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Bone Quality and Fracture Healing among Inhabitants of Marshes in the South of Iraq

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Abstract

Background: Ethnic differences in bone mass and bone fracture healing power have been reported. Marsh-inhabitants, south of Iraq have unique racial and cultural behavior. The study aims to investigate the potential differences in bone quality and fracture healing power between marsh-inhabitants and urbans groups.

Methods: Study was conducted on three groups, Marsh-inhabitants resident in marshlands, Marsh-inhabitants resident in city and urbans population. The groups were compared according to their bone mineral density, which was measured using portable quantitative ultrasound.

Other part of the study involved comparing healing rate of fractures in the three groups. Patients with long bone fractures were followed until fracture consolidation (in Basra city hospitals). Fracture consolidation times (assessed by ordinary radiograph and clinical examination) were recorded.

In both parts study, Socio-demographic and nutritional habits were assessed by a specially designed questionnaire, and their effects on BMD and fracture consolidation time were analyzed.

Results: Average BMD in the Marsh-inhabitants whether they are residents of marshlands or in city, were significantly higher than that of urban group (An average of 0.9 g/cm^2 and 0.13 g/cm^2 for Marsh-inhabitants and urbans respectively). BMD in Marsh-inhabitants resident in marshlands was higher than that of Marsh-inhabitants resident in the city (1.0 g/cm^2 *vs*. 0.8 g/cm^2 for the two groups respectively).

Results showed that fracture consolidation time was significantly shorter in Marsh-inhabitants than urban population (better healing rate of Marsh-inhabitants fractures by 30%).

Conclusion: Marsh Arabs have a unique genetic and environmental influence that can enhance bone quality and fracture healing power.

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Introduction

Bone strength can be assessed by bone quality that includes bone density, structure, and composition, quality of collagen, bone turnover, micro-architecture, and distribution of minerals, micro-damage and its repair. These components are connected to each other. Any abnormality in one could lead to changes in others [1]. Bone Mineral Density (BMD) is an indirect indicator of bone quality measured by a procedure called densitometry [2].

During life, bones undergo frequent cycles of breakdown and repair. This remodeling process is regulated by factors such as nutritional status, gender, physical activity, sun exposure, medications, smoking and alcohol intake, ethnicity and heredity, hormone levels, and vitamin D status [3,4]. Thus, an interaction among multi-physiological and lifestyle factors is required to build and maintain healthy bones [5].

Genetic factors can determine bone mass and bone architecture. Eighty percent of human bone mass is considered to be affected by genes [4]. Genetic factors affect also cytokines, prostaglandins, and interleukins which modulate cellular activities that play a role in bone metabolism and bone remodeling [6]. Several studies report ethnic differences in bone mass and bone fracture healing power. Black-American and East Asian-American individuals have been found to have high mean bone mineral density compared to White-American individuals [7,8]. It has been shown that Up to 7% of fractures in the USA end with non-union regardless the treatment option, mostly due to

genetic variation [9].

Marsh-inhabitants, south of Iraq have unique racial and cultural behavior. The study aims to investigate the potential differences in bone quality and fracture healing power between marsh-inhabitants and urbans groups.

Subjects, Patients and Methods

The study was conducted in the south of Iraq, Basra city on two groups, one living in the southern Iraqi marshes; and other from Basra urban areas (Urban inhabitants and Marshes inhabitants resident in the city). All subjects and patients gave their informed consent to participate in these studies and that the study was approved by the Iraqi council for medical specializations.

Sample selection

Part one (bone quality study): During the period from September 2016 to November 2017. Tribes living in southern marshes in Iraq were visited and available families were interviewed as {group one}. Urban area groups were also interviewed both Marshes-inhabitants living in urban areas of Basra city (after their displacement from the marshes) and non-Marsh-inhabitant urban families as {group two}.

For all candidates: questionnaires are filled, their bone density was measured using portable quantitative ultrasound machine (SonoSite-3000, 2015, Osteosys company, South Korea). Measurements were made by scanning the calcaneus bone of the right foot using Z-score for data collection.

