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CORTICAL BONE LOSS IN JUVENILES OF DICKSON MOUNDS

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Since the 1950's, skeletal biology has professed to be less concerned with anthropometric studies than with developing hypotheses concerning biocultural processes of change. However, Lasker (1967) states that approximately two thirds of published material is still descriptive, i.e. no attempt is made to deal with the effects of cultural change on biological change and vice versa.

On the other hand, the paleoepidemiological approach (host-insult-environment interactions) has been successfully applied to the Dickson Mounds (Lallo et al., 1978), Nubian (Armelagos et al., 1972; Carlson et al., 1974) and Libben populations (Lovejoy et al., Mensforth et al. 1978), allowing statements to be made concerning bone biodynamics in modern populations, variability in growth patterns, etc. The advantages of archaeological over clinical material include large sample size and homogeneous populations. Advantages outweigh limitations, such as preservation problems due to soil type, aging and sexing error, etc. (Dewey et al., 1969). Moreover, both Shackleford (1966) and Stout (1978), working with Mississippian and Archaic Indian bones, maintain that histological structure is preserved through a greater range of soil and drainage conditions than heretofore suspected. Sections from bone samples over a thousand years old often maintain structural integrity similar to that of bone two to three hundred years old, allowing analysis of metabolic disorders which have resulted in skeletal abnormalities or pathologies (Stout and Teitelbaum, 1978: 263). These case studies must then be incorporated into a population analysis in which cultural and environmental variables and degrees of inter-group variation are considered. Comparisons might also be made at the intragroup level.

Further, simultaneous application of several sexing and aging criteria to the same skeletal material has narrowed that margin of error considerably.

While gross pathologies are immediately discernible, the underlying process is not always so apparent. Various stressors may result in similar lesions. It is necessary, therefore, to employ archaeological analysis to establish the cultural context, and to understand bone as a dynamic system, subject to the same environmental variables to which any other somatic tissue responds.

The Dickson Mounds population offers an almost ideal sample for testing hypotheses concerning the subsistence shift from gathering to corn horticulture. ("Almost," because Dickson has been preserved in less than ideal conditions, i.e. exposure to water. This problem will be discussed under Methods). Particularly, changes in cortical bone may be compared to the Nubian studies.

Bone Biodynamics and Nutrition

Briefly stated, bone is a living organ which requires a flow of nutrients to maintain its cellular structure. In the mature skeleton, length and diameter of long bone do not change to an appreciable extent, but cortical remodeling occurs to recycle nutrients, and to meet the needs of functional stress. Constant volume is maintained in the healthy skeleton because deposition is equivalent to resorption. The porosity of aging bone is due to a shift in this ratio, such that deposition does not keep pace with resorption (McComb, n.d.), and may result in osteoporosis, which has been defined as a decrease in skeletal mass (Van Gerven et al., 1969:23).

During the period of growth and development, formation of bone exceeds resorption, with osteoclastic activity at a maximum during the first two decades of life (McComb, n.d.). Various studies have shown that preferential growth occurs during this stage (Dreizen et al., 1967; Frisancho et al., 1970; Garn, 1970; Huss-Ashmore, n.d.; Thissen et al., 1976) and long bone growth is disturbed in conditions of sub- or mal-nutrition. Nutritional imbalances today do not occur in Arctic regions where animal protein is a major part of the diet, but in agricultural regions, where limited assemblages of vegetable nutrients may result in a shortage of essential amino acids (Stini, 1971:1073). Imbalance is aggravated by infection and results in increased morbidity and morality, especially in children. Furthermore, recent animal studies have indicated the existence of an intergenerational effect, in that chronically malnourished mothers give birth to female offspring with significantly impaired brain parameters (i.e., reduced weight, protein content and cell number)--as well as reduction of other growth parameters. Studies in developing countries indicate that maternal malnutrition effectively retards prenatal development and impairs the development of cell-mediated immunity--the results being an increased susceptibility to infectious disease. (Lechtig et al., 1975; Weinstein and Haas, 1977: 26-30).

