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THE INFLUENCE OF NUMEROUS PREGNANCIES AND LACTATIONS ON BONE DIMENSIONS IN SOUTH AFRICAN BANTU AND CAUCASIAN MOTHERS

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SUMMARY

1. In groups of South African Bantu and Caucasian women aged 30–44 years, sub-divided into those having had (i) none to two or (ii) seven or more children, measurements of radiographs of the second metacarpal and of the humerus were made in respect of length, cortical thickness, cortical index, cortical area/total area, cross-sectional area index and cortical/surface area ratio.

2. In Bantu mothers of large compared with small families, there were no significant differences in the means of corresponding variables. This was also the case with the Caucasian mothers. Bantu mothers of large and small families had significantly lower mean values for most variables compared with those of Caucasian mothers of large and small families. In all four groups, ranges of measurements and indices were very wide.

3. It is questioned whether Bantu mothers accustomed to a low calcium intake and to numerous pregnancies and long lactations, suffer from calcium deficiency. The problem of whether the high recommended allowances of calcium during these periods confer a clinically detectable benefit requires re-examination.

Key words: pregnancy, lactation, bone dimensions, calcium intake.

During pregnancy and lactation recommended allowances of calcium are doubled or more (Recommended Dietary Allowances, 1968; Recommended Daily Intake of Energy and Nutrients for the U.K., 1969). In primitive and developing countries mothers very rarely receive calcium supplements, the intake usually being 250–400 mg per day, a third or less of the recommended amount; further, size of family is much larger and breast feeding is practised more frequently and usually for long periods. Since 99% of the total body calcium is found in bone, the physiological loss of calcium among underprivileged mothers, assuming net loss to be severe, would be expected to manifest itself by a demonstrable loss of bone mineral mass. Evidence about this aspect is controversial. Nilsson (1969), using three different methods of

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assessment, found that bone mass did not decrease, but tended to increase with parity. In contrast, Atkinson & West (1970) reported that in a period of 100 days of lactation, there was a loss of about 2% of bone mass in the femur. In the Dominican Republic, Suttapreyasri (1968) found that mean cortical thickness of a metacarpal was not diminished in mothers of large families. We have reported that mean dimensions of a metacarpal in aged Bantu women are closely similar to corresponding values published for aged Caucasian women (Walker, Walker & Richardson, 1970, 1971).

To throw further light on the situation, we have determined dimensions of the second metacarpal and humerus in groups of Bantu and Caucasian women of differing parity.

MATERIALS AND METHODS

Bantu

Large families. Subjects (thirty-seven) were mothers of children attending schools in Soweto, Johannesburg, and were selected as (i) having had seven or more children, (ii) being between 30 and 44 years, and (iii) being housewives, i.e. not going out to work and hence available for study.

Small families. The women (twenty-three) lived in Soweto and had had none to two children.

Caucasians

Large families. Subjects (twenty-two) consisted of all mothers conforming to the above criteria who lived in Vrededorp and Jan Hofmeyer Township, two suburbs of Johannesburg of low socio-economic status.

Small families. The housewives (twenty) were from Vrededorp or were shop assistants from a local branch of a chain store. All were in low socio-economic circumstances.

Assessment of calcium balance

Calcium intake. This was determined by the method of Burke & Stuart (1938) as modified by Lubbe (1968). The recall period was 3 days. The South African Food Composition Tables of Fox (1966) were used. The Bantu mothers had not received calcium supplements. Of the Caucasian mothers of large and small families, 12% and 22% respectively had received calcium supplements, but only sporadically.

Calcium losses. It was assumed that a foetus contains 30 g of calcium (Widdowson & Spray, 1951); no information on Bantu babies is available, although limited studies on ribs from Bantu and Caucasian babies have indicated similar chemical composition and mineral matter per unit volume (Walker & Arvidsson, 1954; Walker, unpublished work). Breast milk of both Bantu and local Caucasian mothers has been found to contain a mean of 28 mg of calcium/100 ml (Walker, Arvidsson & Draper, 1954). A flow of 740 ml/day was assumed (Wallgren, 1945), bearing in mind that Bantu babies grow at the same pace for the first 6 months of breast feeding as Caucasian babies (Brock & Autret, 1952).

