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CHAPTER 11

HEALTH CHANGES AT DICKSON MOUNDS, ILLINOIS (A.D. 950-1300)

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INTRODUCTION AND BACKGROUND

Purpose and Overview

Economic and cultural changes are powerful determinants of the patterns of morbidity, mortality, and stress (see Cassel, 1976; Dubos 1965; Hinkle 1974). This chapter presents a case study of the health effects of economic and cultural change for prehistoric populations from Dickson Mounds, Illinois (ca. A.D. 950-1300). The purposes of this chapter are twofold. The first is to document changing patterns of stress. Stress, or physiological disruption, is used as a general term for any indication of decreased

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ability to adapt biologically. Changing patterns for ten indicators of stress are presented. Indicators include measures of growth disruption, growth retardation, disease, and mortality. Patterns include mean frequency, severity, and distribution of stress by age and sex. The second purpose of this chapter is to make inferences about the role of particular cultural and economic changes as causes of the observed patterns of stress.

Eight of ten indicators of stress increase in severity and/or frequency through time at Dickson. The traditional interpretation of this increase is that it is due to local, ecological changes such as increased population density and intensification of agriculture (see Goodman et al. 1980; Lallo 1973; Lallo et al. 1977, 1978, 1980). We argue that the broad pattern of increasing stress evidenced at Dickson may be equally due to Dickson's increasing involvement in Mississippian-based exchange systems (Harn 1978, 1980).

The Middle Mississippian represents the culmination of three trends at Dickson: (1) increased population density and sedentism, (2) intensification of maize agriculture, and (3) extension and intensification of trade. Increased population density and sedentism and intensification of maize agriculture are essentially local ecological processes, while the extension and intensification of trade represents an extension of local processes into regional systems. In this system, Dickson populations may have become increasingly involved with more powerful Mississippian sociopolitical systems to the south. As Dickson was brought into social and economic spheres controlled by these more powerful Mississippian centers (such as Cahokia), it is likely that Dickson populations would have lost control over their means of production. As Cahokia and other core Mississippian areas expanded their influence, Dickson and other peripheral sites are likely to have become more involved with and dependent on participation in a regional trade-exchange system. The interaction of internal, local processes (i.e., increased population size and density) and regional processes seems to have had a profoundly negative effect on health.

Archaeological Reconstruction

Dickson Mounds is a multicomponent habitation-burial complex. It is located near Lewistown, Illinois, at the confluence of the Illinois and Spoon rivers in the Central Illinois Valley (Figure 11.1). Three cultural horizons have been delimited at the site. These are defined as Late Woodland, Mississippian Acculturated Late Woodland, and Middle Mississippian.

The Late Woodland (LW) occupation (circa A.D. 950-1100) is characterized by a generalized hunting and gathering economy with seasonal camp sites utilized by a relatively small (75-125) group of people. At this time Mississippian culture was developing 180 km to the south at Cahokia in the American Bottoms (see Fowler 1978). At the end of this horizon the LW had come under the influence of the Middle Mississippian (MM) culture sufficiently to be redefined as Mississippian Acculturated Late Woodland (MALW) (approximately A.D. 1100-1200).

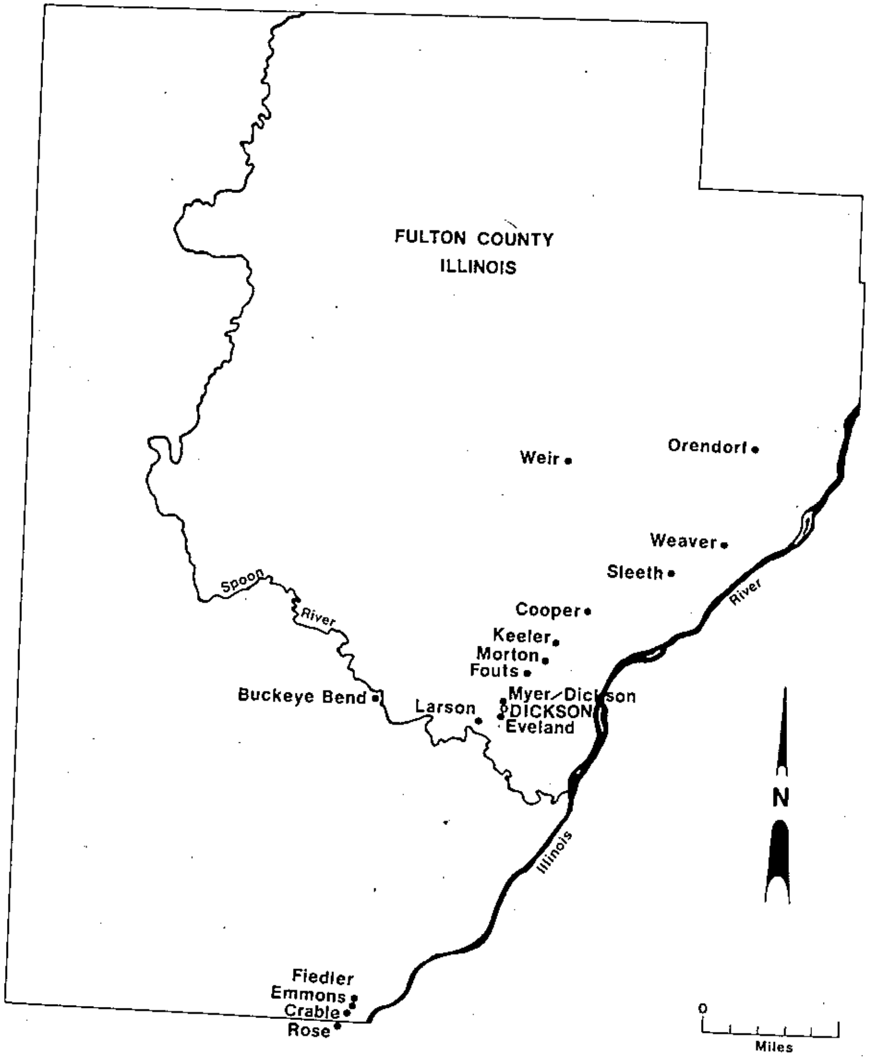

FIGURE 11.1. Area map of Dickson and selected Spoon River Tradition sites (after Harn 1980:x).

The MALW presents a mixed hunting-gathering and agricultural economy. The Eveland site, 230 m to the southwest of the burial complex, covered less than 1.5 ha and is estimated to have been permanently occupied by approximately 50-75 individuals (Harn, personal communication). By the end of this period evidence for long-distance trade is seen in the form of village refuse and grave offerings (Conrad and Harn 1972).

The MM at Dickson (ca. A.D. 1200-1300) represents the culmination of the Mississippian influence begun at the end of the LW. The settlement pattern is characterized as one of hamlets with surrounding support camps, extractive sites, and work stations tied to a local ceremonial center (Harn 1978). The Myer-Dickson site is such a hamlet. Its houses are arranged in rows with an open plaza. It is approximately 8 ha in area and was occupied by as many as 440 individuals (Harn n.d., Table 1). Myer-Dickson is one of 7 hamlets and 31 camps assumed to be associated with the Larson ceremonial center 11 km to the southwest. Larson is fully Mississippian. The site includes 32 ha of dispersed occupation debris and 8 ha of concentrated occupation. A palisade enclosed the mound, plaza, and at least 6 ha of settlement. Large quantities of foreign-made items are found in debris and cemeteries. Harn (1978:251) suggests a population of between 600 and 1170 individuals based on an estimated maximum of 234 habitation structures.

Skeletal Materials

The skeletal materials utilized in the studies cited in this chapter were loaned for study by the staff of the Dickson Mounds Museum, a branch of the Illinois State Museum. These materials include the remains from all 595 burials that were excavated during the 1966 and 1967 field seasons at Dickson. Cultural affiliations were made based on burial clusters and grave furniture by archaeologists at Dickson (Alan Harn, personal communication with John Lallo; Lallo 1973:27).