Caloric deficit is not required for subnutrition. Simple protein deficiency reacts with bacterial infections in a synergistic fashion (Scrimshaw, Taylor and Gordon, 1959). Infection activates the immune response which, in a feedback loop, further reduces labile protein (Stini, 1971). Such a protein deficiency may occur with corn horticulture. Age specific patterns should be discernible in an archaeological population, e.g., in the two to six year old group, considered to be most stressed in developing countries today because of weaning and increased protein requirements for growth (Lechtig et al., 1975).

It has been suggested that, under conditions of nutritional stress, long bone length and width will be maintained at the expense of cortical thickness (Huss-Ashmore 1978). While cortical thickness decreases with age (Dewey et al., 1969), one would not expect to find a decrease during the period of growth and development; such a condition would indicate pathology. Huss-Ashmore has suggested that this type of juvenile osteoporosis is an adaptive process by which bone is recycled to maintain growth and is an indicator of nutritional stress.

I have employed macro-measurements of femoral cross sections to compare Dickson Mounds to both Nubian (Huss-Ashmore, n.d.) and modern (Garn, 1970) populations.

Materials and Methods

The sample population was drawn from each of the three cultural traditions represented in the Dickson Mounds collection. These include a Late Woodland group (A.D. 950-A.D. 1050) whose subsistence is described as transitional, i.e., a gradual shift from hunting-gathering to maize horticulture occurred in this period; and the Middle Mississippian (A.D. 1200 A.D.-1300) in which there is increased reliance on maize, increased population density and some indication of warfare, or at least intensive competition for agricultural land (Lallo et al., 1978:18).

Left femora of males and females in the 0-15 year old age group were obtained for the three groups. Age categories were worked out by Bickerton based on dental eruption patterns which is little effected by poor nutrition (Newman, 1975:239). While the material has been sexed, no attempt has yet been made to divide the sample, so that direct comparison may be made with

Nubian and modern groups. Selection was based on the condition of bone for cross-sectioning and on the presence of right femora for additional study, as well as the presence of dentition for aging, and known cultural affiliation. Because of this limiting criterion, it was necessary to combine the Late Woodland with the transitional sample, due to the insufficient sample size of the former. The resulting sample consisted of 56 Woodland-Transitional (W-T) and 33 Middle Mississippians (M.M.), with concomitant loss of information on the shift from hunting-gathering to the beginnings of horticulture.

No problems were encountered which could be directly related to exposure to water.

Gross measurements were taken of femoral length on a GPM Gneupel osteometric board and femoral breadth and mid-shaft diameter with sliding calipers. The bones were then sawed through transversely at mid shaft, and three thick sections taken. The most distal section was marked in each case. This section was then prepared for measurement by sanding to minimize surface irregularity.

Cross-sectional area of the total femur and the cortex was then obtained by placing a transparent 30 cm grid over the section under a table model 10X microscope, and by counting the number of line intersects over the total cross-sectional area including the medullary cavity, and subtracting the number of line intersects over bone. Hits over trabecular bone were counted as one-half, following the technique of Sedlin, Frost and Villaneuva (1963). A total of three counts was taken on each section and averaged to obtain a measurement of total area occupied by cortical bone.

Percentage of cortical area was then determined by dividing total cortical area by total cross-sectional area. Cortical thickness was computed by direct measurement of cross-section by calipers at six points to include all functional areas of bone excluding the linea aspera. Again a total of three counts was taken on each bone and averaged to obtain cortical thickness.

Results

When femoral length was plotted against dental age, a generalized growth curve was obtained for both groups (Figures 1 and 2), although growth is occurring in a slightly different pattern. A similar curve was found in the Nubian population. Next mid shaft width was plotted against cortical thickness (Figures 3 and 4). Note that in both groups cortical thickness fails to keep pace with mid shaft width and femoral length. Growth is occurring, but maintenance of structural integrity is questionable. The difference, however, is not nearly so dramatic as might be expected if there were significant nutritional differences between the groups, though the Middle Mississippian population does show greater cortical bone loss by age 15.

