NUTRITIONAL HEALTH IN PREHISTORIC SOUTHERN ONTARIO

AN ASSESSMENT OF THE NUTRITIONAL HEALTH STATUS

OF

PREHISTORIC ABORIGINAL POPULATIONS FROM SOUTHERN ONTARIO

By

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ABSTRACT

This study was conducted to evaluate the nutritional health status of prehistoric aboriginal populations from southern Ontario. An investigation of femoral midshaft cross-sectional bone areas was undertaken to examine possible diachronic changes in these bone areas among three time periods represented by eight Ontario skeletal samples. Each sample was chosen because it falls into a critical period in Ontario prehistory. The samples included: Cameron's Point, Serpent Mounds and LeVesconte Mound Middle Woodland (MW) populations which practiced a hunter-gatherer economy; Bennett, Richardson, Miller and Serpent Pits whose populations practiced a mixed economy supplemented by cultigens introduced prior to and during the Early Ontario Iroquois (EOI) stage; and Orchid, a Middle Ontario Iroquois (MOI) population which was supported by an increasing reliance on maize agriculture.

It has been demonstrated that populations undergoing nutritional stress exhibit reduced cortical bone areas, in particular per cent cortical area (PCA). Furthermore, it has also been demonstrated that populations which rely heavily on a maize diet exhibit nutritional stress.

Therefore, if later Ontario aboriginal populations were heavily dependent on maize, there should be a diachronic change in the cross-sectional bone areas of these populations.

A total of 343 femora were obtained from individuals of all ages and both sexes. The midshaft cross-sectional bone areas were measured using a Kroton MOP Video-Plan Stereological and Morphometric electronic digitizer. Only the adult samples of each time period included enough individuals to be statistically significant, and thus form the basis of the analysis.

The results of this investigation indicate an overall maintenance of cross-sectional bone areas over time. The mean PCA of the MW and EOI samples did not significantly differ from each other, perhaps indicating the maintenance of a mixed economy later supplemented by maize. The mean PCA of the MOI sample is significantly greater than that of the EOI sample. The inclusion of beans into the later diet may have produced a diet of higher nutritional value, as indicated by this higher mean PCA. However, the MOI sample may be composed of a greater number of younger adults, who would have a higher PCA. Additionally, the mean PCA of the MW and MOI samples do not differ significantly, again indicating the maintenance of a nutritionally varied diet.

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CHAPTER I

INTRODUCTION

The purpose of this study is an assessment of the nutritional health status of prehistoric aboriginal populations of southern Ontario. Both chemical analysis of bone (Katzenberg 1984, Schwarcz et al 1985) and archaeological data (Noble 1975) suggest a shift beginning in the seventh and eighth centuries A.D. in Ontario from a hunter/gatherer economy towards an agricultural subsistence base with an increasing reliance on maize cultivation. The effects of this shift in economic strategy on nutritional health have not been fully explored. Recent osteological work using archaeological samples of these populations has centered on dental health status (Patterson 1984), on evidence for gross skeletal pathology (Hartney 1978) and on reconstructing paleodiet (Schwarcz et al 1985, Katzenberg 1984). However, the question of whether nutritional health patterns changed over time in Ontario populations has not been addressed. Hartney (1978) states that:

> ... a reinvestigation of many [Ontario] samples for evidence of malnutrition is needed (p.270).

Nutritional health studies of archaeological populations have been carried out in various parts of the world (Keith 1981, Cook 1979 in North America; Huss-Ashmore 1981, Hummert 1983 in the Sudan; Sweeney et al 1971, Garn et al 1968 in South America). A recent study of nutritional stress in two protohistoric Iroquoian populations has been done by Pfeiffer and King (1983), but to date, no-one has examined aboriginal health status over time in Ontario.

