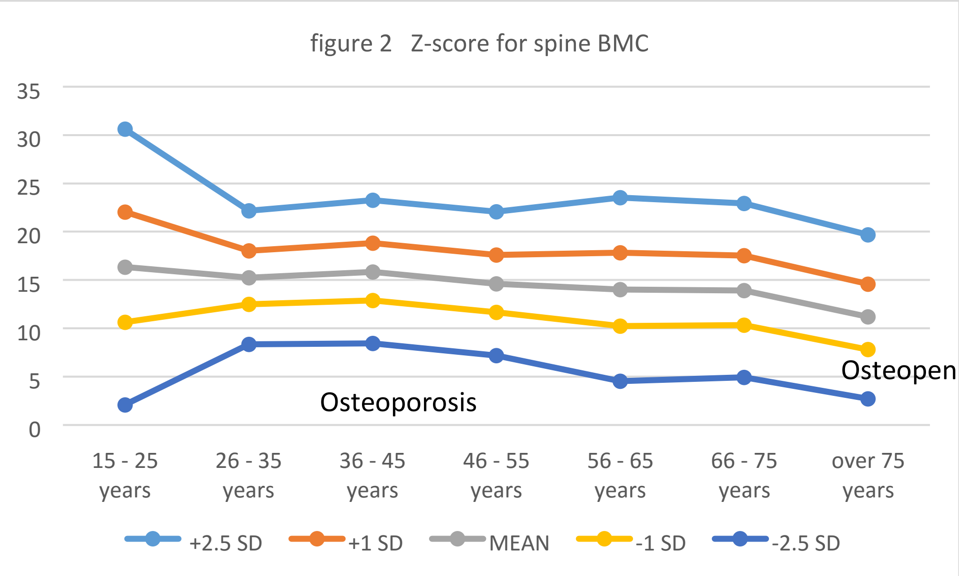
The standard deviations are wide at the beginning and the end of growth, generating a fan-shaped profile osteopenia being defined between the curves mean minus 1 standard deviation and the curve mean minus 1 s.d and the curve mean minus 2.5 standard
osteoporosis is defined by the area below of the curve of mean minus 2.5 standard deviations

The age-related variations of means and standards deviation (means + 1s.d ,+ 205 s.d and minus 1 s.d and minus 2.5 s.d) of BMC assessed on L2 to L4 spine vertebrae in congolese urban females are presented in table 4 wich enables to generate curves of Z-score

Table 5 :Age-related variations of means BMC and s.d in Congolese female subjects

	15 - 25 years	26 - 35 years	36 - 45 years	46 - 55 years	56 - 65 years	66 - 75 years	over 75 years
+2.5 SD	30.6022	22.1746	23.2560	22.0691	23.5116	22.9248	19.6850
+1 SD	22.0503	18.0238	18.8129	17.6027	17.8235	17.5285	14.5933
MEAN	16.3490	15.2566	15.8508	14.6251	14,0314	13.9308	11,1988
-1 SD	10.6477	12.4894	12.8887	11.6475	10.2393	10.3332	7.8043
-2.5 SD	2,0958	8.3386	8.4456	7.1811	4.5512	4.9368	2.7126

Figure 2 is a normogram for BMC showing the curves of the mean plus or minus 1 and 2.5 standard deviation. Osteopenia being defined between the curves of mean minus one standard deviation and the curve of mean minus 2.5 standard deviations.
Below the curve of the mean minus 2.5 standard deviation ,osteoporosis is is located



Osteopenia and osteoporosis are defined as reported for BMD

3.5 T- score

Table 6 reporte means values,range and standards deviations of parameters measured in young adulte female subjects aged 30 to 40 years of age to assess T-score.