Age and sex determinations were based on the agreement of multiple methods. Methods utilized in aging subadults (0-15 years) included the following: (1) the pattern of dental eruption (after Schour and Massler 1944), (2) epiphyseal closure (after Krogman 1962), (3) fusion of the vertebrae (after Anderson 1962), and (4) the appearance of centers of ossification (after Krogman 1962). Methods utilized to age adults (15-65 years) included the following: (1) the pattern of dental eruption (after Schour and Massler 1944), (2) epiphyseal closure (after Krogman 1962), (3) changes in the public symphysis (Todd-Lyon [after Todd 1937] and McKern-Stewart [1957]), and (4) the dental attrition pattern for Dickson Mounds (see Harn 1971 and 1980).

Based on these methods, age was determined to yearly intervals for subadults (e.g., 0-1, 1-2, 3-4, ..., 14-15) and to 5-year intervals for adults (e.g., 15-20, 20-25, 25-30, ..., 60-65). For purposes of analysis these age classes have been collapsed, as is evidenced in the life tables (see Tables 11.1 and 11.2) (Lallo et al., 1978).

TABLE 11.1 Life Table for the Late Woodland and the Mississippian Acculturated Late Woodland for the Ages 0-60 Years

x	d'_x	d_x	l_x	q_x	L_x	E_x
0	45	128	1000	128	936	26
1	28	80	872	92	832	29
2	18	51	792	64	2299.5	30
5	21	60	741	81	3555.0	29
10	13	37	681	54	3312.5	27
15	26	74	644	115	3035.0	23
20	49	140	570	246	5000	21
30	33	94	430	219	3830	16
40	70	199	336	592	2365	10
50	48	137	137	1000	685	5
	351	1000	0			

TABLE 11.2 Life Table for the Middle Mississippian for the Ages 0-60 Years

x	d'_x	d_x	l_x	q_x	L_x	E_x
0	48	217	1000	217	891.5	19
1	19	86	783	110	740	23
2	16	72	697	103	1983	24
5	17	77	625	123	2932.5	24
10	10	45	548	82	2627.5	22
15	23	104	503	207	2255	18
20	24	109	399	273	3445	18
30	27	122	290	421	2290	13
40	25	114	168	678	1110	8
50	12	54	54	1000	270	5
	221	1000	0			

Sex determination for adults commenced after completion of age determinations. The following methods were utilized in determination of sex (after Lallo 1973:36): (1) dental metrics for Dickson Mounds (see Ditch and Rose 1972); (2) discriminant function analysis based on Dickson Mounds pelvic measures (see Gustav 1972), complemented by observation of the sciatic notch and preauricular sulcus; (3) discriminant function analysis based on Dickson Mounds femoral measures (Van Gerven 1972), and (4) cranial morphology (after Ascadi and Nemeskeri 1971): supra-orbital ridge, nuchal crest, mastoid process, eye orbits, and general robusticity.

State of preservation was generally good to excellent. Periosteal bone generally suffered little from interment. Most individuals were represented by near-complete or complete skeletons. Therefore, all but a handful of individuals ($N = 38$) could be aged, sexed, *and* assigned to a cultural horizon. The following studies are based on the sample that could be given an age, sex, and cultural assignment ($N = 557$). While analysis of mortality includes this entire sample, other analyses, dependent on the availability of specific bone or teeth, are based on sub-samples of these individuals. Although representativeness cannot be measured for archaeological populations, it is reasonable to assume that the sample is a fair representation of the base populations based on archaeological evidence for exclusive use of the burial mounds (see Harn 1980).

An additional strength of these materials for an analysis of health changes through time is a high degree of genetic homogeneity through time. Cohen (1974) assessed the relative degree of genetic distance between the three Dickson populations and Mound 72 from Cahokia, a Mississippian group (Fowler 1969). In her analysis, Cohen compares distances based on dental traits considered to be of either high or low heritability. As well, relative distance measures such as Mahalanobis *D*-square were computed based on a variety of measures. Analysis of the Dickson series revealed no significant differences between cultural phases in traits of high heritability. However, comparison of Dickson with the Cahokia series yielded significant differences in incisor and canine shoveling, median ridges, gingival borders, Carabelli's cusp, and molar groove patterns. All of these traits are considered to be under strong genetic control. Mahalanobis *D*-square values corroborate these findings. The *D*-square for comparison of Dickson with Cahokia is nearly ten times greater than the *D*-square for internal comparison (4.01 versus 0.41). These results strongly suggest that the Dickson series is genetically continuous and they strongly suggest against rapid *in situ* evolution or migration-population replacement senarios.

In summary, Dickson affords an excellent opportunity for studying the health effects of cultural change. The skeletal material provides an excellent data base for a paleoepidemiological analysis. Extensive archaeological reconstruction has pointed toward the wholesale nature of cultural and ecological change. In other words, Dickson represents a well-preserved skeletal sample of a population that underwent rapid cultural and economic change.

INDICATORS OF STRESS

Model for Studying Stress in Skeletal Populations

Our paleoepidemiological study is organized with reference to a model of the causes of physiological disruptions and indicators of disruption available for study in skeletal populations (Figure 11.2) (Armelagos et al. 1980; Huss-Ashmore et al. 1982). The biophysical environment imposes constraints (resource limitations and stressors) on human populations (box 1 in Figure 11.2). Although cultural systems may function to buffer or modify the effects of biophysical constraints, often cultural features may act to impose new stressors or to limit access to critical resources (box 2). For example, while agricultural intensification may lead to a greater net extraction of energy, it may come at a cost of decreased availability and use of other essential resources and increased exposure to critical stressors such as novel pathogens.

The impact of constraints on an individual is also mediated by host resistance factors (box 3). The general health of an individual, age, sex, genetic makeup, and many other factors may influence the magnitude of physiological disruption (stress) caused by a given constraint (box 4). While physiological disruption is not directly measurable in the dead, it may be inferred from a variety of its effects (box 5). If stress is severe and long lasting, then it will be evidenced in growth disruption, in mortality, and ultimately in death (Selye 1976). Death may be the ultimate measure of the biological organism's inability to suffer the consequences of poorly buffered stressors and resource limitations (Huss-Ashmore et al. 1982).

The model is operationalized as follows. Impacts of stress are measurable in a skeletal series. Variations in the resulting indicators of stress are assumed to be due to variations in the experience of physiological disruptions. These, in turn, are assumed to be a function of the amount of cultural buffering and

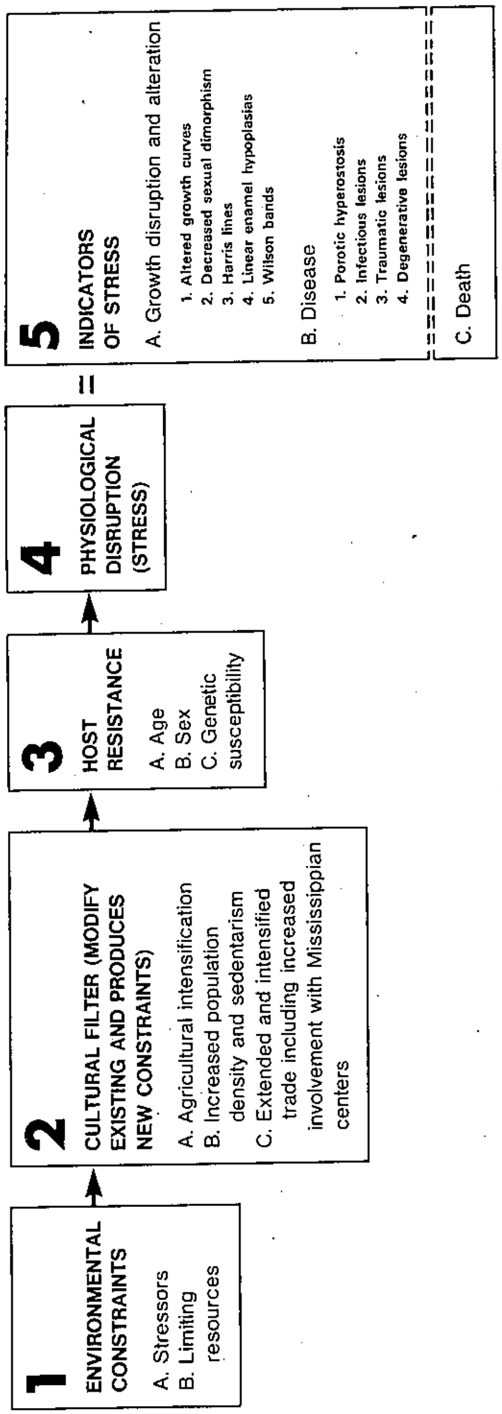

FIGURE 11.2 *Model of the causes of physiological disruptions and indicators of disruption.*

host resistance subtracted from the severity of culturally and ecologically produced constraints.

