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EPIDEMIOLOGY OF FRACTURES OF BONES OF THE FOREARM IN A MIXED SOUTH EAST ASIAN COMMUNITY, SINGAPORE

1. *A Preliminary Study*

By

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INTRODUCTION

The object of the present survey is:

1. To determine the absolute incidence of fractures of the forearm in a mixed South East Asian Society and compare the findings with a European one, Malmo (*Bauer* 1961, and *Alffram & Bauer* 1962).
2. To test further the hypothesis that fracture patterns may reveal how bone strength changes with age.
3. To determine whether the dietary or hormonal environment, or both have any influence upon fracture incidence patterns.
4. To determine the role of race on fracture patterns.

This survey is also a part of a South East Asian investigation into the role of Osteoporosis in the aetiology of fractures in the aged.

It is believed this is the first epidemiologic survey of fractures of the forearm in a South East Asian community ever undertaken.

It is to be emphasized that this is only a preliminary study and the work will be extended when further data become available.

The survey follows closely the work of *Alffram & Bauer* (1962).

THE POPULATION AT RISK

Singapore with its mixed Asian Population of 1,445,929, where accurate knowledge of the Race, age and sex of the community at risk is available, presents unique opportunities for epidemiologic studies of fractures in a well defined community. That part of the 1957 census

TABLE 1
Population of Singapore 1957 in Thousands.

Detailed age groups	Male	Female
0 - 4	136.7	128.0
5 - 9	112.0	106.1
10 - 14	71.2	65.1
15 - 19	70.1	65.5
20 - 24	61.3	58.0
25 - 29	59.8	52.0
30 - 34	50.1	39.8
35 - 39	46.5	36.2
40 - 44	43.0	33.2
45 - 49	37.8	28.9
50 - 54	29.3	22.5
55 - 59	20.6	16.9
60 - 64	12.0	12.3
65 - 69	6.8	8.6
70 - 74	3.4	5.3
75 and above	2.2	4.7

(which is the one used in this survey) showing the mixed population by sex and 5 year age groups is shown in Table 1.

There is only one General Hospital in Singapore and all fracture cases are treated there.

M A T E R I A L

The period under study is from 1962 to 1963 inclusive *i.e.* two complete years, and the material consists of 1724 fractures of the forearm in 1711 patients. The two annual totals of patients did not differ by very much, being 852 and 872 respectively.

Seven women and four men had bilateral Colles fractures, and 2 boys had simultaneous bilateral displacements of the distal radial epiphysis.

Only fresh fractures are included and pathological ones are not considered.

Classification of Fracture Types (according to Alffram & Bauer 1962).

1. Distal fractures (1,034 cases) include fractures of the distal radius or ulna, or both, within 2 cms of the wrist joint.
2. Shaft fractures of the radius or ulna, or both (636 cases).
3. Proximal fractures of the radius (41 cases) include fractures of the neck of the radius (22 cases) and fractures of the head of the radius (19 cases).

Definitions (after Alffram & Bauer 1962).

1. Degree of Trauma.

Moderate trauma is violence less than, or equivalent to a fall to the ground from the standing position. This includes falling from a chair or bed.

Severe trauma includes all others, *e.g.* falling from a height, traffic accidents, a fall downstairs etc.

In the material collected it is possible to determine the degree of trauma in 62 per cent of the distal fractures, 69 per cent of the shaft fractures, and 76 per cent of the proximal radial fractures.

2. Incidence of Displacement.

Reduction of a fracture before immobilization means that the fracture was initially displaced, whereas immobilization without reduction means there was no displacement or minimally so.

The index of the incidence of displacement is defined as the ratio of the number of reduced over non reduced fractures. In the material it is possible to determine whether the fractures are displaced or not in 69 per cent of the shaft fractures and 76 per cent of the proximal radial fractures.

3. Age Specific Rates.

These are calculated from the population figures (Table 1) as the annual incidence of fractures per 10,000 males or females in each 5 years age group.

4. Sex Ratio.

This is defined as the female divided by the male incidence.

5. Male to Female Ratio.

This is defined as the number of male fractures divided by the number of female fractures in a particular series.

6. Children (boys and girls) are between the ages of 0 to 19, young adults 20 to 39, middle aged are those from 40 through 59, and aged are those 60 and above.

RESULTS AND INFERENCES

Distal Fractures.