When the percentage of cortical area is compared to normals in a modern reference population, the results are more dramatic (Figures 5 and 6). Both groups show a deficiency of cortical bone, with greater deficiency appearing in the Middle Mississippian group. Note also the range of variation around the mean in the M.M. group, especially the 0-3 age class.

Acknowledgements

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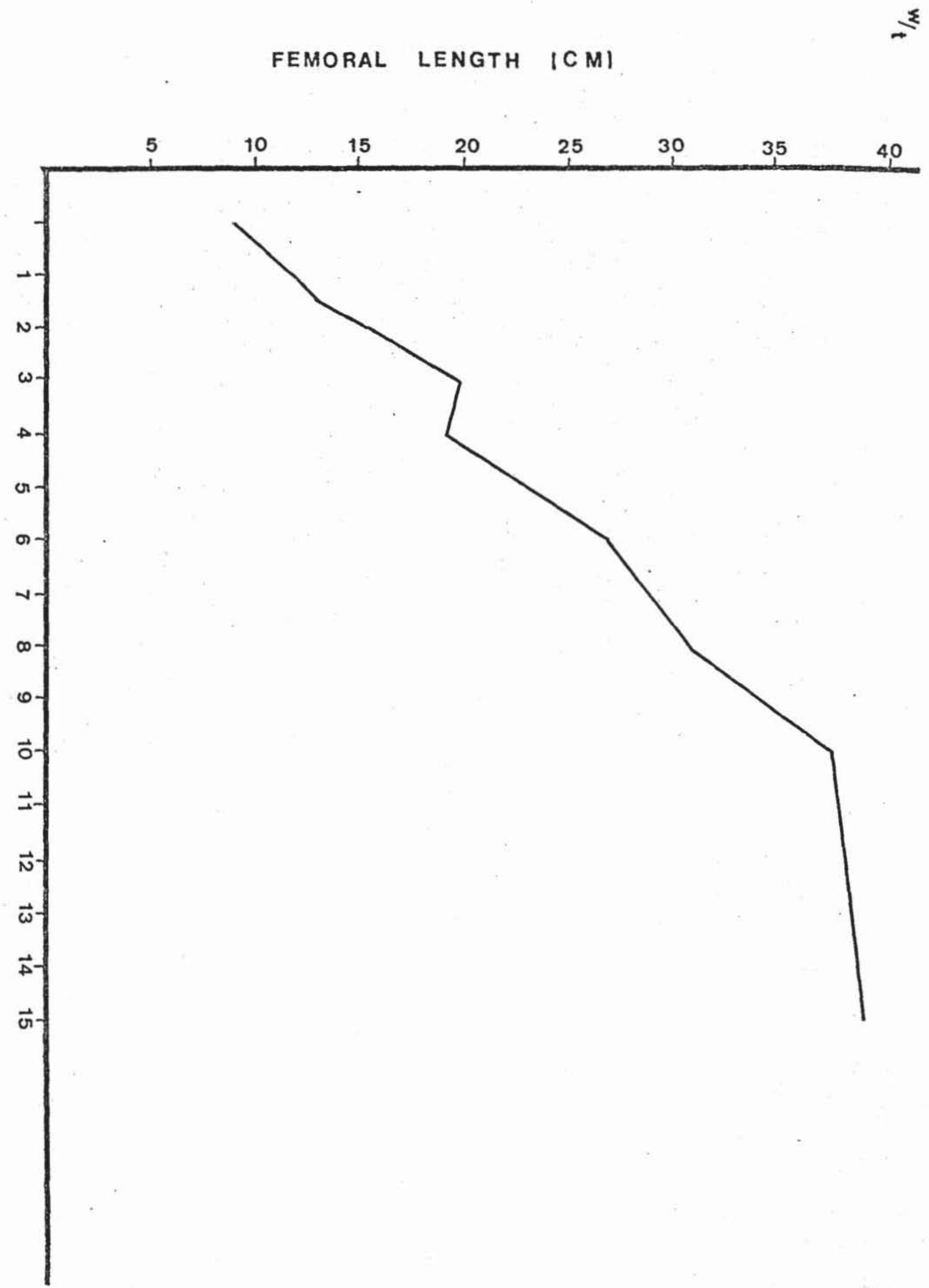