The questionnaire involved, among others, factors affecting bone mineral density; Name, age, gender, address, race, lifestyle activity, educational level, sun exposure, body mass index, dietary habits, dentation and their bone density measurement using QUS.

The study include both males and females, aged 20 years to 70 years and having BMI between 18.5 kg/m^2 and 30 kg/m^2 with no history of drug use e.g. steroids, and no history of chronic diseases. Smokers, ex-smokers, and alcoholics were excluded.

Part two (fracture healing study): During the same period of time, same inclusion and exclusion criteria.

Traumatic fractures of long bones in patients admitted to Basra general hospitals were assessed by full history and clinical examination. Soft tissue conditions were classified using Tscherne and Gustilo classification. Fracture location and description were made by radiographs or CT-scans and categorized according to the AO classification system. Treatment options whether conservative or operative were recorded. These options were selected by the orthopedic surgeons themselves without interference by the researchers including the need for bone graft. Patients were, then, followed by history and clinical examination, radiological findings, until achievement of consolidation.

Fracture consolidation was measured in weeks both clinically and radiologically. Clinical healing parameters include wound healing, absence of signs of osteomyelitis or other types of infections, or other complications, no pain or tenderness examination of the fracture site, no residual warmth or motion at fracture site, full range of motion of adjacent joint, no pain or tenderness when bearing weight, and ability to perform activities of daily living without pain.

Radiological healing parameters include presence of bridging callus at three of four possible cortices on AP and lateral views, and obliteration of fracture site.

Fractured patients were categorized into three groups; Marsh-inhabitants living in marshlands, Marsh-inhabitants living in the city, and urbans living in Basra city.

Data analysis

All statistical analyses were performed using Statistical Package for Social Sciences (SPSS), version 16. Analysis of variance was used to detect significant differences between the 3 groups and comparison between each two groups was made using independent sample t-test. The level of significance was taken as $P<0.05$.

Results

Part one: Bone quality study

Socio-demographic characteristics: Among the 159 Marshes inhabitants; 129 of them were living in marshlands (mean age of 37.48 years). 84.5% of the 129 were males and 15.5% females. Marshes inhabitants living in the city were 30 individuals (mean age of 39.2 years); they were all males. The majority of both groups of marshes inhabitants were illiterate, had active lifestyle, working as shepherds, with at least one hour duration of sun exposure per day in addition to full dentation.

The 165 urban individuals had a mean age of 37.6 years; 75.8% were males. 43.6% of urbans had completed their secondary school education, 43% had sedentary lifestyle, and 20% of the females were housewives, whereas 18.8% of the males were soldiers. Nearly half of the urban individuals (48.5%) had less than twenty minute-duration of sun exposure per day, and only 62.4% of them had full dentation.

Nutrition: Both marshes inhabitant groups consumed dairy products daily mainly as buffalo or cow milk. They also consumed more than two fish meals and more than two meat meals per week. Daily egg meals had been consumed by the majority of individuals. The cooking oil was mainly of animal type. More than 80% of them had their body mass index between 18.5 and 24.9.

Around 85% of urban individuals consumed dairy products occasionally. The type of these products was artificial in 93.9% of cases. 86.7% of individuals consumed fish meals in less than one meal per week; 85.5% consumed from one to two meat meals per week, while egg meals had been infrequently consumed (i.e. not daily). The cooking oil was mainly of plant origin. Body mass index ranged between 18.5 to 24.9 in 34.5% of the total urban individuals.

Body mineral density: When the three groups; Marsh-inhabitants (city residents), Marsh-inhabitants (marshland residents) and urban population were compared according to their BMD, a higher percentage of osteoporosis (9.6%) was found in urban group compared with none in Marshes inhabitant groups.

The average BMD of Marsh-inhabitants (both marshland and city resident) groups was significantly higher than that of urban group (0.9 g/cm^2 *vs.* 0.13 g/cm^2 for both Marsh-inhabitants groups and urban group respectively, $P<0.001$). BMD was slightly but not significantly higher in marshland resident than city resident Marsh-inhabitants (1.0 g/cm^2 *vs.* 0.8 g/cm^2 for the two groups respectively) (Table 1).