Fractures of the distal radius or ulna, or both (1034 cases) constitute 60.4 per cent of all fractures of the forearm (Table 2); 761 or 72.6 per cent males, and 273 or 27.4 per cent are females. The male to female ratio for the series is 2.8. In childhood this is 5, young adults 4.6, middle aged 1.3 and in old age it is 0.8.

In both sexes the incidence reaches a peak in childhood (but is far less convincing among the girls) and drops to a minimum in young adults. There is no similarity in the incidences in these two age groups; fracture of the distal radius and ulna is predominantly a male disease (Fig. 1).

There is a very gradual rise from the age of 40 onwards, both sexes participating, and with incidences in the various 5 year age groups which either are very close or identical, and reaches a maximum in the 60s, remaining more or less constant thereafter. The peak does not reach the peak of infancy and childhood (Fig. 1).

Compared with Malmo the incidence of the local boys is low. In young adults and middle aged males the incidences correspond reasonably

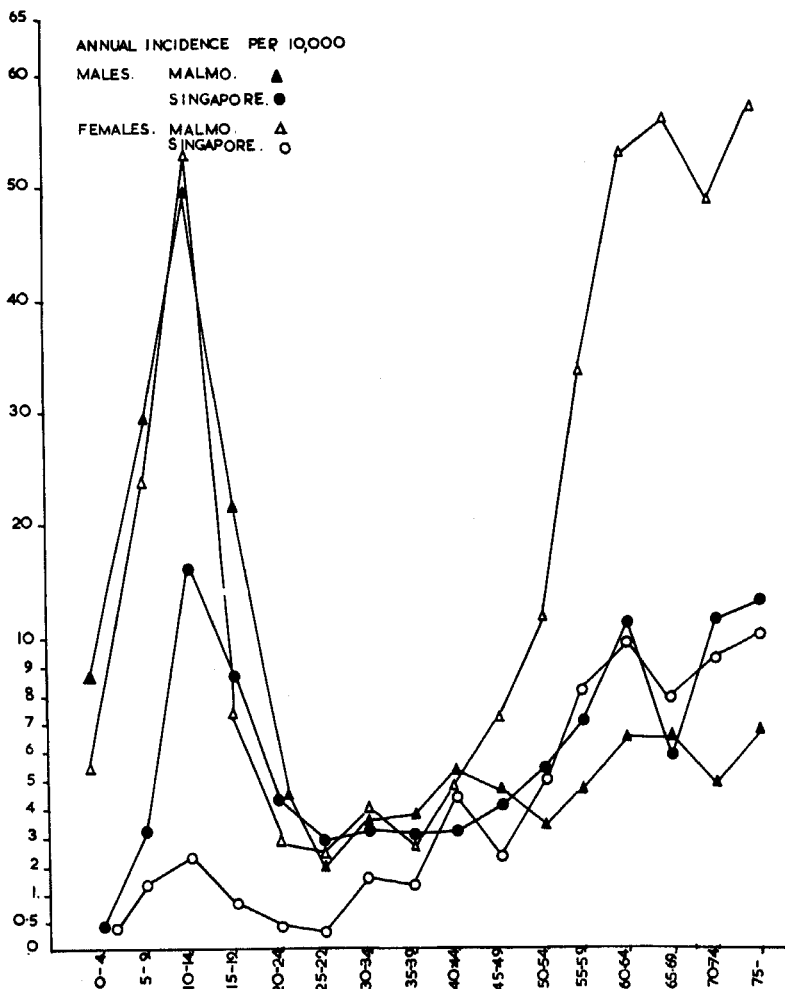


Fig. 1.

Annual male and female incidence of fractures of distal Forearm per 10,000 of population according to age in Singapore. The Malmo incidences are superimposed.

closely, but in the aged, the Singapore results are probably a little higher (Fig. 1).

The local female results are completely different from those of *Alffram & Bauer* (1962). For girls and middle aged females these are markedly different from those of the corresponding ages in Malmo. Nor is there the dramatic rise over the 20 year period from 40 to 60 as in the Swedish Community (Fig. 1).