For the Dickson case study, one can assume that environmental constraints have remained roughly constant through time (Harn 1980). As well, since the population shows a high degree of genetic continuity through time (Cohen 1974), it is likely that genetically based host resistance factors have remained constant (save for changes that are a function of cultural constraints). Thus, we are left to assume that changes in stress levels may be due to changes in cultural factors. These changes are evaluated with reference to multiple indicators of disruption.

Long Bone Growth

Attained Length and Circumference. Lallo (1973) has presented an analysis of length and circumference data for tibiae, humeri, and femora. Data are presented as incremental increase, relative percentage increase, and attained distance. Below we present data from Lallo (1973) in the form of distance curves. Five hundred fifty-seven burials are included in the following analysis. This represents the entire sample that could be aged, sexed, and assigned to a cultural horizon.

Figures 11.3 and 11.4 are distance curves for total length and circumference of the tibia. On average, the Middle Mississippian tibia are longer at birth (Figure 11.3). However, there is a slowing of growth in the Mississippian relative to the Late Woodland and Mississippian Acculturated Late Woodland samples. This relative slowing is most evident from 2 to 5 years of age. It is at this time that the attained length for the MM falls below that for the MALW and the LW. Once the greater attained growth of the LW and MALW samples are achieved, they remain relatively constant until maturity.

Figure 11.4 demonstrates that the pattern observed for attained circumference is similar to the pattern presented for attained length. The main similarities are the greater size at birth of the Middle Mississippians and the slowing of growth of the Mississippian relative to the other populations, resulting in a lesser attained growth by the age of five. The circumference curves differ from the length curves in the following ways: (1) the age at which the differences between growth curves is greatest, (2) the amount of "catch-up" growth evidenced from ages 15 to 25, and (3) the relative differences in actual attained growth at different ages between cultural horizons. The greatest distance between growth curves is found between ages 10 and 15 with subsequently the greatest catch-up by age 25.

A series of analyses of variance (ANOVAs) were performed in order to ascertain whether or not differences in attained growth were statistically significant for any of the age groups (Table 11.4). Significant results ($p \leq .05$) were obtained for both tibial length and circumference for the 5- 10-year age group. However, no significant differences are found for either measure in any of

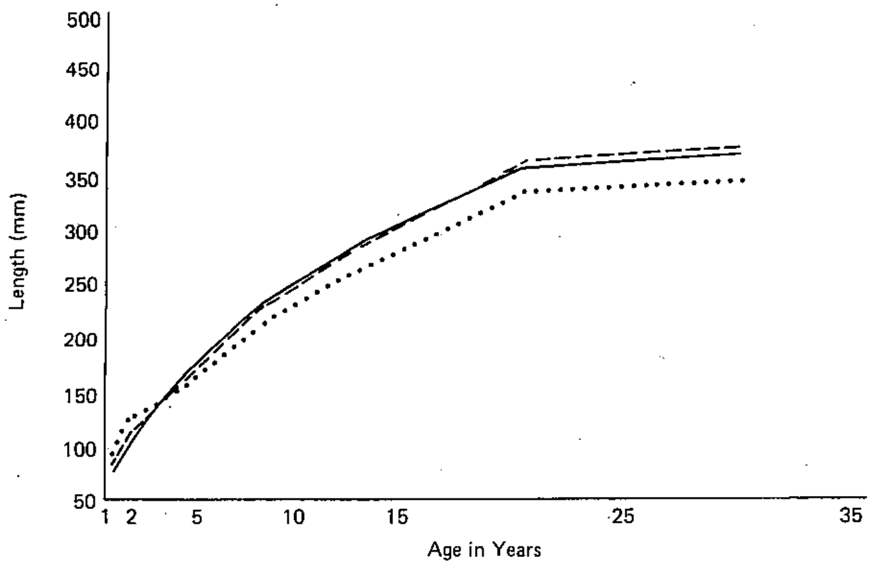

FIGURE 11.3. Distance curves of tibial length for the Late Woodland (———), Mississippian Acculturated Late Woodland (----), and Mississippian (•••••) cultural horizons (ages 0-35 years). Values for ages 15, 25, and 35 years include the epiphysis (from Lallo 1973:84).

the other age classes. While most results are not statistically significant, all measures from the 2-5-year class to older age classes are in the expected direction.

Evidence for an unusual decrease in growth velocity around the age of two also comes from an attempt to fit tibial length against dentally aged individuals (birth to 7 years, data from Bickerton 1979). A third-degree polynomial gave a significantly better fit to the data than the standard second-degree function (Goodman 1980). The additional degree utilized for curve fitting seems to be a result of the decrease in observed length over that "predicted" by the second-degree fit for individuals between the ages of 1.5 and 3 years. In summary, tibial growth data suggest increased stress in the Middle Mississippian. Furthermore, these data highlight the 2-5 year period as one in which stress may be most severe.

Sexual Dimorphism

While Lallo (1973) was able to ascertain that long bone length and circumference growth velocities and achieved growth are generally dampened in the Middle Mississippian relative to the prior cultural horizons, it remained to be seen whether this slowing of growth differentially affected males, thus decreasing the amount of sexual dimorphism.

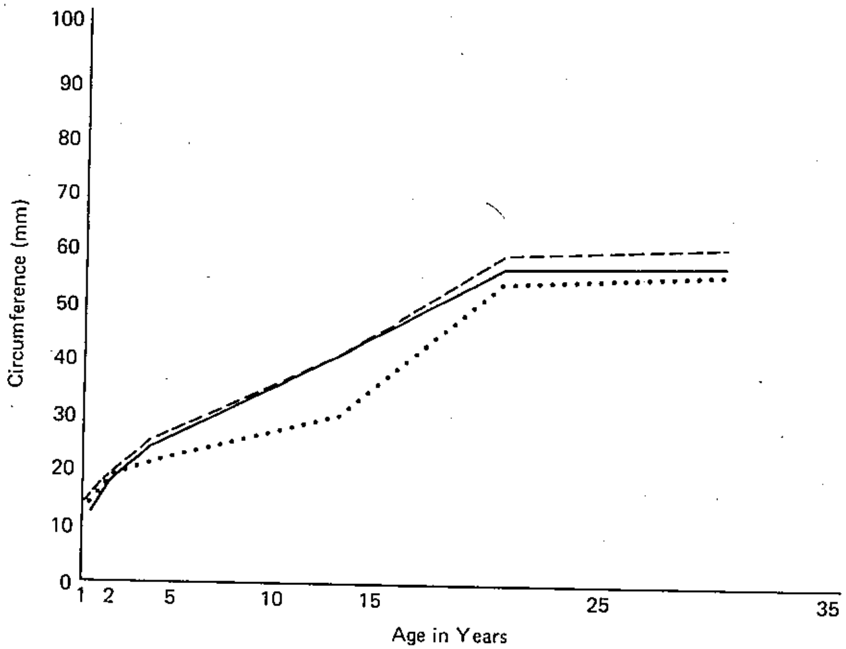

FIGURE 11.4. Distance curves for tibial circumference for the Late Woodland (———), Mississippian Acculturated Late Woodland (-----), and Mississippian (•••••) cultural horizons (ages 0-35 years) (Lallo 1973:87).