Table 6 parameters in 30 to 40 years bantoues female in kinshasa

	n	mean	Std .d.	maximum	minimum
HEIGHT (m)	115	1.65	0.07	1.81	1.46
WEIGHT (kg)	115	75.31	13.83	114.99	31
BMI (kg/m²)	115	27.68	4.85	41.31	11.53
BMC spine (gr)	115	16.58	2.81	25.55	11.45
BMD spine (gr/cm²)	115	1.14	0.14	1.52	0.70
SURFACE spine(cm²)	115	14.62	1.50	19.43	11.31
BMC total Hip (gr)	115	4.31	0.80	6.11	2.35
BMD total Hip(gr/cm²)	115	0.94	0.17	1.27	0.49
SURFACE total Hip(cm²)	115	4.43	0.62	5.19	2.22

DISCUSSION

Many studies have assessed BMC and BMD, but a standard source for reference values for Congolese population were lacking

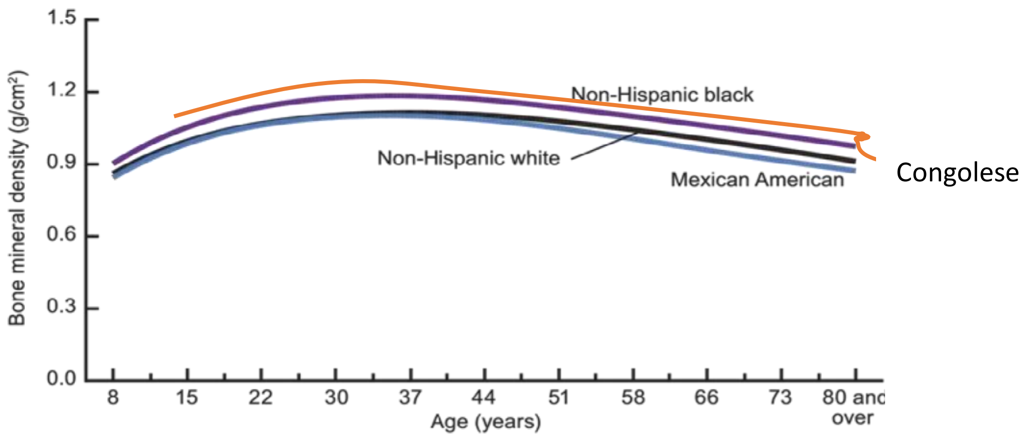
Data for these reference values were acquired using well-established DXA technology wich is ,for the first time installed in our country of not less 80 millions of people in the Harish Jagtani hospital (a private hospital of kinshasa)

These references values did not include the tutsi ethnic population of Congo whom only 4 individuals were respondant,

Our subjects mean height (table 1) is surimposable to others peoplehaven't showns the significant attended decrease in height, even in subjets aged over 75 years of age.this may be a consequence of rare vertebral fractures (Kabeya KJM et al.; 2017) or due to non linearity of data in a cross sectional study like ours. Weight and BMI in our subjets (table 2) are higher than others peoples and efhnicities (El Maghraoui A et al., 2006 : Luckey MM et al. ,2013) .These patterns possibly reflect the increase in the prevalence rate of severe obesity among the Congolese female.

However, when we define overweightness and obesity according to fat mass index (FMI) classification (Kelly TL et al. , 2009), the rate of obesity and overweightness were similar to those of other ethnicities in the American's NHANES (Luckey MM et al. ,2013)

.After a regular increase from 16-25 to 6th decade of life, there is not increase after 60 years of age. Lack of



increase of BMI after 60 years of age must be questioned. is it due to the worldwide concern about sarcopenia (the degenerative loss of skeletal muscle mass with age) ? .

Altough all subjects of our study group were ambulant and self dependant,a study involving elderly subjects showed that sarcopenia was an indicator of self-reported physical disability in elderly independent of other covariates such as age, obesity, ethnicity, and income levels (Wulan SN et al. , 2010)

Furthers studies on body composition are needed to answers.

Among our subject,BMD and BMC in persons aged less than 46 years was significantly higher than in those aged 46–75, and significantly lower in persons aged over 75 than in those aged 46-75.