Socio-demographic variables and BMD contribution: In marshland resident Marsh-inhabitants, only age was significantly associated with changes in BMD. While, in city resident Marsh-inhabitants, life-style, sun exposure and dentation were significantly

Table 1: Bone mineral density comparison.

		M Marshes inhabitants			Urbans
		City residents	Marshland residents	Both marshes groups	
Bone mineral density (g/cm^2)	Mean	0.8*	1.0	0.9**	0.13
	SD	0.54	0.75	0.7	0.87
	Minimum	-0.3	-0.7	-0.7	-2.5
	Maximum	2.0	2.9	2.9	2.1
Osteoporosis	No.	0	0	0	16
	%	0%	0%	0%	9.6%

Statistically significant difference between Marshes-inhabitants (city resident) and Urban groups* and between both Marsh-inhabitant groups and Urban group**

Table 2: Group characteristics and their correlation to BMD.

Variables	Marshes inhabitants		Urbans
	City residents	Marshland residents	
Age	0.125	0.031**	0.001**
Gender	------	0.150	0.006**
Education	0.506	0.364	0.489
Occupation	0.403	0.422	0.718
Lifestyle	0.001**	0.296	0.001**
Sun exposure	0.041**	------	0.001**
BMI	0.451	0.085	0.001**
Dairy amount	0.460	------	0.037*
Dairy type	0.345	------	0.089
Fish meat amount	0.118	0.336	0.035**
Meat amount	0.122	0.439	0.735
Oil type	------	0.280	0.64
Dentition	0.001**	0.090	0.001**

Data are expressed as P values, and statistical significance was taken at P<0.05 level. Multiple regressions were used to test the contribution of each variable to BMD
*Pearson correlation, *Multiple regression

associated with changes in BMD. In urban group, more variables (age, gender, life-style, sun exposure, BMI, dairy amount, fish meat, and dentation) all were significantly associated with changes in BMD (Table 2).

Part two: Fracture healing

The study was conducted on 60 patients with long bone fractures. Out of these 60 patients, 35 patients were Marsh-inhabitants (25 marshland residents and 10 city residents), and 25 urban patients.

Patient characteristics: All the 35 Marshes-inhabitant fractured patients were males. 25 of them lived in the marshlands, whereas 10 lived in Basra city. Nearly all of them were illiterate, active, exposed to sunlight for more than 60 min per day, and having normal BMI range.

Fractured patients from urban population were 25; all were males. 92% were engaged in active lifestyle, and 80% had more than 60 min of sun exposure per day. 68% of them completed their primary schools. Their BMI were nearly equally distributed between normal and overweight ranges.

Fracture characteristics: Road traffic accidents were the major cause of fractures among the three groups followed by bullet injuries. In all groups, the fracture morphology was distributed almost equally between moderate and severe comminution.

Soft tissue conditions in fractured patients were categorized in three major types; Gustilo 3a, Tscherne 1 and Tscherne 2.

The major lines of fracture management were open reduction and internal fixation followed by open reduction and external fixation.

Between 20% to 30% of the fractured marsh-inhabitants and urban patients had bone grafts. Complications occurred more frequently in urbans group (32% *vs.* average of 11% in Marsh-inhabitants).

Fracture consolidation time: Fractures were categorized according to their location in the body by AO classification system. Each fracture location was compared separately in the three groups by the time needed for consolidation.

When the consolidation time in Marsh-inhabitants (marshland resident) group was compared with Marsh-inhabitants (city resident) group, all fractures consolidation times were shorter in marshland resident individuals, except fracture shaft tibia which had similar consolidation time in both groups (Table 3).

The consolidation times of all fractures in city resident Marsh-inhabitants were shorter than that of urban group, except fracture shaft humerus which had similar consolidation time in both groups (Table 3).

Comparison of Marsh-inhabitants as one group with urban group showed that fracture consolidation time was significantly shorter in Marshes inhabitant group in all types of fractures studied, except distal femur fracture which was only one patient and had similar

Table 3: Fracture location and consolidation time (in weeks) in marshes inhabitant and urban groups.