Lallo utilized an extensive set of osteometric measures of the pelvis and femur in his analysis of sexual dimorphism. These measures and data were obtained from Gustav (1972) for the pelvis and Van Gerven (1972) for the femur. Both of these studies include stepwise discriminant analyses of sex based on the respective femoral or pelvic measures. Lallo, therefore, had the advantage of utilizing two sets of measures that had previously been isolated as discriminators of sex in the Dickson collection.

A series of two-way ANOVAs (sex and culture as main effects) were run with data from 14 femoral and 21 pelvic measures (Lallo, 1973:112-113). If sexual dimorphism decreases through time, then we would expect a significant interaction between sex and culture (the two main effects). However, significant interactions were not found.

While the sexual dimorphism results are not significant, they require discussion. The hypothesis that stress would differentially affect males derives from Stini (1969), who theorizes that the female endocrinological system is better able to buffer nutritional insults. However, he is referring to a differentiation

TABLE 11.3 Summary Statistics of Long Bone Measurements for Late Woodland, Mississippian Acculturated Late Woodland, and Mississippian Individuals Ages 5-10 Years (Sexes Combined)

Measurement	*N*	*Mean*	*SD*	*f-value*[a]	*df*
Tibia length				*3.56*	*2/23*
LW	*16*	*228.6*	*6.3*		
MALW	*31*	*229.2*	*10.6*		
M	*20*	*209.0*	*8.4*		
Tibia circumference				*3.96*	*2/23*
LW	*16*	*33.3*	*2.6*		
MALW	*31*	*32.8*	*2.4*		
M	*20*	*25.2*	*1.9*		

[a] *Denotes significant f-value at .05.*

that occurs beginning with sexual maturation. This hypothesis may not be relevant to the Dickson situation, as it appears that maximum stress is evidenced much *before* sexual maturation. Finally, the Stini hypothesis does not account for the possibility that males were able to "keep up" relative to females because they were given greater access to resources and were more buffered from stress.

There are also a series of methodological reasons why the Stini hypothesis may not be evidenced in the Dickson data. First and foremost is the confounding problem of both sexing and analyzing for stress using the same set of measures. Second, the sample sizes utilized in this study are small (84 in the pelvic measures and 97 for the femoral measures) for a two-way ANOVA with six cells. And third, the study of Gustav (1972) and Van Gerven (1972) purposely excluded pathological specimens. While this is sensible in an analysis of measures that discriminate for sex, it may greatly reduce the possibility for discovering differences in the degree of sexual dimorphism based on the amount of stress.

We conclude that the amount of sexual dimorphism is relatively invariable among the three Dickson cultural horizons. While these data may be evidence that stress did not increase through time at Dickson, they may also be insignificant to this hypothesis.

Harris Lines

Frequencies. Goodman and Clark (1981) have presented an analysis of changing stress through time at Dickson as evidenced in the frequency and time of occurrence of Harris lines on distal and proximal tibia. Means and standard deviations for the frequency of Harris lines are presented in Table 11.5. Results are given per individual and are given for the entire sample (N = 130), and are broken down by age class (younger and older adults), sex, and cul-

TABLE 11.4 Harris Lines in the Dickson Mounds Populations: Means and Standard Deviations for the Number of Lines on Distal and Proximal Tibias

	Distal tibia		*Proximal tibia*	
Sample (N)	*Mean*	*Standard deviation*	*Mean*	*Standard deviation*
By Culture:				
LW (10)	*1.30*	*1.49*	*0.70*	*1.88*
MALW (47)	*1.19*	*1.33*	*0.49*	*1.00*
MM (51)	*1.06*	*1.22*	*0.57*	*1.03*
By Age:				
15-39 years (40)	*1.38*	*1.30*	*0.75*	*1.43*
40-60 years (30)	*1.23*	*1.19*	*0.57*	*0.73*
By Sex:				
Females (43)	*1.21*	*1.23*	*0.53*	*0.98*
Males (65)	*1.46*	*1.30*	*0.74*	*1.33*
Total Sample (130)	*1.13*	*1.27*	*0.55*	*1.12*

The mean number of lines/tibia is 1.68 (1.13 distally and 0.55 proximally). This frequency is within the range given by Wells (1967) for his Anglo-Saxon populations (0.8-5.1 lines/tibia). The figure is less than that found by Nichens (1975) for a Mesa Verde sample and by Woodall (1968) for a sample from Casas Grandes. On the other hand, McHenry (1968) reports a mean of 8.01 lines/*femur* for a prehistoric series from the San Joaquin Valley, California.

There are more Harris lines found on the distal than on the proximal end (mean of 1.13 versus 0.55). This confirms the finding of other researchers (Garn et al. 1968; Park 1964).

Cultural differences in the percentage of individuals with and without one or more Harris lines on the proximal or distal tibia were tested for statistical significance. No cultural comparison yielded a significant chi-square value (based on Siegel 1956). Furthermore, the slight trend of decreased frequency of Harris lines through time runs counter to the hypothesis.

Although the differences were not found to be statistically significant, males have a higher frequency of lines than do females. This trend may support the view that the growing male is more susceptible to stress than the growing female. However, somewhat contrary to the Stini hypothesis, females have a greater frequency of Harris lines during the adolescent growth spurt while males have a higher frequency during the first 7 years of life.

Distribution by Age at Occurrence. The distribution of Harris lines by the time of their development for the distal tibia is presented in Figure 11.5. Chronologies are presented for the MALW

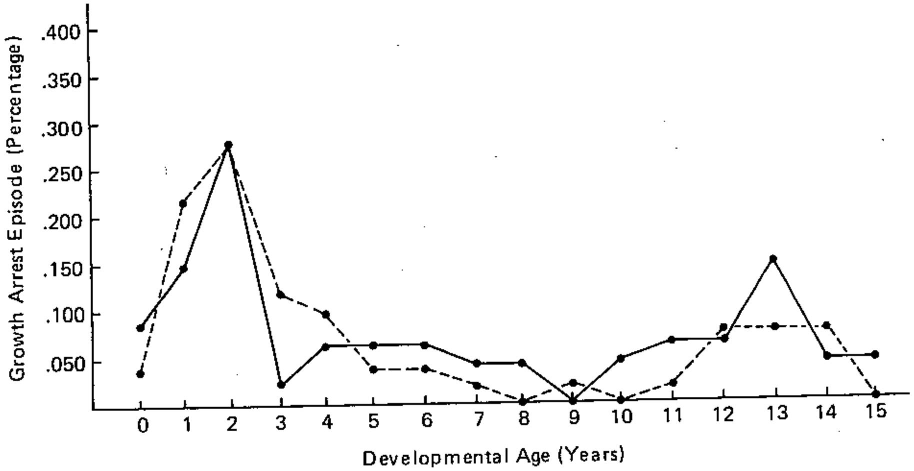

FIGURE 11.5. Percentage of growth arrest lines in combined male and female distal tibias for Mississippian Acculturated Late Woodland (———) (N = 47) and Middle Mississippian (-----) (N = 51) populations (Goodman and Clark 1981:45).

and MM samples. Both chronologies show two peaks. A major peak is found between the ages of birth and 3 years, and a minor peak around the ages of 12–14 years. The chronologies do not differ significantly from each other (Kolmogorov-Smirnov test) and, indeed, are remarkably similar in shape.