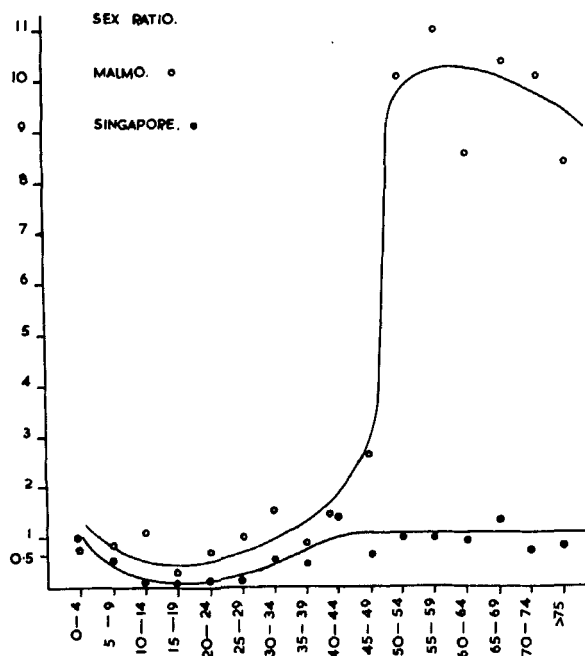


Fig. 2.

The ratio of female to male incidences of fractures of the distal Forearm in Singapore. Malmo results are superimposed.

The sex ratio is remarkably even in middle age and the aged, but is in favour of the males in young adults and childhood, again contrasting strongly with Malmo where the sex ratio was even in childhood and young adults but rising to about 10 during middle age and in the aged (Fig. 2).

Severe trauma in the male, except in the very young and the very aged, is equal to or greater more common than moderate trauma in all other age groups. This contrasts strongly with Malmo where only the young adults have severe trauma equal to or more common than moderate trauma. In the females, except in the 20-29 group, moderate trauma prevails in all age groups (Fig. 3).

Slipped Distal Radial Epiphysis.

There are 37 slipped radial epiphyses in the material, constituting 4.0 per cent of all the distal fractures (*c.f.* 3.9 per cent in Malmo). Two of the cases are bilateral. Of the 37 cases only 2 are girls, thereby giving a male to female ratio of 17.5 to 1 (*c.f.* Malmo 2.4 to 1).

TABLE 2
Fractures of the Distal Radius or Ulna or both in Singapore 1962-63.

Age	Male	Female
0 - 4	13	13
5 - 9	73	32
10 - 14	233	32
15 - 19	124	11
20 - 24	53	5
25 - 29	35	4
30 - 34	34	14
35 - 39	30	10
40 - 44	27	29
45 - 49	31	14
50 - 54	31	24
55 - 59	30	27
60 - 64	27	25
65 - 69	7	14
70 - 74	7	10
75 and above	6	9
Total	761	273

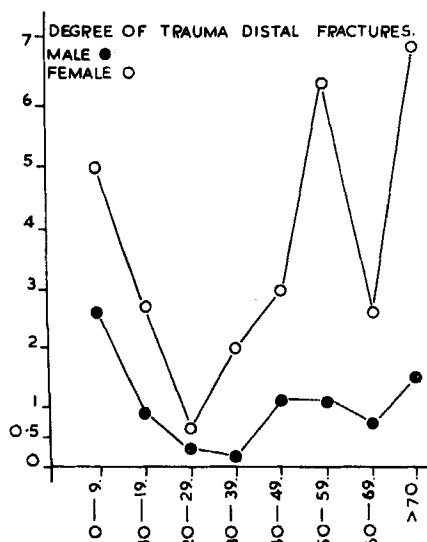


Fig. 3.

The ratio of severe to moderate trauma in fractures of the distal Forearm in Singapore.

SLIPPED DISTAL RADIAL EPIPHYSIS
INCIDENCE PER 10,000

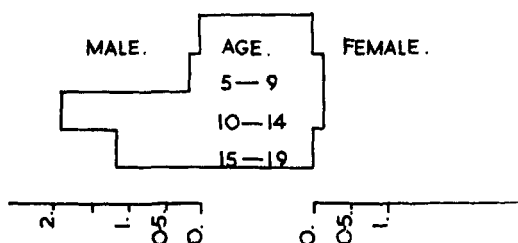


Fig. 4.

Annual incidence of slipped radial epiphyses per 10,000 of the Singapore population according to age and sex.

The youngest is 8 and the oldest is 18.

The annual incidence is low when compared to Malmo (Fig. 4). Severe and moderate trauma are about even, and reduction is necessary in all cases.

Shaft Fractures.

There are 636 fractures of the radius or ulna or both, making up 36.6 per cent of the material under survey (Table 3). There are 512 (or 80.5 per cent) males and 124 (or 19.5 per cent) females. The male to female ratio in the series is 4.1: 1. In Malmo it is 2: 1. More than $\frac{3}{4}$ (76.1 per cent) occur in children and thereafter in women it is rare. In boys the incidence is a little less than $\frac{1}{3}$ of that of Malmo but about 4 times that of the local girls. The young male adults and middle aged males are comparable to, but the aged incidence is perhaps a little higher than that in Malmo (Fig. 5).

