Feasibility of Dual-Energy X-ray Absorptiometry in Arctic field studies

Stig Andersen 1, Eskild Boeskov 2, Jakob Holm 2, Peter Laurberg 1

1 Department of Endocrinology and Medicine, Århus University Hospital, Reberhansgade, Denmark
2 Ilulissat Hospital, Greenland

ABSTRACT

Background. Bone strength decreases with age. Bone mineral density (BMD) is a measure of bone strength. Data on BMD in present-day Inuit are limited, and data on circumpolar populations using Dual Energy X-ray Absorptiometry (DEXA scanning) are lacking. Objectives. Our aims were to validate DEXA scanning for use in field studies in the Arctic region and to obtain data on BMD in Greenland Inuit. Methods. We measured BMD in 52 healthy Inuit living in Ilulissat and Saqqaq in North Greenland using a portable peripheral DEXA scanner. The measurement sites were forearms and calcaneal bones. Two measurements were performed at both radii and both calcanei. Triplicate measurements were performed in eleven Inuit. Results. The portable scanner fitted into a standard bag suitable for transportation in the arctic winter. Imprecision was well within 2% for all calibrations. CV% were 0.16% to 1.79% in the forearms and 0.38% to 1.53% in the heels. The overall CV% was 1.09% in forearm and 1.01% in heel. Mean BMD in men was 0.569 g/cm² in forearms and 0.542 in heel. In women it was 0.479 in forearms and 0.468 in heel. Conclusion. DEXA scanning is a feasible, reliable and comfortable method in rural Greenland. BMD values are now available for Greenland Inuit.

Keywords: Bone mineral density, DEXA, portable scanner, Greenland

INTRODUCTION

The growing elderly Inuit population puts focus on bone strength, as bone loss ensues as a result of aging (1). Bone mineral density (BMD) correlates strongly with bone strength (2) although it is not completely representative of the changes in bone architecture that are responsible for skeletal fragility (1).

Bone density can be assessed using different techniques such as bone incineration, single photon absorptiometry, radiographic absorptiometry, quantitative computed tomography, and dual energy X-ray absorptiometry (DEXA) (2).

Some of these techniques have been applied to the Inuit. Incineration studies have been performed in Alaska Inuit cadavers (3) and Canadian Inuit skeletons measuring ash density (4). Single photon absorptiometry using a 125I source has been applied to archaic Inuit skeleton femoral bones (5), tibiae of Inuit cadavers (3), and Canadian Inuit forearms (6, 7), and X-ray studies have been performed on living Alaska Inuit forearms (8). Despite the increasing availability of DEXA scanners such data are lacking among the Inuit.

Our aims were to evaluate the feasibility of DEXA scanning in a rural Arctic setting and to measure BMD in the forearm and heel in a Greenlandic population using a peripheral DEXA bone densitometer.

METHODS

Participants were 52 healthy Inuit living in Ilulissat or Saqqaq in the Disco Bay area in North
Greenland. A random sample was drawn from the National Civil Registration System in which every person living in Denmark, the Faroe Islands and Greenland is registered. Participants were stratified by age and gender, and only individuals born in Greenland were included.

We measured height and weight and calculated Body Mass Index (BMI; weight in kilograms divided by height in metres squared).

BMD was measured using Dual Energy X-ray Absorptiometry (DEXA) by the Peripheral Instantaneous X-ray Imager (PIXI) supplied by GE Medical Systems (Lunar Corporation, 726 Heartland Trail, Madison, WI 53717, USA). This is a portable scanner (30 x 63 x 33 cm) weighing 27 kg. Wrapped in a duvet it fitted into a standard bag for helicopter, snowmobile and dog sled transportation.

Field calibration was performed twice daily or if the scanner had been moved. The scanner was left on for fifteen minutes to warm up before calibration. This consisted of five measurements on a standard phantom calcaneus (BMD 0.549 g/cm²) and radius (BMD 0.415 g/cm²). The goal for imprecision set up was ± 2% as a trend over time. In addition, we performed triplicate measurements in 11 subjects to evaluate within individual variation.

The participant was seated comfortably. BMD was measured in both forearms and both heels. Each scanning took less than five seconds, giving a radiation dose of less than 2 µSv. Measurements were performed twice at each site with the participant removing the limb from the cradle in the scanner between each measurement. Participants were informed of the results instantly.

Data followed the normal distribution (Kolmogorov-Smirnov p=0.92-1.0) and differences between groups were tested using t-test. A p-value of less than 0.05 was considered significant.

Ethical approval by the Commission for Scientific Research in Greenland was obtained prior to the commencement of this study, and all subjects gave informed written consent in Danish or Greenlandic according to participant choice.

RESULTS
Participants were healthy Inuit aged 30 to 49 years, and their descriptives are shown in Table I.

| Number | Age (years) | Height (cm) | Weight (kg) | BMI (kg/cm²) |
|--------|-------------|-------------|-------------|--------------|
| Men    | 21          | 40.8        | 169.4       | 76.6         | 26.7         |
| Women  | 31          | 40.4        | 160.7       | 72.3         | 28.1         |

Validity of DEXA-scanning in Arctic field study
Calibrations were performed vigorously. No drift of phantom BMD was found with either time or between investigational sites for heel or forearm. The imprecision found was well within the 2 % goal set up for all calibrations.