FEMORAL LENGTH (CM)
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40
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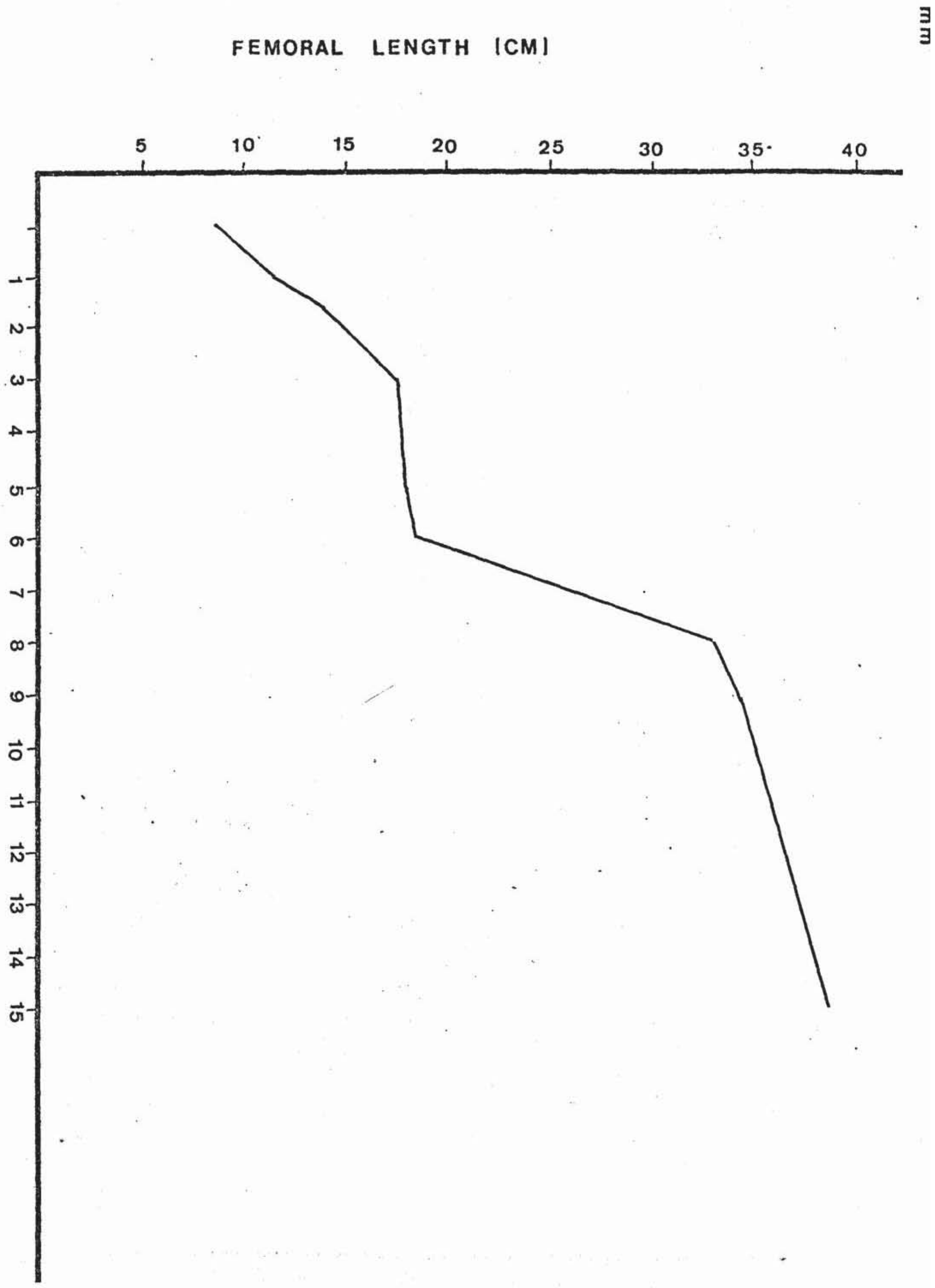
FEMORAL LENGTH (CM)