Radiological studies

Hand. Radiographs (posterior–anterior) were made of both hands as described by Barnett & Nordin (1960) and Exton-Smith, Millard, Payne & Wheeler (1969b). At the midpoint of the second metacarpal of the right hand, measurements were made of external diameter (D), internal diameter (d) and length (L). With plates on a standard viewing box, measurements

were made by two persons to 0·25 mm, a transparent graduated scale and lens (3 ×) being used. On plates from thirty-seven Bantu mothers, mean differences between measurements (in mm) made by the two observers were: D 1·5%, d 3·8% and L 0·5%. Calculations were made of total cortical thickness, D − d, cortical index, (D − d)/D, as described by Barnett & Nordin (1960), cortical area/total area, $(D^2 - d^2)/D^2$, as used by Hossain, Smith & Nordin (1970), cross-sectional area index, $(D^2 - d^2)$, as used by Dequeker (1970), and cortical/surface area ratio, $(D^2 - d^2)/DL$, as described by Exton-Smith, Millard, Payne & Wheeler (1969a) and Gryfe, Exton-Smith, Payne & Wheeler (1971).

Humerus. The subject lay on the table with the left arm in supination. Anterior–posterior films of the humerus were made as indicated by Bloom & Laws (1970). Cortical thickness was measured at a point on the shaft of the bone where the endosteal borders of the lateral and medial cortices were parallel to each other and to the outer margins. In practice, this point was usually about 10–12 cm from the more distal end of the bone. By using a lens (3 ×) the endosteal border of the cortices was marked with a fine pencil and the thickness of the cortex measured with a graduated scale. Total cortical thickness was recorded to the nearest 0·25 mm and length was also measured. This was accomplished by having a steel rule with small holes, perforated at 1 cm intervals, placed on the X-ray table parallel to the shaft of the humerus. By using lens and scale, humerus length was measured from the X-ray plate. Measurements were made from the head of the humerus along the mid-axis to the point of intersection of a line joining the distal surfaces of the trochlea. This length was corrected by multiplying by the distortion factor. For example, if say 300·0 mm depicted on the steel rule in the X-ray plate measured 305·0 mm on the graduated scale, the correction factor would be 300·0/305·0 = 0·984. On plates from thirty-nine Bantu mothers mean differences (in mm) between measurements made by two observers were: D 1·7%, d 3·3% and L 0·3%. As with the metacarpal, calculations were made of total cortical thickness, cortical index, cortical area/total area, cross-sectional area index, and cortical/surface area ratio.

The X-rays on urban Bantu were carried out at Mofolo Clinic, Soweto (Johannesburg City Health Department); tube distance was 110 cm. X-rays on the Caucasians were made at the Miners Medical Bureau of the Transvaal and Orange Free State Chamber of Mines, Johannesburg; tube distance was 110 cm.

RESULTS

Particulars of mothers and their habitual calcium intakes and losses are given in Table 1. Data on mean losses of calcium in a group relate to the amounts calculated from the mean number of children born plus calcium losses during lactation. Since data on most aspects were derived from recall, they must be regarded as approximate.

In the Bantu groups intakes of calcium were far less than those of Caucasians. In both groups calcium intakes were significantly lower ($P < 0·01$) in mothers of large compared with small families. Most mothers of large families were lactating at the time of the investigation. They were, therefore, at a further disadvantage compared with mothers of small families who had had their last child some years previously.

Radiological measurements (Tables 2 and 3)

In the Bantu mothers of large compared with small families there were no significant differences ($P > 0·05$) between the means of the respective dimensions or indices of both second

metacarpal bone and humerus. Similarly, in the Caucasian mothers of large compared with small families, the corresponding data did not differ significantly.

In contrast, in Bantu compared with Caucasian mothers of large families, all means on the metacarpal were significantly lower ($P<0{\cdot}01$). This did not apply in the case of the humerus, except for cortical thickness and cross-sectional area index.