The Harris line frequency data do not support the view that health decreased through time at Dickson. Indeed, there is a trend of increased frequency of lines in the earlier groups. These data are equivocal. Recent reviews (Buikstra and Cook 1980; Huss-Ashmore et al. 1982) suggest that the frequency of Harris lines may not be a valid indicator of the degree of physiological disruption (stress). This reasoning lies mainly with the poor association of Harris line frequencies with other measures of stress in archaeological populations and the poor associations of Harris lines with known stressors in both animal and human clinical studies. If one questions whether or not Harris lines themselves are valid stress indicators, then chronologies of Harris lines as reflections of the degree of physiological stress through periods of skeletal maturation also must be questioned. Our data show a peak frequency of Harris lines precisely when growth velocity is greatest and when the growing individuals might be expected to be more susceptible to growth disruption. Thus, the Harris line chronologies may reflect host susceptibility to stress more than exposure to and strength of stressors.

TABLE 11.5 Mean Number of Growth Disruptions (Hypoplasias) per Individual in the Dickson Populations

	Growth disruptions/individual							
	All individuals				Individuals with complete measurements[a,b]			
Population	M	F	A	Total	M	F	A	Total
LW	.17	1.42	.00	.90	.00	1.29	.00	.90
MALW	1.26	.82	2.00	1.18	1.25	1.29	2.00	1.45
MM	1.43	1.47	3.25	1.61	1.43	1.64	3.25	1.86
	1.20	1.24	2.09	1.31	1.25	1.44	2.09	1.52

[a] M, males; F, females; A, adolescents.
[b] Birth to 7 years.

Linear Enamel Hypoplasia

Frequencies. Enamel hypoplasias are deficiencies in enamel thickness resulting from systemic physiological disruptions (Goodman et al. 1980). The pattern of hypoplasias on dental enamel can be read as a kymographic record of physiological disruption (stress) during the time of the enamel's development (Kreshover 1960; Sarnat and Schour 1941). And, because mature enamel is unalterable by internal biological events, hypoplasias may provide a permanent "memory" of physiological disruptions during the time of the enamel's development (Goodman et al. 1980).

Goodman and co-workers (1980) have presented an analysis of the frequency of enamel hypoplasias for the Dickson Mound individuals with permanent dentitions. The sample consisted of all adolescents and adults with relatively complete dentition (*N* = 111). Ages of individuals and available enamel (a potential source of error due to tooth loss and attrition) did not vary significantly by sex or cultural horizon.

The mean number of hypoplasias per individual in the Dickson population is presented in Table 11.6. The means are presented both for all individuals in the sample and for individuals with complete enamel allowing measurements from birth to 7 years of age. This second set of means helps to control for differential availability of enamel for study caused mainly by dental attrition.

A clear trend of increased growth disruption is evident through time at Dickson. Mean frequencies by cultural horizon increase from 0.90 in the LW to 1.18 in the MALW to 1.61 in the MM. This trend is also evident in individuals with complete measurements from birth to 7 years (Table 11.6) and is evidenced that the trend is not due to a differential availability of enamel for study. In fact, when controlling for enamel availability, the

TABLE 11.6 Number of Individuals without Growth Disruptions (Hypoplasias) and the Number of Individuals with One or More Growth Disruptions by Cultural Horizon

	Hypoplasias		*One or more hypoplasias*		*Total*	
	No.	*%*	*No.*	*%*	*No.*	*%*
Late Woodland (LW)	*11*	*55*	*9*	*45*	*20*	*100*
Mississippian Acculturated Late Woodland (MALW)	*18*	*40*	*27*	*60*	*45*	*100*
Middle Mississippian (MM)	*9*	*20*	*37*	*80*	*46*	*100*
	38	*34*	*73*	*66*	*111*	*100*

Summary of Chi-Square Tests Where the Frequency of Individuals with One or More Growth Arrest Episodes Were Compared to Those without a Growth Arrest Episode (see Table 3). Yates' Correction Is Used When df Equals 1

	Chi-square value (df)
LW versus MALW	*.7 (1)*
LW versus MM	*6.8 (1)*[a]
MALW versus MM	*3.8 (1)*[b]
LW versus MALW versus MM	*11.0 (2)*[a]

[a] $p \le .01$.
[b] $p \le .05$.

trend toward increased frequencies of hypoplasias becomes more pronounced.

Chi-square analyses are performed in order to determine whether these cultural differences are of statistical significance. The sample was dichotomized into those with one or more growth disruptions and those without growth disruptions (see Table 11.7). The LW and MALW did not differ significantly from each other. However, the MM differed significantly from both the LW and the MALW ($p \le .01$ and $p \le .05$, respectively). In sum, the hypoplasia data support the hypothesis that physiological disruption was more frequent and severe in the Middle Mississippian.

Annual Cycles of Stress (Seasonality). Frequencies of occurrence of two growth disruptions separated by 12 and 6 months are presented in Table 11.8. The number of growth disruptions separated by a year is greater than the number of disruptions separated by 6 months in all horizons. Results for the MALW approach significance, and over all results are significant ($p = .0336$).

TABLE 11.7 Number of Cases in Which Two Growth Disruptions (Hypoplasias) Are Separated by a Half Year and Number of Cases in Which Two Growth Disruptions Are Separated by a Year

	.5 Years	*1.0 Years*	*Binomial one-tailed probability*[a]
Late Woodland	*1*	*3*	--
Mississippian Acculturated Late Woodland	*5*	*12*	*.072*
Middle Mississippian	*10*	*14*	*.271*
	16	*29*	*.0336*

[a] *Siegel 1956.*

The occurrence of growth disruptions over time within an individual is not random. The occurrence of growth disruption separated by yearly intervals is greater than that predicted by chance. This phenomena is likely to be due to an annual cycle of stress (Goodman et al. 1980) such as might occur if a given season were regularly more stressful than the others. Since agriculture may provide a resource base to buffer these seasonal deprivations, these data may help to explain why agriculture became intensified in the Middle Mississippian.

Wilson Bands

Frequencies. Rose et al. (1978) have presented a thorough analysis of Wilson bands in a Middle Woodland sample from Gibson Mound and the MALW and Middle Mississippian from Dickson. Data are presented on the frequency of occurrence of Wilson bands (see Table 11.9), the chronology and peak period of their development; and their association with age at death (see Table 11.10). The sample was randomly selected from individuals 15 years old or older and includes 87 mandibular canines.

A nearly fourfold increase in percentage of individuals with Wilson bands is seen if one compares the MW at Gibson (10.3%) to the MALW at Dickson (21.4%) and the Mississippian at Dickson (40.0%). These researchers also calculated the percentage of half-year enamel units with Wilson bands (a method used to control for differential availability of enamel). This method of calculation reduces the difference between the two Dickson samples. The percentage of enamel units with Wilson bands is 4.4 in the MALW and 7.7 in the MM. Only the difference between the MW and MM was found to be statistically significant (chi-square test corrected for continuity; Siegel 1956).

TABLE 11.8 Prevalence and Percentages per Individual and One-half Year Enamel Unit of Wilson Bands

	Wilson bands	*Individuals*	*Enamel units*	*Percentage individual*	*Percentage enamel unit*
Middle Woodland (Gibson)	*3*	*29*	*157*	*10.3*	*1.9*
MALW (Dickson)	*6*	*28*	*136*	*21.4*	*4.4*
Mississippian (Dickson)	*12*	*30*	*163*	*40.0*	*7.4*
	21	*87*	*456*	*24.1*	*4.6*

TABLE 11.9 A Comparison of the Mean Ages at Death (in years) of Individuals with At Least One Wilson Band and Those without Wilson Bands

	With Wilson bands	*With no Wilson bands*	*Difference*
Middle Woodland (Gibson)	*20.0*	*45.0*	*25.0*
MALW (Dickson)	*28.4*	*40.2*	*11.8*
Mississippian (Dickson)	*27.6*	*40.4*	*12.8*

Distribution by Age at Occurrence. The mean age of occurrence and the chronology of occurrence of Wilson bands were also calculated. The mean age of occurrence is 2.25 years for the MW, 2.92 years for the MALW, and 2.40 years for the MM. The chronological distributions of bands are also slightly different. The MW curve has a broad and flat peak from 0.5 to 4.0 years. The MALW has a broad peak from 2.0 to 4.5 with a high point at 2.25 years. The MW has a plateau from 1.0 to 3.5 with high peaks at 1.75 and 3.25 years.