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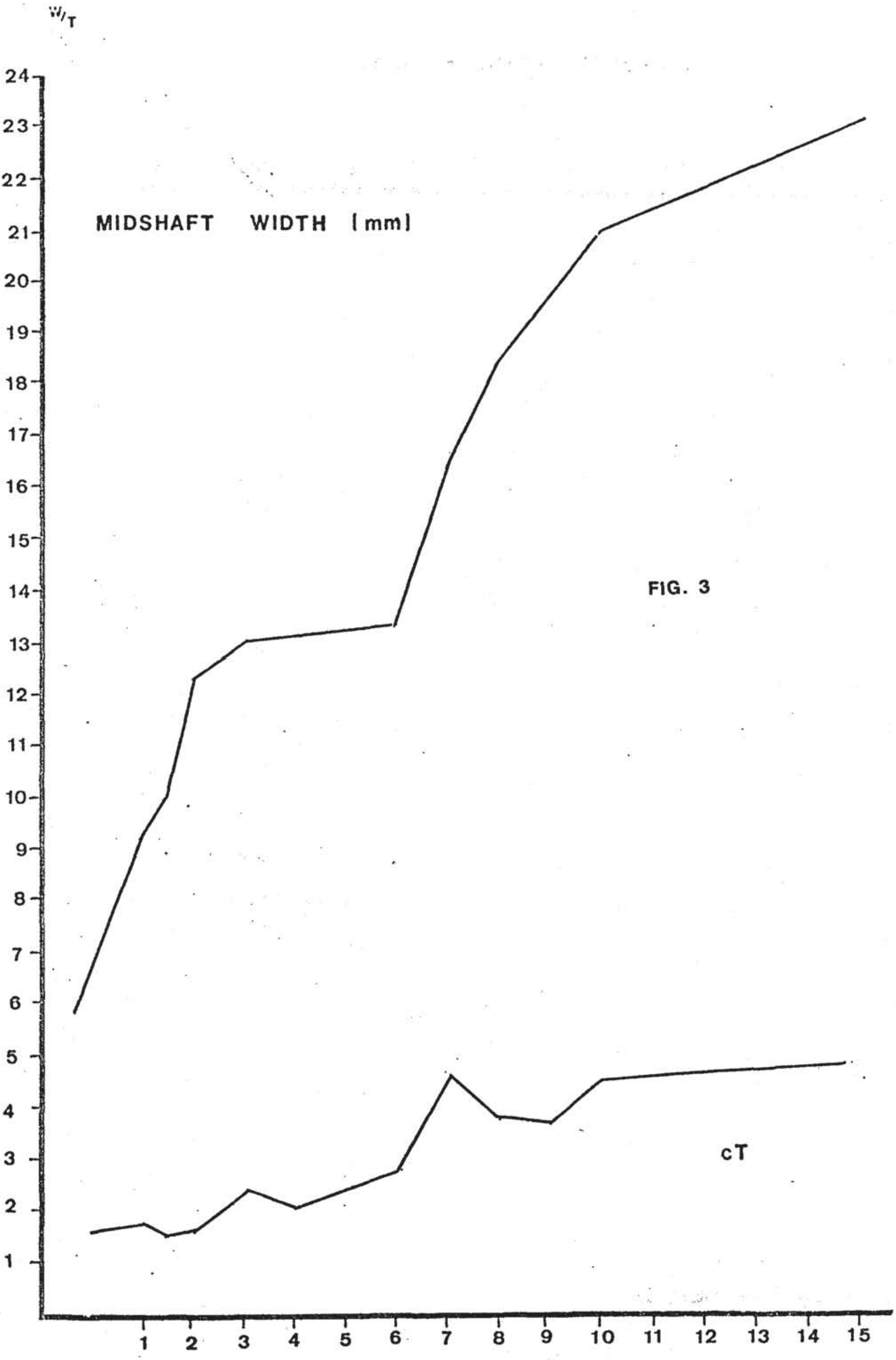
W/T
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1
MIDSHAFT WIDTH (mm)
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