				Consolidation time (weeks)	
Fracture location	**Race**	**Residence**	**No.**	**Mean**	**SD**
Shaft humerus AO(12)	Marshes inhabitants	Marshlands	4	11.2	1.7
		City	2	17.0	1.4
	Urbans	City	2	20.5	2.9
Distal humerus AO(13)	Marshes inhabitants	City	Zero		
		Marshlands	3	15	2.5
	Urbans	City	3	21.3	3.0
Radius and ulna AO(22)	Marshes inhabitants	Marshlands	4	12.5	2.0
		City	3	15.3	1.5
	Urbans	City	4	17.7	1.0
Shaft femur AO(32)	Marshes inhabitants	City	Zero		
		Marshlands	3	18.0	1.7
	Urbans	City	4	23.7	1.4
Distal femur AO(33)	Marshes inhabitants	City	Zero		
		Marshlands	2	23.5	0.7
	Urbans	City	1	26	----
Shaft tibia AO(42)	Marshes inhabitants	Marshlands	6	13.8	2.8
		City	5	14.8	2.1
	Urbans	City	8	23.3	3.6
Distal tibia AO(43)	Marshes inhabitants	City	Zero		
		Marshlands	2	16.5	0.7
	Urbans	City	2	25.5	3.7
All fractures	Marshes inhabitants	City	10	**15.4**	1.89
		Marshlands	25	**15.08**	4.09
	Urbans	City	25	**21.96**	5.71

Table 4: Correlation of fracture consolidation times between groups.

	P values for correlation between:		
Fracture location	**Marsh-inhabitants (marshland resident *vs.* city resident)**	**Marsh-inhabitants (city resident) *vs.* Urbans**	**Marsh-inhabitants (both groups) *vs.* Urbans**
Fracture shaft humerus (AO 12)	0.01*	0.43	0.03*
Distal humerus fracture (AO 13)	------	------	0.02*
Fracture radius and ulna (AO 22)	0.02*	0.01*	0.02*
Fracture femoral shaft (AO32)	------	------	0.01*
Distal femur fracture (AO 33)	------	------	0.32
Fracture shaft tibia (AO 42)	0.51	0.01*	0.04*
Fracture distal 1/3 tibia (AO 43)	------	------	0.02*
Sum of fractures consolidation time	0.14	0.01*	0.02*

*Correlation is significant at the <0.05 P value level

consolidation time (Table 4).

When the average consolidation time of all fractures together in each of the three groups was calculated, it was found that although city resident and marshland resident Marshes-inhabitants had close average consolidation times, the average time for Marshes-inhabitant groups was significantly shorter by 30.6% than urban group (Table 3 and 4).

Socio-demographic and nutritional contribution on fracture consolidation time: In urban group, a significant correlation was found only between lifestyle and fracture consolidation for the urbans group. High activity lifestyle decreased time for fracture consolidation. None of the other variables showed a significant correlation (Table 5).

In all groups, there were significant correlations between BMD and fracture consolidation time. Individuals with high BMD had shorter duration for fracture consolidation (Table 5).

Discussion

Bone mineral density

The study involved 324 individuals. They were divided into two groups; Marsh-inhabitants (n=159) and urbans (n=165). The Marsh-

Table 5: Sociodemographic and nutritional contribution on fracture consolidation time.

Variables	P values for the correlation between each variable and fracture consolidation time		
	City	Marsh lands	Urbans
Age	0.435	0.587	0.144
Education	0.321	0.962	0.713
Occupation	0.212	0.396	0.512
Lifestyle	0.512	0.431	0.016**
Sun exposure	0.209	0.896	0.600
BMI	0.801	0.207	0.475
Dairy-amount	0.734	0.661	0.544
Dairy type	0.656	0.640	0.989
Fish-meat-amount	0.118	0.110	0.271
Red-meat-amount	0.324	0.557	0.096
Oil type	0.645	O.521	0.082
Dentition	0.166	0.170	0.098
BMD	0.048**	0.036**	0.012**

Correlation is significant at P<0.05 level
*Pearson correlation, *Multiple regression

inhabitants group was subdivided according to their residence into Marsh-inhabitants living in the city and those living in marshlands. The effect of racial, socio-demographic and nutritional factors on BMD was compared in the three groups.