Association with Age at Death. Rose et al. (1978) examined the relationship between Wilson bands and age at death in adulthood (see Table 11.7). This analysis yielded two noteworthy results. First, the mean age at death for individuals with Wilson bands is lower than that for individuals without Wilson bands in all cultures--from 11.8 to 25.0 years earlier. Furthermore, this difference is greater in the Dickson series than in the less stressed Gibson Mound series. Statistical analysis of the relationship between age at death and childhood stress (Wilson band frequencies) is not presented.

The analysis of Wilson bands helps to refine the picture of increased stress at Dickson. First, Wilson band frequency data are strong evidence for increased stress through time. Second, the chronologies, with peak periods of stress around the ages of 2-3 years, corroborate the timing of maximum stress evidenced in the Harris line and long bone growth data. Finally, the Wilson band data demonstrate that childhood stress, as measured by Wilson band frequencies, is "predictive" of age at death. Therefore, childhood stress (or a covariate of it) is highly significant to survival. Furthermore, this relationship increases in importance through time.

Porotic Hyperostosis

Frequencies. Porotic hyperostosis is a general term used to identify bony lesions that are localized on the superior border of the orbits and the external surface of the crania and are characterized by a thinning of the subperiosteal cortical bone and corresponding expansion of the dipole (Armelagos 1967; Carlson et al. 1974; Lallo et al. 1977). Lallo and co-workers (1977) provide a detailed study of the presence of porotic lesions in subadult crania from Dickson. This sample consists of 238 individuals, of which 87 (36.5%) show evidence for porotic hyperostosis (Table 11.11). The frequency of porotic hyperostosis increases from 13.6% in the LW to 32.2% in the MALW and 51.5% in the MM. Differences between cultural horizons in the frequency of porotic hyperostosis are statistically significant by chi-square analysis ($p \leq .05$; Lallo et al. 1977).

Degree of Involvement (Severity) of Porotic Hyperostosis. The frequency of occurrence of porotic hyperostosis by site and type of involvement is presented in Table 11.8. The orbits are the primary site of occurrence of porotic hyperostosis. In the LW, porotic hyperostosis is limited to the orbitas (cribra orbitalia). However, in the MALW and MM, individuals with cribra orbitalia tend increasingly to have porotic involvement at other sites in the form of spongy hyperostosis and/or osteoporotic pitting. The involvement of porotic hyperostosis at sites other than the orbits suggests a more inclusive and a more severe manifestation. Not only does porotic hyperostosis show a four-fold increase in frequency, but it also increases in percentage of "severe" cases from 0.0% in the LW to 6.5% in the MALW to 17.8% in the MM. As these authors hypothesized, the frequency and degree of involvement of porotic hyperostosis increases with increased utilization of maize agriculture.

TABLE 11.10 *The Age-Specific Frequency of Porotic Hyperostosis*[a]

Age	N	Porotic Hyperostosis	Cribra Orbitalia	Osteoporotic Pitting	Spongy Hyperostosis	O.P.[b] and S.H.
Late Woodland, Dickson Mounds						
0-.9	11	0	0	0	0	0
1-1.9	7	0	0	0	0	0
2-4.9	9	2 (22.2)	2 (100.0)	0	0	0
5-9.9	10	3 (30.0)	3 (100.0)	0	0	0
10-14.9	7	1 (14.3)	1 (100.0)	0	0	0
	44	6 (13.6)	6 (100.0)	0	0	0
Mississippian Acculturated Late Woodland, Dickson Mounds						
0-.9	29	3 (10.3)	3 (100.0)	0	0	0
1-1.9	19	4 (21.1)	4 (100.0)	1 (25.0)	1 (25.0)	0
2-4.9	18	7 (39.0)	7 (100.0)	1 (14.3)	1 (14.3)	2 (28.6)
5-9.9	18	12 (66.7)	12 (100.0)	2 (16.7)	1 (8.3)	3 (25.0)
10-14.9	9	3 (33.3)	3 (100.0)	1 (33.3)	1 (33.3)	1 (33.3)
	93	29 (31.2)	29 (100.0)	5 (17.2)	4 (13.8)	6 (20.7)
Middle Mississippian, Dickson Mounds						
0-.9	39	13 (33.3)	13 (100.0)	2 (15.4)	3 (23.1)	1 (7.7)
1-1.9	19	9 (47.4)	9 (100.0)	2 (22.2)	3 (33.3)	2 (22.2)
2-4.9	16	11 (68.8)	11 (100.0)	4 (36.4)	2 (18.2)	5 (45.5)
5-9.9	17	13 (76.5)	13 (100.0)	4 (30.8)	2 (15.4)	7 (53.8)
10-14.9	10	6 (60.0)	6 (100.0)	2 (33.3)	1 (16.7)	3 (50.0)
	101	52	52 (100.0)	14 (26.9)	11 (21.2)	18 (34.6)

[a] Percentages in parentheses.

[b] O.P. and S.H. = osteoporotic pitting and spongy hyperostosis.

Infectious Lesions

Frequencies. Lallo and co-workers (1978) have summarized the evidence for changing frequencies of infectious lesions through time at Dickson. The analysis is based on both adults and subadults. The LW and the MALW are combined into a low-intensity agriculture population and this combined sample is compared to a MM sample. Infectious lesions include periostitis and osteomyelitis. Although these two types of infection were recorded separately, this analysis considers them together. Frequencies are for the combination of either or both types of infectious lesions.

The percentage of individuals with infectious lesions doubles from the low-intensity agriculture LW-MALW horizons to the more intensified MM period (31 to 67%) (Table 11.12). This overall pattern is evidenced in both the adult and subadult segments of the population and in females and males. In summary, the increased rate of infection through time is a general phenomenon, characteristic of all age and sex classes.

Severity and Association with Age at Death

Severity of infection was determined by analysis of the degree of infectious involvement for the tibia. The selection of the tibia was based on the following: (1) its high rate of preservation among long bones, (2) its broad periosteal surface, which facilitates observation, and (3) the fact that it is the bone with the highest rate of infection in this sample (Lallo et al. 1978). Severity was determined on the basis of the following criteria: (1) extent of involvement of the periosteal surface, (2) characterization of the tissue destruction (pitted, ridged, scarred, or sinus tracked), and (3) the amount of bone tissue destructions. Nine stages of severity (from Lallo 1973) were combined into three severity levels (Lallo et al. 1978).

The percentage of tibiae with evidence for infection increases from 26% in LW-MALW sample to 84% in the MM sample (Table 11.13). Thus, the pattern of infection through time for the tibia is similar to the pattern of infection through time for all skeletal remains, save for an even more pronounced rate of increase in the MM sample. For individuals aged 15-25 years, the frequency of tibial infections increases from 25% in the low agricultural intensity sample to 77% in the agriculturally more intensified MM (Table 11.14). Furthermore, of individuals with infections in this age class, those in the MM are much more likely to have either moderate or severe involvement (Table 11.4). Finally, these researchers have also noted that the mean age at death for adults with tibial infections is less than the mean age at death for adults without tibial infections and that this relationship holds for both samples in this study. As an example, the mean age at death for adults (over 20 years) in the MALW is 39.5 years. However, the mean age at death for individuals with slight tibial infections is 37 years and 35.1 years for individuals with severe infections.