Triplicate measurements in the 11 subjects demonstrated individual CV% s ranging from 0.16 % to 1.79 % in the forearms and 0.38 % to 1.53 % in the heels. The overall CV% was 1.09 % in the forearm and 1.01 % in the heel.

BMD in Inuit

Figure 1. Bone mineral density in Inuit men (n=21) and women (n=31) in Ilulissat and Saqqaq in North Greenland measured by Dual Energy X-ray Absorptiometry. Measurements in each individual included two measurements on both left and right forearm and heel.
No difference was found between Inuit in Ilulissat (town) and Saqqaq (settlement) (men, arm p=0.11, heel p=0.95; women, arm p=0.1, heel p=0.98), and there was no difference in BMD between the age groups 30-39 and 40-49 (men, arm p=0.38, heel p=0.93; women, arm p=0.2; heel p=0.25). Thus, the data on radius and calcaneus bones were grouped for Figure 1 illustrating gender differences and level of Inuit BMD as assessed by DEXA scanning.

DISCUSSION

We conducted a field study of bone mineral density in North Greenland using a portable peripheral DEXA scanner. The characteristics of the scanner made it suitable for most kinds of transportation. The investigation took place during January 2002, and despite the frigid Arctic winter, measures of both accuracy (drift with time) and precision (reproducibility) were certainly comparable to international standards (9).

The sites measured were heel and forearm. These are not the sites where fractures associate with a higher risk of chronic disability and mortality (10), such as spine and hip. Site-specific measurements improve the prediction for fractures at that particular site but they do not improve the prediction for all fractures compared to peripheral measurements (2). Thus, peripheral measurements are applicable to risk assessment. Also, it is impractical to travel with a DEXA scanner for axial measurements. In addition, the Inuit may have a high occurrence of extraneous calcifications in the spine, which may artificially increase bone density values measured in lumbar spine (10).

Bone mass can be measured by different techniques. Incineration is relevant for skeleton and cadaver studies but has obvious disadvantages for field studies and in everyday clinic. Photon absorptiometry was used previously. The procedure is somewhat cumbersome with a relatively short half-life of the nucleid (125I, 60 days), and the need for the limb to be immersed in water or wrapped in a tissue-equivalent substance because photon absorption is affected by soft tissue. Also, it gives a relatively high radiation dose of 200 µSv. Ultrasound densitometry has the advantage of not involving ionizing radiation, but it has some practical requirements similar to photon absorptiometry. Furthermore, it measures the speed of ultrasound, which associates only modestly with bone density (9). However, it does associate well with fracture risk (2). Computed tomography has the advantage that it can differentiate cancellous bone from cortical bone and aortic calcification (2) with high accuracy and precision (9), but it is expensive and the radiation dose is 50 µSv. This is relatively high compared to the 2 µSv from the peripheral DEXA scanning which is less than the background radiation dose of one day in the US. Also, the DEXA scanner was easy to operate, fast, and convenient for the participant. The high accuracy is in contrast with the 5 % to 10 % found in radiographic absorptiometry of sites with just a slight tissue cover (9). Still, this technique is applicable with standard radiographic equipment.

In conclusion, we found peripheral DEXA scanning to be very feasible and reliable in a rural Arctic setting, although it had limitations in measuring sites. Furthermore, BMD data are now available for Greenland Inuit aged 30-49 years. Future studies should compare these with data on other ethnic groups, i.e. Caucasians, taking into consideration the differences in body build.

Acknowledgements

We are grateful to Carla Hame and Ruth Møller Jensen at sygeplejestationen in Saqqaq for invaluable help.
REFERENCES

1. Melton LJ. Osteoporosis epidemiology worldwide. Endocrinol Metab Clin N Am 2003; 32: 1-13.

2. Assessment of bone mass and osteoporosis. In: Kanis JA, ed. Osteoporosis. Blackwell Science: Oxford 1994; 114-146.

3. Thompson DD, Harper AB, Laughlin WS, Jørgensen JB. Bone loss in Eskimos. Circumpolar Health 1981 Nordic Council for Arctic Medical Research Report Series 33, pp 327-330.

4. Mazess RB. Bone density in Sadlermiut Eskimo. Hum Biol 1966; 38: 42-49.

5. Martin RB, Burr DB, Schaffler MB. Effects of age and sex on the amount and distribution of mineral in Eskimo Tibiae. Am J Phys Anthropol 1985; 67: 371-380.

6. Mazess RB, Mather WE. Bone mineral content in Canadian Eskimos. Hum Biol 1975; 47: 45-63.

7. Mazess RB, Mather W. Bone mineral content in North Alaskan Eskimos. Am J Clin Nutr 1974; 27: 916-925.

8. Pawson IG. Radiographic determination of excessive bone loss in Alaskan Eskimos. Hum Biol 1974; 46: 369-380.

9. Eddy DM, Johnston CC, Cummings SR et al. Osteoporosis: review of the evidence for prevention, diagnosis, and treatment and cost-effectiveness analysis. Status report. National Osteoporosis Foundation. 1998; 1-80.

10. Merbs CF. Spondylolysis of the sacrum in Alaskan and Canadian Inuit skeletons. Am J Phys Anthropol 1996; 101: 357-367.

Stig Andersen
Department of Endocrinology and Medicine
Aalborg Hospital, Aarhus University Hospital
Box 561
DK-9100 Aalborg
Denmark
Telephone: +45 99321960
Fax number: +45 98120253

E-mail: stiga@dadlnet.dk