TABLE 1. Details of subjects and estimates of calcium intake and losses: mean values are given

Group of mothers	Age (years)	No. of babies born	No. of babies breast fed*	Period of breast feeding (months)†	Habitual calcium intake (mg/day)	Gross weight of calcium lost in reproductive period (g)‡	Time since last child was born (years)
Large families							
Bantu mothers ($n=37$)	39	10·2	8·3	10	320	829	0·2
Caucasian mothers ($n=22$)	39	8·1	4·8	13	550	696	4·5
Small families							
Bantu mothers ($n=23$)	36	1·6	1·4	11	375	145	0·8
Caucasian mothers ($n=20$)	36	1·8	1·3	4	675	87	8·1

* Breast fed for more than 1 month.

† In babies breast fed for more than 1 month.

‡ Mean losses due to the foetuses and milk calculated from mean data given.

Further, in mothers of small families most values for Bantu were significantly lower than those for Caucasians. For the metacarpal this obtained with cortical thickness, cortical area/total area, and cortical/surface area ratio ($P<0{\cdot}01$). For the humerus this applied to all variables ($P<0{\cdot}01$), except cortical thickness and cortical/surface area ratio.

Despite these differences, results in the Bantu groups were closely similar to those in the corresponding local Caucasian groups and also to those in the Caucasian groups reported on by other workers, in which the subjects were mainly accustomed to relatively high calcium intakes and had produced relatively few children. However, in all four groups, the ranges of measurements and of indices were very wide.

DISCUSSION

With regard to relation between cortical measurements and indices and mineral content of skeleton, it must be borne in mind that chemical composition differs from bone to bone, even within the same bone, e.g. the rib (Nicholls & Nimalasuriya, 1939; Mitchell, Hamilton, Steggerda & Bean, 1945; Forbes, Cooper & Mitchell, 1953). In respect of the bones studied in the present investigation, there is a highly significant correlation ($P<0{\cdot}001$) between cortical thickness of the finger bones and their actual mineral content (Virtama & Mahonen, 1960); further, when cortical index of humerus and femur were compared with their mineral contents,

TABLE 2. Right second metacarpal dimensions in South African Bantu and caucasian mothers

	D	d	D−d	$\frac{D-d}{D}$	$\frac{D^2-d^2}{D^2}$	D^2-d^2	L	$\frac{D^2-d^2}{DL}$
Large families								
Bantu Mean	7·81	3·36	4·45	0·57	0·81	49·7	65·88	0·096
SD	0·58	0·63	0·55	0·07	0·05	7·2	3·28	0·008
Caucasian Mean	8·18	3·02	5·15	0·63	0·86	57·6	66·16	0·106
SD	0·58	0·78	0·58	0·08	0·06	7·5	2·61	0·009
Small families								
Bantu Mean	7·89	3·33	4·56	0·58	0·82	51·1	66·09	0·097
SD	0·66	0·76	0·58	0·08	0·06	3·0	4·24	0·008
Caucasian Mean	7·95	3·05	4·90	0·61	0·85	54·0	65·68	0·102
SD	0·66	0·56	0·70	0·07	0·05	9·9	3·44	0·011
Caucasians elsewhere								
Garn (1970): U.S.A.	7·4	2·5	4·9	0·66				
Nordin, MacGregor & Smith (1966): Scotland				0·63				
Morgan, Spiers, Pulvertaft & Fourman (1967): England				0·53				
Hossain *et al.* (1970): Scotland					0·86			
Dequeker (1970): Holland						49		
Gryfe *et al.* (1971): England								0·106

D and d are external and internal diameters of cortex; L=length; D−d=total cortical thickness; $\frac{D-d}{D}$= cortical index; $\frac{D^2-d^2}{D^2}$=cortical area/total area index: D^2-d^2=cross-sectional area index; $\frac{D^2-d^2}{DL}$=cortical/surface area ratio.

TABLE 3. Left humerus dimensions in South African Bantu and Caucasian mothers

	D	d	D−d	$\frac{D-d}{D}$	$\frac{D^2-d^2}{D^2}$	D^2-d^2	L	$\frac{D^2-d^2}{DL}$
Large families								
Bantu Mean	19·53	10·91	8·62	0·44	0·68	260·6	316·9	0·042
SD	1·23	1·79	1·33	0·07	0·08	36·1	19·5	0·005
Caucasian Mean	18·70	9·85	8·85	0·47	0·72	252·0	325·4	0·041
SD	1·00	1·36	1·11	0·06	0·06	30·4	12·8	0·003
Small families								
Bantu Mean	19·68	10·69	8·99	0·46	0·70	270·2	320·2	0·042
SD	1·23	2·16	1·40	0·09	0·09	31·5	20·8	0·004
Caucasian Mean	18·00	8·88	9·12	0·51	0·75	245·9	335·4	0·040
SD	1·58	1·30	1·67	0·07	0·07	56·0	24·4	0·004
Caucasians elsewhere								
Bloom & Laws (1970):								
England Mean			8·95					
SD			0·77					