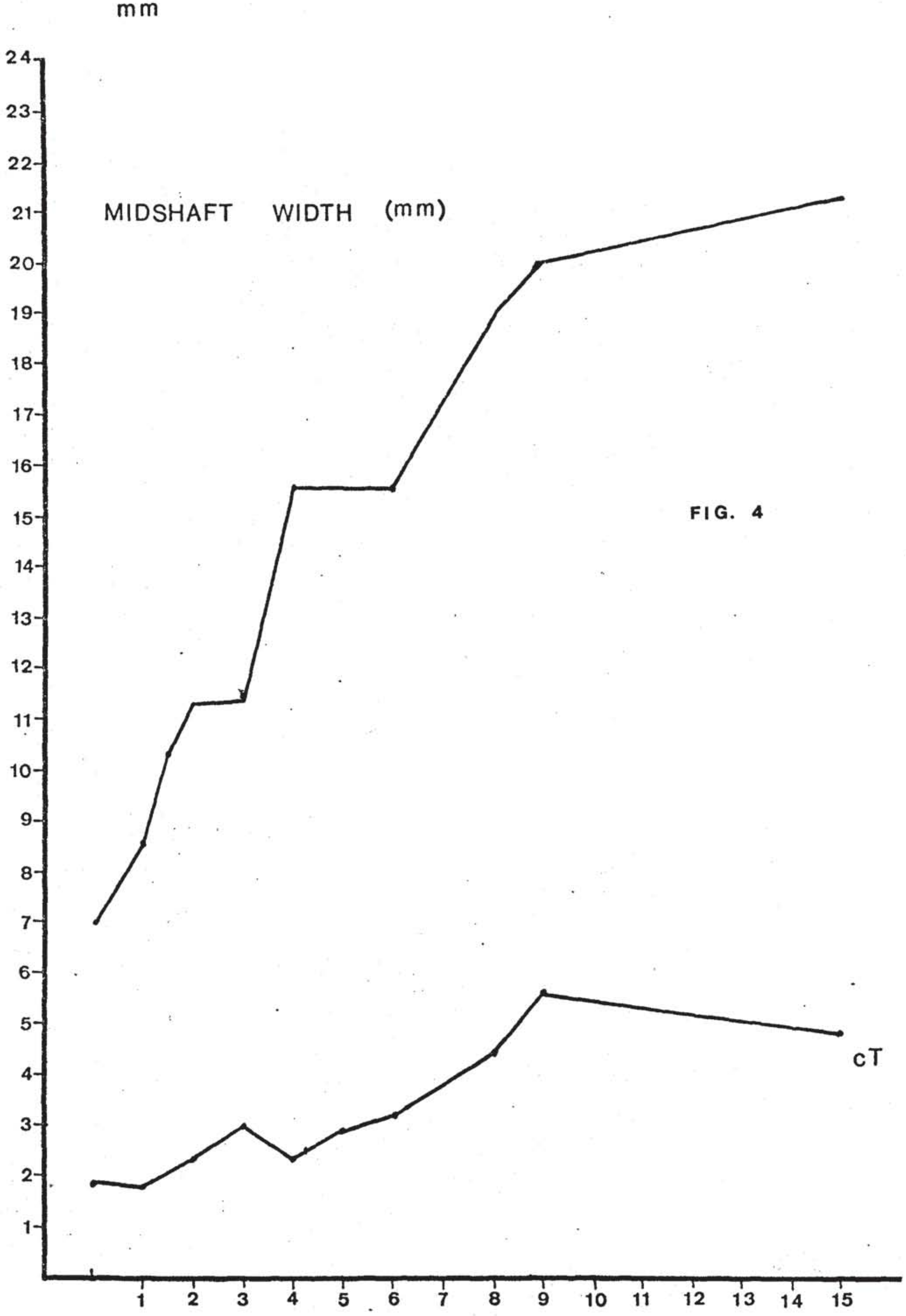
FIG. 3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MIDSHAFT WIDTH (mm)
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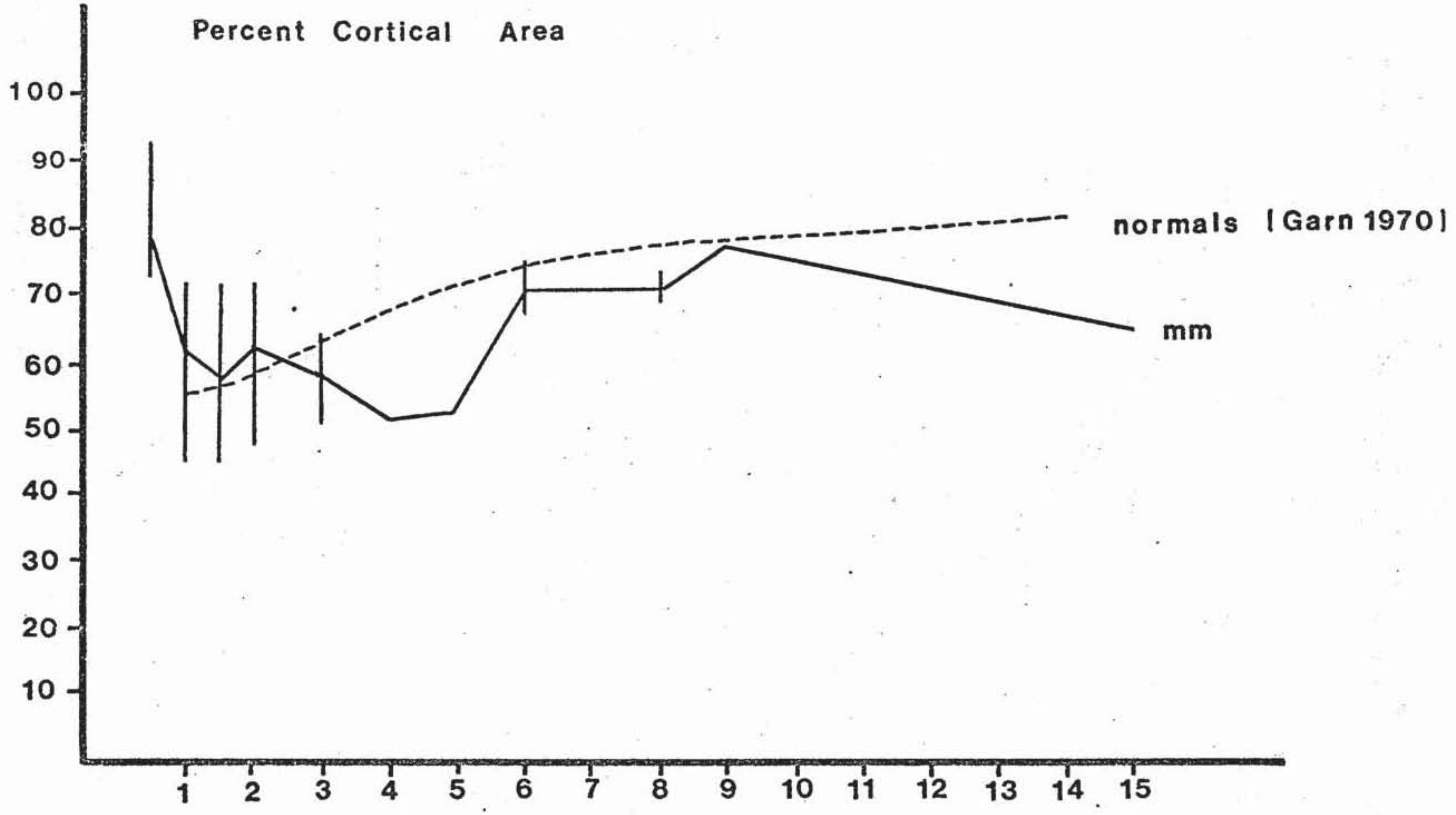
FIG. 4