TABLE 3

Fractures of the Shaft of the Radius or Ulna or both in Singapore 1962-63.

Age	Male	Female
0-19	387	97
20-39	73	14
40-59	40	8
60 and above	12	5
Total	512	124

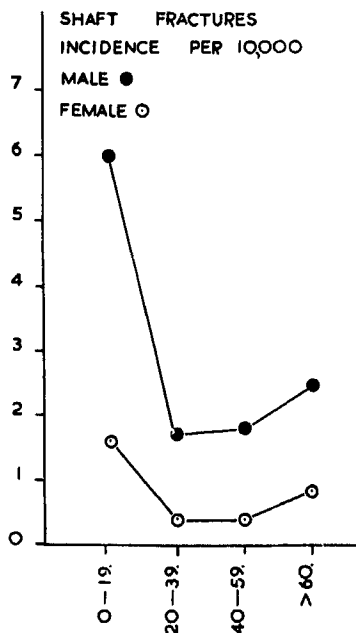


Fig. 5.

Annual incidence of shaft fractures per 10,000 of the Singapore population according to age and sex.

The incidence in the Singapore girls is much lower, but in young adults, the middle aged and aged females the incidences are comparable to those of Malmo (Fig. 5).

In girls moderate trauma predominates, in young adults severe and moderate trauma are equal, and in the middle aged and the aged women severe trauma is more common than moderate trauma (Fig. 6a). The men follow the Malmo pattern *i.e.* in boys moderate trauma prevails but thereafter severe trauma is more common than moderate trauma.

In girls non displaced fractures prevail over displaced, in young adult females displacement and non displacement are about equal, but in the middle aged and the aged females displacement is more common. In boys and young male adults displacement and non displacement are about equal but thereafter displacement predominates (Fig. 6b).

Proximal Radial Fractures.

These are relatively rare fractures in Singapore (Table 4). There are only 41 (2.3 per cent) in the material, 26 or 63.4 per cent are male and 15 or 36.6 per cent are women. Fractures of the head and neck are rare

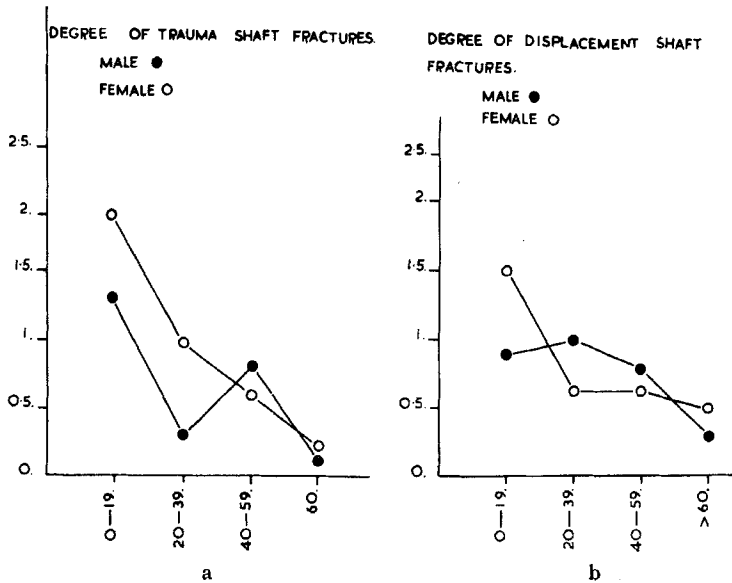


Fig. 6.

Ration of severe to moderate trauma in fractures of the shafts of the radius and ulna, and the ratio of non-displaced to displaced shaft fractures.

in middle age in both sexes, and none are recorded in the aged. These fractures are common in females but rare in males in these ages in Malmo. Fractures of the neck predominate in children and fractures of the head in young adults.

TABLE 4
Fractures of the Proximal Radius-Head and Neck in Singapore 1962-63.

Age	Male	Female
9-19	12	9
20-39	11	3
40-59	3	3
60 and above	0	0
Total	26	15

The men to women ratio of these fractures in Singapore is 2.7 to 1 but in Malmo it is a female to male ratio of 1.8 to 1. In both males and females moderate trauma prevails in childhood but severe thereafter, and in both sexes displacement is common in children but non displacement more common thereafter.