Luckey MM et al.,2013 reported that BMD was significantly higher in non-Hispanic black persons than in non-Hispanic white persons, regardless of age or sex

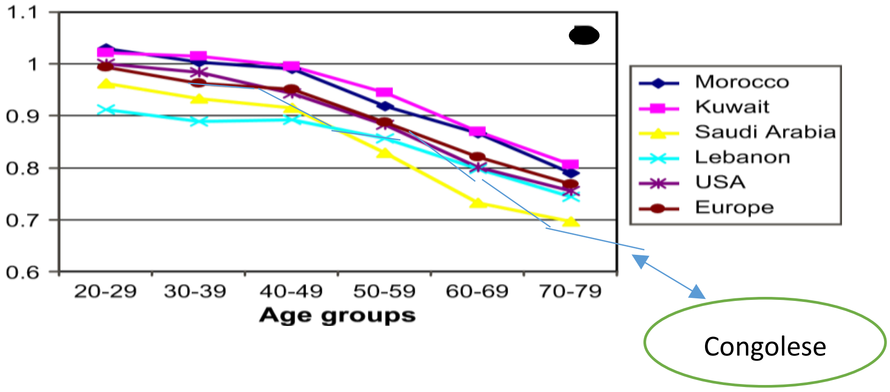
As seen in modified comparative curve from luckey et al.,2013 (figure 3) below, Congolese females

Figure 3 : Comparative curve of spine BMD

have, in general, higher BMD about 2 to 11% at the spine than the U.S.citizens of all ethnicities. , (Figure 4)

When curves of Bone mineral density (g/cm^2) (figure 4) of congolese's total hip are compared with United States and European Caucasian, and other Arab

Figure 4 Comparative values of hip BMD



women especially Kuwaitis , lebanon , morocco,saudi arabia and Moroccans ,Congolese women total hip have surimposable values up to 6th decade of life but thereafter,the decrease rate is higher in congolese.
The differences in BMD values between arab females were thought to be a result of the differences in exercise and lifestyle (Gougherty G et al. ,2001 ; Hammoudeha M et al. ;2005 ; Kelly TL et al.,2009) body weight and obesity are well known to correlate well positively with BMD (Chen Z et al.,1997 ; Kim JY et al.,2010; Leslie WD et al.,2017). Our population study had a mean BMI of 29.35 kg/m2 which is higher than the values (about 24 in most series) reported in Western, arab and aseans populations (Albala C et al.,1996 ; El Maghraoui A. et al.,2006, Sangmo H et al. ,2011 ;Leslie WD et al. ,2017)

One must remark that a decrease in BMD is noted in our series after 65 year of age, concommitant with decrease in BMI.

Furthermore, most females have a sedentary lifestyle and have experienced multiparity and lactation, which are well recognized as important osteoporosis risk factors altough out door activities are regular

Our data demonstrate significant differences spine and hip in BMD between Congolese and caucasians ,aseans and arab populations

The present study is the first large-scale report on normative values on the BMD and BMC of the lumbar spine and the hip in healthy ambulatory Congolese women aged 16 to 92 years with defined exclusion criteria. The main limitation of our study lies in the cross sectional study of urban population to establish a reference database for the whole country whose rural inhabitants are in the majority

Conclusion

A Congolese reference BMD and BMC for women has been established for the lumbar spine and hip on a selected sample of adequate size of the Urban population of Kinshasa. from the period of adolescence ,we note a growth in bone mass parameters up to the peak that is reached in the fourth decade followed by a slow decay that causes a loss of nearly 14.2% in BMD and BMC
over a period of almost 20 years and then a decrease towards the sixtieth year, which seems more pronounced (1.5% yearly), than among CaucasiansAsians and Arabs .We found that the references curves for the lumbar spine and total hip are significantly differents from the Caucasian,asean or arab normative data .However, validation of these results requires further studies

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