Percent Cortical Area
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60
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40
30
20
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4
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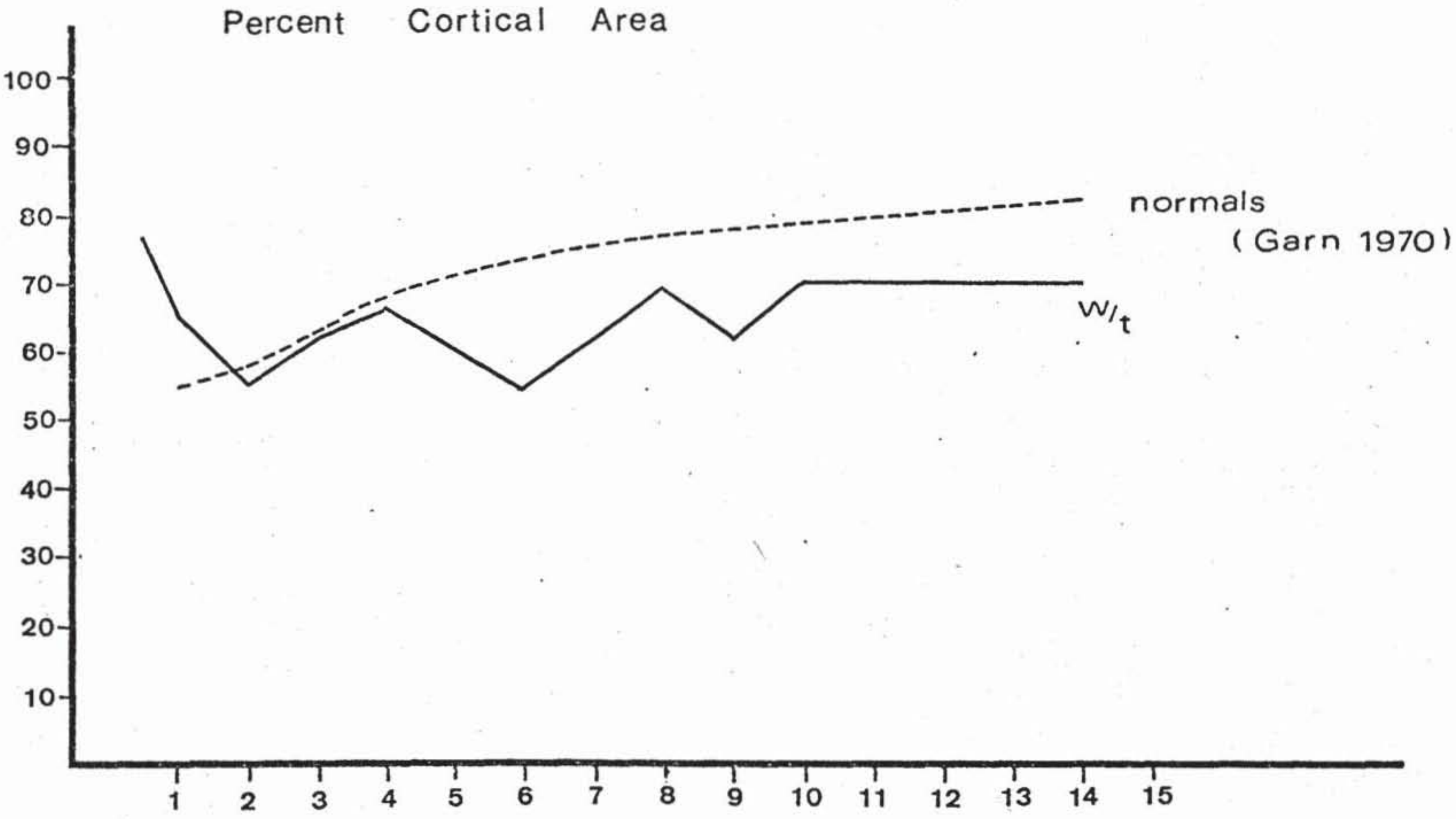
normals [Garn 1970]
mm

FIG. 5


Percent Cortical Area
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normals
(Garn 1970)
W/t

FIG. 6