TABLE 11.11 *Summary Figures for the Frequency of Occurrence of Infectious Disease*

Age	*N*	*Number with infection*	*%*[a]
0–59.9 years[b]			
LW + MALW	351	108	31
MM	221	149	67
0–14.9 years[b]			
LW + MALW	125	34	27
MM	110	74	67
15–59.9 years[b]			
LW + MALW	226	74	33
MM	111	75	68
15–15.9 years			
Females			
LW + MALW	110	35	32
MM	61	43	71
Males			
LW + MALW	116	39	34
MM	50	32	64

[a] *All percentages have been rounded off to the nearest whole number.*

[b] *These frequencies include the combined male and female totals.*

TABLE 11.12 *Frequency of Infectious Lesions of the Tibia*

	N	*Number infected*	*%*[a]
LW + MALW	353	90	26
MM	194	163	84

Severity of Tibial Involvement

	N	*Slight*	*Moderate*	*Severe*
LW + MALW	90	56 (62%)	27 (30%)	7 (8%)
MM	163	45 (28%)	80 (49%)	38 (23%)

[a] *All percentages have been rounded off to the nearest whole number.*

These data are evidence that infection and its variates are significant health events for all populations.

TABLE 11.13 *Frequency of Infectious Lesions of the Tibia, Young Adults (15–25 Years)*

	N	*Number infected*	*%*[a]
LW + MALW	114	28	25
MM	43	33	77

Severity of Tibial Involvement

	N	*Slight*	*Moderate*	*Severe*
LW + MALW	28	21 (75%)	5 (18%)	2 (7%)
MM	33	10 (30%)	16 (49%)	7 (21%)

[a] *All percentages have been rounded off to the nearest whole number.*

Traumatic Lesions

Lallo (1973) has presented an analysis of both cranial and postcranial traumatic pathologies. Data presented below are for postcranial fractures (Table 11.15). The most common sites of fractures are the humerus, clavicle, ulna, and radius. Since the distribution of pathologies within individual skeletons is not significantly different among cultural horizons, all postcranial freactures are combined. For the entire sample (ages 0–65 years), the Mississippian has a slightly higher frequency of fractures than the MALW and the LW (19.5, 16.4, and 13.4%, respectively). However, this pattern is not consistent among age and sex classes. For subadults the overall trend is reversed. LW subadults have a higher frequency of fractures than those in the MALW and the MM (10.2, 9.8, and 6.4%, respectively). Adults (males and females combined) in the Mississippian have nearly twice the frequency of traumatic pathologies as adults in the MALW and LW groups (32.4 to 16.4 and 20.5%). Finally, when data for the sexes are analyzed separately, it becomes clear that adult males, especially in the Mississippian, are most frequently affected by traumatic conditions. The frequency of traumatic lesions increases from 23.5% in LW females and 16.4% in MALW females to 31.1% in MM females. The frequency of traumatic lesions increases from 17.9% in LW males and 16.4% in MALW males to 38.0% in MM males. In summary, postcranial traumatic pathologies follow the trend of increased incidence through time. Furthermore, this trend is most pronounced for males.

TABLE 11.14 Summary of the Analysis of Variance and Duncan's New Multiple Range Test for Trauma for the Late Woodland, Mississippian Acculturated Late Woodland, and the Mississippian (Ages 0-65)

Age (years)	*Mean frequency of trauma*	*Duncan's New Multiple Range Test*		
0-65				
LW	*16.4*			
MALW	*13.4*			
M	*19.4*			
0-15				
LW	*10.2*			
MALW	*9.8*			
M	*6.4*			
15-65				
LW	*20.5*			
MALW	*16.4*			
M	*32.4*			
15-65 (Females)		*MALW* *16.4*	*LW* *17.9*	*M* *38.0*
LW	*23.5*			
MALW	*16.4*			
M	*31.1*			
15-65 (Males)				
LW	*17.9*			
MALW	*16.4*			
M	*38.0*[a]			

[a]*Denotes significant f-value at* $p \leq .05$.

Degenerative Pathologies

Lallo (1973) has presented an analysis of osteoarthritis, osteophytosis, and degeneration of the vertebral centrum in the Dickson populations (Table 11.16). For all adults there is a significant increase in the frequency of degenerative pathologic (of all sites combined) from 39.7% in the LW to 41.8% in the MAL and 65.8% in the MW. All cultural frequencies are significantly different from each other (Duncan's multiple ranges test; see Lallo 1973:222). This trend is similar and is evidenced in both males and females.

Data are also presented for stages of severity of degenerat of the centrum and osteophytosis (see Lallo 1973:223-248). Da are for individual vertebrae and not for individual persons. both centrum degeneration and osteophytosis there is a clear t of increased frequency of affected vertebrae by cultural horizo

TABLE 11.15 Summary of the Analysis of Variance and Duncan's New Multiple Range Test for Degenerative Pathology Frequencies among Cultural Horizons

	Mean frequency of degenerative pathology	*Duncan's multiple range test results*		
		LW	*MALW*	*M*
Females aged 15-65				
LW	*41.2*	*41.2*	*41.0*	*67.4*
MALW	*41.0*			
M	*67.4*[a]			
Males aged 15-65				
LW	*38.5*[a]	*38.5*	*42.6*	*76.0*
MALW	*42.6*[a]			
M	*76.0*[a]			

[a]*Denotes significant f-value at* $p \leq .05$.

increased frequency of severe cases by cultural horizons, and more serious affliction of males than females.

In sum, the pattern of degenerative pathologies is similar to that of traumatic pathologies. Degenerative pathologies significantly increase through time and affect males more frequently than females.

Mortality

Mortality or age-at-death information has been presented using a wide variety of methods for prehistoric populations. These methods include composite life tables, probability-of-dying curves, age-specific mortality curves, and mean age at death-life expectancy figures. Lallo and colleagues (Lallo et al. 1978; 1980) have presented an analysis of mortality changes at Dickson. While they utilize a variety of methods in their analysis, they started by constructing life tables. They argue that life tables, once constructed, provide the maximum amount of information about the mortality of a population.

Life tables for the three cultural horizons are presented in Tables 11.1-11.2. The d_x values (age-specific mortality) and q_x values (age-specific probability of dying) consistently increase through the horizons at Dickson while the l_x (survivorship) and e_x^o (age-specific life expectancy) consistently decrease through the cultural horizons. In all age classes there appears to be a general trend toward increased chance of dying in the MM relative to the LW. The statistical significance of this trend was determined using the Kolmogorov-Smirnov two-tailed test (see Siegel 1956:117-118). Kolmogorov-Smirnov is a test of differences in distribution

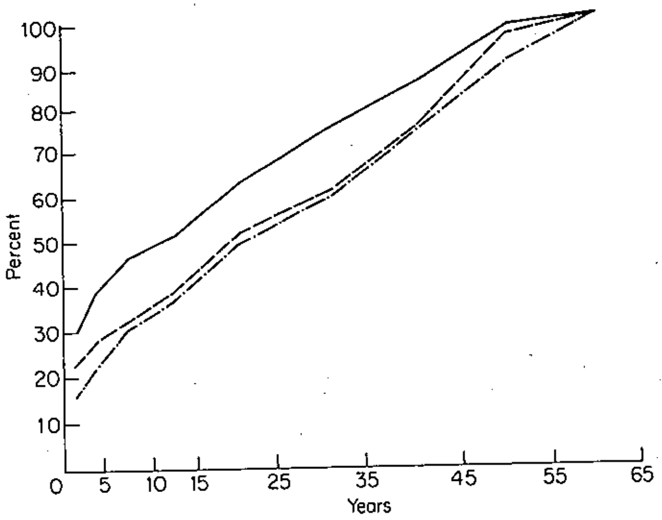

FIGURE 11.6. Cumulative percentages of mortality by age for the Late Woodland (—•—), Mississippian Acculturated Late Woodland (-----), and Middle Mississippian (———) populations (ages 0-65) (from Lallo et al. 1980:220).

and is utilized to test whether or not two distributions are sufficiently similar to have been drawn from the same population. Kolmogorov-Smirnov was applied to the cumulative distributions of mortality (Figure 11.6). The maximum difference between the LW and the MALW was not significant. However, the maximum differences between the LW and the MM, and between the MALW and the MM, were significant ($p \leq .05$) (Lallo et al. 1980:219-220).