Bone mass starts to decrease gradually with age due to the process of bone tissue aging [5]. In the present study, age was negatively correlated with BMD in Marsh-inhabitants (marshland residents) and urban groups, where BMD decreased with increasing age in both groups. Marsh-inhabitants (city residents) were mainly of young age group, and this may explain the lack of a significant correlation between BMD and age in this subgroup.

Sex hormones had been reported to affect BMD and can lead to differences in bone mass between males and females [10]. Urban females tended to live a more sedentary life with less sun exposure than males. This had resulted in a lower BMD in urban females compared with urban males. However, Marsh-inhabitants (marshland resident) females had daily activities and sun exposure similar to males, and both had similar BMD. Marsh-inhabitants (city residents) were, coincidentally, all males.

Physical activity can lead to an increase in BMD as they affect bone remodeling and microarchitecture. Sun exposure is an important source of activated vitamin D, which plays a vital role in the formation of bone mass [11]. In the present study, physical activity and sun exposure showed positive correlation with BMD in urban and Marsh-inhabitants (city resident) groups. BMD had been found to increase with increasing daily activity and time of sun exposure. On the other hand, the correlation is not that clear in Marshes-inhabitants (marshland resident) group, since all of them had similar daily activities and sun exposure.

Obesity and underweight are reported to cause low BMD [12]. In urban group, overweight was associated with a decrease in BMD. However, lack of association in both groups of Marsh-inhabitants might be explained by the normal range of their BMI.

A healthy tooth has been shown to reflect good oral hygiene and general health [13]. Good dental health, in this study, was associated with high BMD in all groups.

Calcium and vitamin D rich diet such as milk, cheese and fish can lead to healthy bones [2]. Such association was found significant only in urban group, where BMD increased with increasing dairy and fish-meat consumption. In both Marshes groups, no correlation with BMD was found, probably, because of the similarity of their dietary habits.

Studies conducted on white and black Americans showed a significant difference in BMD between races [14]. Americans of Asian origin also differ from Caucasians in their BMD [15].

Marsh-inhabitants (regardless of their residence) had significantly higher BMD than urban group. This indicates that genetic variation could play a role in bone quality, since urban group and Marsh-inhabitants (city resident) group, have, generally, similar environment. On the other hand, BMD did not differ between the two subgroups of Marsh-inhabitants despite differences in environment (Marshes residents versus city residents). This result is different from that reported by Nordström and Lorentzon [16], where changing environmental factors like, daily activity, sun exposure, dietary habits, pollution were all found to cause changes in BMD, and might point to the importance of the racial contribution.

Fracture healing among marshes inhabitants

This part of the study was conducted on 60 patients with fractures. Marsh-inhabitant patients were 35 (25 lived in marshlands and 10 lived in city areas), while the urbans were 25.

All fractured patients were males, having active lifestyle and more than 60 min sun exposure per day and average BMI range.

Young age has been shown to be associated with more bone mass and better fracture healing power. In addition, physical activity can enhance bone quality and vascularity leading to high BMD and better healing rate [17]. In accordance with these findings, the results of the present study showed a significant positive correlation between lifestyle and bone healing for the urbans group; the more active lifestyle, the shorter fracture consolidation time.

Patients in both Marshes-inhabitant groups had almost similar lifestyle. This lack of variability might be responsible for the lack of

significant correlation between lifestyle and fracture consolidation time.

Also fracture healing power was enhanced by increasing in bone mineral density.

Fracture healing in each of the three groups is affected by different factors. Some of these factors depend on the fracture itself; others on patient general health [18]. Bone strength and callus formation vary according to environmental variables and dietary habits [16]. Genetics, also, plays an important role in body built and healing powers [19].

The consolidation time was reduced significantly in Marshes-inhabitant groups when compared with urban group. These points to a better healing power of fractures in Marshes inhabitants, which can be attributed to racial differences, with a role of environmental and dietary factors [20].

In conclusion, inhabitants of marshes in the south of Iraq seem to have inherent ability that enhances bone quality and fracture healing power. This potential genetic effect can be enhanced by several dietary and environmental habits. None of the Marshes inhabitants (healthy or fractured) have osteoporosis.

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