DISCUSSION

Although not convincingly so, it would appear in the local material that the highest incidence of fractures of the distal forearm occurs in boys of the 10–14 age group, the summit reached by the aged being a little below the peak attained by this group of boys.

In spite of this, however, the injury is still the most common among the aged, in men a little more so than in women.

The survey has shown that the incidence of distal forearm fractures rises from 40 years onwards reaching a constant peak in the 60s, both sexes participating, but neither the rise nor the peak is as dramatic as that occurring among the women in Malmo.

In women this rise is accompanied by an increase in the proportion of moderate trauma, whereas among the men severe trauma continues to be equal to or in excess of moderate trauma until very aged. The difference in trauma rate between the two sexes is explained by the fact that whereas there is an increased tendency to adopt a more sedentary existence with increase in age on the part of the female, among men, economic necessity often renders it essential even for the older ones to persist in heavy occupations and thereby to continue to expose themselves to the risks of such occupations.

The data on distal forearm fractures among the females indicate clearly that the increase in fragility of the cancellous portion of the distal radius is small when compared with the women of Malmo.

The increase in fragility with increase in age among the males is probably even smaller, and the existing aged male fracture pattern is probably an expression of the failure of this group to adopt a more sedentary existence as they advance in years.

The sex ratios in the fractures of the proximal radius also gives little evidence of any great increase in bone fragility among the men.

In children cortical and cancellous fragility are about even, but the latter increases with age more strikingly among the females (Fig. 7). This merely indicates that the degenerative process in cancellous bone progresses with age, more so in females than males, and that cortical bone when once matured, degenerates very slowly if at all.

To explain the local mixed population fracture pattern and to ascertain reasons for the marked contrast between this and that of a European Community (Malmo) the following will be discussed:

1. The factor of race.
2. Exoskeletal factors which include accident proneness due to

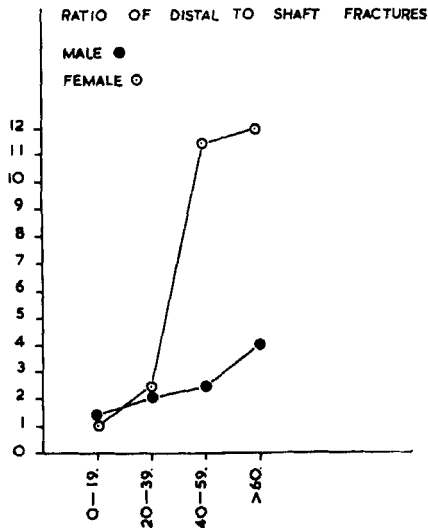


Fig. 7.

The ratio of distal to shaft fractures.

physical defects commonly associated with the aged (*Buhr & Cooke 1959*) and severe trauma.

3. Endoskeletal factors which include the anabolic steroid-osteoporosis relationship (*Reifenstein 1957*) and the role of diet.

Race Factor.

It is to be emphasized that the fracture pattern deduced in the present survey is that emanating from a mixed community consisting predominantly of three major and different races—Chinese and Malays (of Mongoloid composition), Indians (including Ceylonese) of a Caucasoid “Carpentarian” composition (*Del Tufo 1949*). That it should differ from one produced by a European Society (Malmo) consisting of a population with a uniform race is therefore not unexpected.

There is strong evidence to support that skeletal structure is different in different races. *Trotter et al.* (1960) have shown that the skeleton of the American Negro (Negroid) is of greater density than that of the American White (Caucasoid).

Thus the differences between the European pattern (Malmo) of fractures and that emanating from a mixed South East Asian Community (Singapore) may therefore be a matter of race.

Exoskeletal Factors.

Accident-proneness on account of the common physical defects associated with the aged (Buhr & Cooke 1959) increases the risk of fractures in this age group. These exoskeletal factors, no doubt, operate with equal frequency in Singapore as elsewhere.

Even thus fracture incidence among the local aged females is still remarkably small.

There is evidence to show that severe trauma among the aged males may in part contribute to the coincidence of the fracture rates between the two sexes in this age group.

The Anabolic Steroid-osteoporosis Relationship.

Reifenstein (1957) found in European Societies that which he ascribed on account of decline of anabolic steroids about the time of the Menopause, osteoporosis in the aging women is approximately five times of that of aging men. Even taking into consideration that severe trauma among men continues to be equal to or in excess of moderate trauma until the very elderly, the incidence of fractures among the older females in Singapore is very far from being five times that of the corresponding males.