In summary, the LW and MALW demonstrate similar patterns of distribution of mortality, while the difference between those patterns and that of the MM is significant. The maximum differences occur during childhood. In comparison of the LW and the MM, the maximum difference is 16.1% and occurs in the 2-5-year age class (21.8-37.9% dead). In comparison of the MALW and MM, the maximum difference is 14.5% and occurs in the 10-15-year age class (38.8-50.3%). Since the distribution by age class of mortality in prehistoric populations is generally considered to be relatively homogeneous (see Weiss 1973), evidence for statistically significant differences in temporally different populations from the same site is notable.

DISCUSSION AND CONCLUSIONS

Changing Patterns of Stress

We have presented evidence for an increased level of general stress through time at Dickson. This pattern is evidenced in 8 of 10 indicators of stress (Table 11.17). Increases in stress are indicated by (1) decreased age-specific attained long bone length and circumference, (2) increased frequency of enamel hypoplasias, (3) increased frequency of Wilson bands, (4) increased frequency of porotic hyperostosis, (5) increased frequency of infectious lesions, (6) increased frequency of degenerative lesions, (7) increased frequency of traumatic lesions, and (8) increased cumulative mortality. No differences are found for the frequency of Harris lines and the degree of sexual dimorphism. Independent observations consider Harris lines and sexual dimorphism to be weak and/or low-validity indicators of stress (Buikstra and Cook, 1980; Huss-Ashmore et al. 1982). Therefore, these results are considered to be multiple confirmations of the general hypothesis that stress increased through time at Dickson.

There seems to be more than one critical stressor or cultural dimension leading to increased stress. Growth indicators (long bone length and circumference, enamel hypoplasias, and Wilson bands) are consistent in demonstrating a decrease in growth velocity and an increase in growth disruption around the ages of -4 years. Based on ethnographic observations on weanling time and practice among Amerindians (Cook 1971), these data may implicate the diet of the weanling and, specifically, the increased use of maize in this diet. These data, in consort with an increase in the frequency and severity of porotic hyperostosis, point to the increased adoption of a maize diet, especially among weanlings, as a cause of poor nutrition and an increase in nutrition-related stress indicators.

Other stress indicators may implicate other cultural changes. The increased frequency of infection may be bound synergically to nutritional problems resulting from ubiquitous pathogens that were becoming increasingly virulent under the influence of decreased host resistance due to under-nutrition (Dubos 1965; Scrimshaw 1964). Decreased host resistance is therefore likely to have been one cause of the increase in infectious lesions, as there is evidence for association of infectious and nutritional (porotic hyperostosis) lesions in prehistoric populations (see Mensforth et al. 1978). However, it is unlikely that decreased quality of diet is the only cause of the increasing frequency and severity of infection. Changing settlement practices with increased population density and sedentism, combined with the use of virgin agricultural soils, a less complex ecosystem, and increased trade, affords ample chance for the introduction of novel pathogens and their maintenance within the population. In sum, increases in infectious disease may be due to a variety of causes that perhaps worked together in synergetic fashion

TABLE 11.17 Summary of Stress Indicators

Indicator	Patterns of stress[a]	Subgroup affected (age in years)	Differences observed	General comment
Long bone growth	+	1-7	Attained growth is less for tibia and femur in the 5-10-yr. group[b]	Decreased growth velocity at 2-5 yr.: chronic (nutrition-related) stress in infancy and childhood. Some catch-up occurs.
Sexual dimorphism	0		None (pelvic and femoral measures)	Weak indicator-test of stress for methodological and theoretical reasons.
Harris lines	0		None (distal and proximal tibia)	Weak indicator based on experimental evidence
Enamel hypoplasia	+	2-4	Frequency and lines in MM is twice that of LW. MALW is intermediate[b]	Good seasonal (nutrition-related) stress indicator.
[illegible]	[illegible]	[illegible]	Approximately 70% increase [illegible] MM with increase in severity and involvement[b]	Nutrition-related. Strong [illegible] Modeled and unremodeled not distinguished.
Infectious lesions	++	All ages	Threefold increase from LW-MALW to MM. Also, increase in severity[b]	Chronic infection. Endemic in MM. Synergistic with porotic hyperostosis. Good predictor of age at death.
Trauma	+	15-65	Twofold increase from LW-MALW to MM for appendicular fractures	Strongest difference noted in males. Suggests interpersonal strife.
Degenerative lesions	+	15-65	65% increase from LW to MM. Increase in severity (centrum and osteophytosis)[b]	Chronic wear and tear (physical stress) is greatest in males.
Mortality	++	0-10	$d_x + g_x$ increase while l_x and e_x^o decrease. Cumulative differences are significant.[b]	Best indicator of stress and inability to adapt. Most severe in subadults.

[a] −, decrease through time; 0, no change through time; +, increase through time; ++, strong increase through time.

[b] Observed differences were statistically significant.

The frequency of degenerative and traumatic pathologies increased over time in adults and especially adult males. Degenerative pathology is inferred to be due to increased physical-work stress. Traumatic pathology may be interpreted as the result of physical-work stress or interpersonal strife. The latter explanation is not unlikely given the evidence for fortification at the Larson site. These data point to an increased degree of competition.

Toward a Regional Model of Prehistoric Health

The Dickson Mounds case is one in which increased population density and sedentism occur roughly contemporaneously with intensified agriculture and increased evidence for physiological disruption. However, it is difficult to explain the extreme degree to which stress increases based only on these or other local ecological factors. Harn (1980:1,7-8) documents the unusually well-balanced natural environment of the Dickson area (Fulton County) and believes that the natural productivity of the area is great enough throughout Dickson's prehistory to sustain even the larger MM population (also see Caldwell 1958). Furthermore, there is abundant evidence from artifact analyses that hunting and gathering are major activities throughout the MM (Harn 1980:81-82). Local archaeological and ecological reconstruction leads one to believe that this is an excellent environment for a prehistoric population and that abundant use was made of the local resources throughout the period of occupation. One would predict that nutrition would be adequate. Left to its own, as a closed cultural-ecological system, Dickson would seem to be able to do well. However, it is not a closed system and the evidence is that it does not do well.

The model we propose for Dickson is one of increased stress through time resulting primarily from its occupying exploitable position in a regional system of ideological and economic exchange. Increases in population density and sedentism and increased use of agriculture may be of secondary importance to the possession of an exploitable position within a larger system. Increased population density and sedentism and increased use of agriculture may become important only when local ecological conditions are poor and/or are related to a regional system of exploitation. At Dickson it appears that the stresses of agriculture are absorbed locally but the benefits are enjoyed at a place outside of the local ecosystem. The biocultural systems of the Dickson populations may have been able to adjust to the constraints of local changes such as an increase in populations and intensification of maize agriculture. However, participation in regional Mississippian systems in the Illinois Valley placed additional constraints on the local populations. The interaction of local and regional changes, especially those revolving around a possibly unbalanced flow of economic resources, may have imposed a stress load that could no longer be buffered by the subordinate populations such as Dickson.

In conclusion, we have presented Dickson as a case study of health change at a single site. Our data have provided multiple confirmations that stress increased through time. This is evidenced in measures of growth disruption and retardation, disease, and mortality. Our conclusions about the causes of increased stress are based on an examination of both local and larger regional processes. Just as it would be ill advised to explain patterns of disease in contemporary societies without reference to their involvement in the modern world system, so also would it be ill advised to explain health at this prehistoric site without reference to the precapitalist systems of which the Mississippian culture is an example. The bones and teeth from Dickson tell a tale of increased stress which may be due to the exploitable position of the Dickson population within a regional system. Testing this model is possible by comparison of the health effects of agricultural intensification, increased population density, and increased sedentism on populations that vary in their involvement in larger systems and in their position within these systems. Information for a preliminary testing of this model may be provided within this volume.

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