it was found that for the humerus a highly significant correlation ($P<0{\cdot}001$) prevailed, whereas for the femur the correlation was only just significant ($P<0{\cdot}05$) (Virtama & Telkka, 1962). The three other indices described, cortical area/total area, cross-sectional area index and cortical/surface area ratio, are believed to be truer reflections of bone mineral concentration than cortical index. However, the precise correlation between each index and bone mineral, involving radiological and bone density studies on necropsy material, has not yet been reported. Despite uncertainties it would seem reasonable to consider that measurements and indices secured on metacarpal and humerus broadly reflect the mineral situation in the total skeleton.

Studies on necropsy material from Indian (Begum & Pereira, 1969), Bantu (Walker & Arvidsson, 1954), Ugandan (Dickerson & John, 1969) and Caucasian subjects have revealed that the mean mineral composition of specific bones is fairly constant. The present studies indicate a similar constancy in respect of mean dimensions and indices of bones from contrasting groups of Bantu and Caucasian mothers of large and small families.

The most important finding is that multiple pregnancies and long lactations in both Bantu and Caucasian mothers were not accompanied by radiological evidence of significant bone loss, in spite of a relatively low calcium intake. That a slight net loss occurs is probable; for lactating Caucasian mothers, a loss of 0·022% day in the femur was given by Atkinson & West (1970). But whatever loss occurs, it must be viewed against the wide range of bone dimensions and indices that obtain in well people, as found in our own studies and those of others. Clearly, there is an urgent need for valid information about the lower limits of bone thickness and other indices which are consistent with good health and activity.

There appears to be no evidence that indigent mothers of very large families suffer clinically from a sustained drain of calcium, nor that such mothers would benefit clinically from calcium supplements given at amounts suggested in the tables of recommended allowances. It cannot therefore be sustained that mothers of very large families, such as the Bantu and Caucasian subjects studied, suffer from calcium deficiency. As Garn (1970) has emphasized, the whole problem of calcium intake and deficiency stigmata requires critical re-examination.

Our results, with those of Suttapreyasri (1968) and Nilsson (1969), indicate that the net loss/day of calcium is small throughout reproductive life, and that the negative balances that may result from many pregnancies and long lactations are not cumulative. Such losses as occur could be offset by more efficient use of the calcium ingested; low intakes of the element are normally associated with increased absorption and with lower excretion (Nicholls & Nimalasuriya, 1939; Walker, Fox & Irving, 1948; Luyken & Luyken-Koning, 1961; Begum & Pereira, 1969; Spencer, Lewin, Fowler & Samachson, 1969). High absorption of calcium during pregnancy in under-privileged females has been reported by Shenolikar (1970).

The similarity of mean values in Bantu and Caucasian mothers suggests that an ethnic factor is not present. Others, however, consider that race has a bearing on differences in (i) physical bone density (mineral matter per unit volume) as found in U.S.A. Negroes compared with Caucasians (Broman, Trotter & Peterson, 1958; Seale, 1959), (ii) cortical thickness of the metacarpal as seen in U.S.A. Negroes, also in Japanese and Chinese subjects, compared with U.S.A. Caucasians (Garn, Pao & Rihl, 1964; Smith & Rizek, 1966), and (iii) osteoporosis in U.S.A. Negroes compared with Caucasians (Lutwak, 1963).

The accurate assessment of calcium stores is unsatisfactory. It will be a considerable time before newer approaches, such as neutron activation analysis (Nelp, Palmer, Murano, Pailthorp, Hinn, Rich, Williams, Rudd & Denney, 1970) or the use of radioactive isotopes

as a source of monochromatic light (Schuster, Reiss & Kramer, 1970), become available or applicable to epidemiological investigations.

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