Lugg & Bowness (1957) have shown that "any differences in anabolic steroid excretion (17 ketosteroid) by the male subjects of the different ethnic groups (including Europeans) of Singapore could be regarded as reflections of differences in weight". In the light of this evidence, therefore, it would not be unreasonable to assume that the anabolic steroid-osteoporosis relationships of the local aging females are also analogous one with the other and with that of the European females as well. Is then, the local female fracture pattern another example of the lack of correspondence between osteoporosis incidence and fracture incidence? It may be that the local anabolic steroid-osteoporosis relationship is different (unlikely), and that the local fracture pattern is an expression of this difference.

The Role of Diet.

The caloric intake per capita per day in Singapore has been given as 2555 (May & Jarcho 1961). The diet is deficient in protein and is low in calcium ("House hold Budget Survey" Federation of Malaya 1957-1958). The given figure is a very optimistic estimate as it is certain that the more prosperous contribute considerably to this value. It is

therefore reasonable to assume that in that portion of the population among whom fractures are rife, the food intake is less, with the females the worse off (*Llewellyn-Jones 1962*). If therefore diet alone is considered paramount in fracture aetiology it would not be unreasonable to expect the local female fracture incidence to exceed both the local male and also the Malmo female incidences. The Survey has shown that it is not so. Yet it is inconceivable that diet, in spite of *Bauer's* opinion (1960) to the contrary, can be dismissed in any discussion on fracture aetiology.

CONCLUSIONS AND SUMMARY

The survey has shown that:

1. Differences of fracture pattern between East (Singapore) and West (Malmo) is principally a matter of race influenced by environmental factors of which the most important is probably diet.
2. There is further evidence of the lack of correspondence between osteoporosis incidence and fracture incidence, thereby lending support to the hypothesis that osteoporosis and bone fragility may be different diseases (*Alffram & Bauer 1962*).

Whether the local pattern is normal or not, however, can only be known if epidemiological surveys are conducted upon similar racial groups living elsewhere under similar, better or more adverse environmental conditions (diet).

It can also be predicted from this study that when the same material is broken up into its racial components there will be as many fracture patterns as there are racial groups.

This work will be extended when more data become available.

R E S U M E

L'étude a montré que:

1. Les différences dans les modèles des fractures entre l'Est (Singapour) et l'Ouest (Malmö) sont principalement une question de race, fonction de facteurs environnants dont le plus important est probablement le régime alimentaire.
2. Le manque de corrélation entre l'incidence de l'ostéoporose et l'incidence de la fracture s'est avéré prêter appui à l'hypothèse que l'ostéoporose et la fragilité des os peuvent être des maladies différentes (*Alffram & Bauer 1962*).

De toute manière, la question de savoir si le modèle local est normal

ou non, ne pourra être élucidée que si des recherches épidémiologiques sont entreprises pour des groupes raciaux similaires, résidant ailleurs et dont les conditions environnantes (régime diététique) sont similaires, meilleures ou plus mauvaises.

En partant de cette étude, il peut aussi être établi que quand le matériel d'observation est divisé dans ses composantes raciales, il y a autant de modèles de fractures qu'il y a de groupes raciaux.

Cette étude sera complétée lorsque de nouvelles données seront obtenues.

ZUSAMMENFASSUNG

Die Untersuchung hat gezeigt dass:

1. Verschiedenheit der Bruchformen zwischen Ost (Singapore) und West (Malmö) ist im Prinzip eine Angelegenheit der Rasse und des Einflusses von Faktoren der Umgebung von denen der wichtigste wahrscheinlich die Ernährung ist.

2. Man findet ferner Beweise für eine mangelhafte Übereinstimmung zwischen dem Auftreten von Osteoporose und Bruch, was die Hypothese unterstützt, dass Osteoporose und Knochenbrüchigkeit verschiedene Erkrankungen darstellen könnten (*Alffram & Bauer 1962*).

Ob die örtlichen Formen normal oder nicht normal sind, kann man jedoch nur feststellen, wenn epidemiologische Untersuchungen an gleichen Rassegruppen, die anderswo unter gleichen, besseren oder schlechteren Umgebungsbedingungen leben (Ernährung) ausgeführt werden.

Man kann auch aus dieser Untersuchung voraussagen, dass man, wenn dieses Material in seine rassischen Komponenten aufgeteilt wird, ebensoviele Bruchformen finden wird als Rassegruppen vorhanden sind.

Diese Arbeit wird ausgeweitet werden, sobald zahlreichere Daten erhältlich sein werden.

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