Stress has been variously defined as 'any extrinsic variable or combination of variables which causes [an] organism to react' (Buikstra and Cook 1980:444) and as being 'any disruption of the normal functions and homeostasis of a living organism' (Powell 1988:34). The term stress has been used in a variety of contexts, such as nutritional, disease and mechanical stresses, with each having a different meaning. Powell (1988) argues that the major sources of systemic physiological stress are malnutrition and pathological conditions, with psychological and mechanical factors as minor sources. Of the former sources, nutritional stress rarely involves a single deficiency but most commonly results from insufficient consumption of calories and protein of high biological quality to meet the energy demands of an organism (Ibid.:34). Stress may be defined as being acute or chronic, according to duration. Acute stress usually lasts for a short, well-defined period of time. Chronic stress persists for a longer duration as from 'long-term suboptimal nutrition resulting from a diet containing inadequate protein of high biological value' (Ibid.:pf34). One of the most significant biological results of stress is the cessation of normal growth, wherein energy formerly utilized for growth is diverted towards the maintenance of the organism. If the stress event is acute, growth will resume. However, chronic stresses can permanently affect growth and development and can alter adult skeletal dimensions (Buikstra and Cook 1980:444).

Various skeletal criteria have been investigated as indicators of general physiological stress (see Huss-Ashmore et al 1982). These include stature (Haviland 1967), porotic hyperostosis (El-Najjar et al 1976, Cybulski 1977), enamel hypoplasia (Sweeney et al 1971, Jelliffe and Jelliffe 1971, Goodman et al 1980), Harris lines (Blanco et al 1974, McHenry and Schulz 1976, Hummert 1983) and microscopic bone quality (Cook 1979, Hummert 1983). One of the best indicators of stress is the analysis of cortical bone thickness (Pfeiffer and King 1983, Hummert 1983, Keith 1981, Huss-Ashmore 1981).

Far from being a static system, bone requires a constant 'flow of nutrients to maintain its cellular structure' (Keith 1981:85), and even after longitudinal and transverse growth is completed in the adult skeleton the cortical and trabecular bone is still remodelling. Under conditions of nutritional stress, however, 'growth in long-bone length and width are preferentially maintained at the expense of growth in cortical thickness' (Huss-Ashmore 1981:85). In other words, populations undergoing nutritional or disease stress should exhibit reduced cortical thicknesses as compared with 'normal' (non-stressed) populations. Keith (1981) and Pfeiffer and King (1983) indicate that populations which rely heavily on a maize diet exhibit reduced cortical thicknesses.

The Middle Woodland period in Ontario (ca. 300 B.C. - A.D. 800) is represented by the Saugeen culture in the southwest and by the Point Peninsula culture in the southeast. Both can be characterized by territorial bands of hunters and gatherers (Spence et al 1984). Although little or no flotation of features has been done on many Middle Woodland sites, corn, which is identifiable and recoverable archaeologically without the need of special excavation techniques, does not appear to have been a part of the Middle Woodland diet. There have been no reliable dates reported for corn in Ontario until Princess Point times (Stothers 1977), although Jackson (1983) has reported an earlier date for corn (ca. A.D. 550) from Dawson Creek in south-central Ontario. In the Rice Lake region, Middle Woodland populations (Point Peninsula) as represented by LeVesconte, Cameron's Point and Serpent Mounds are thought to have subsisted on fish, mussels, rice, nuts, waterfowl and deer (Pihl 1978).

The Early Ontario Iroquois period (ca. A.D. 800-1300) has been characterized by:

> ...small longhouses clustered in palisaded villages or associated with seasonal food procurement and food processing camps ... endemic warfare ... similar burial practices (bundle burials within villages), limited long-distance exchange and a poorly developed pipe complex (Warrick 1984:10).

Corn as a cultigen had been introduced into the diet during the Princess Point component of this period. Two further cultures developed during this time: Glen Meyer, located in southwestern Ontario and Pickering, located in southeastern Ontario. The Pickering component is represented by several sites: Auda, Bennett, Boys, Gunby, Miller and Richardson. Skeletal material from this period is scarce, being represented by burials at Bennett, Miller,Gunby, Richardson and a later set of burials at Serpent Mounds called Serpent Pits (Johnson 1979, Schwarcz et al 1985).

By the Middle Ontario Iroquois period (ca. A.D. 1300 - 1450) it appears that the Glen Meyer and Pickering branches fused into one cultural tradition, Middleport. This has been characterized by general population growth and an increase in population density. The number of village sites increases and ossuary burial practices begin (Warrick 1984). The use of cultigens in the diet increases, and it has been suggested that the amount of corn in this diet may have been as high as 50% (Schwarcz et al 1985). Although there have been several sites excavated that are associated with the Middle Ontario Iroquois Middleport substage, ossuaries, which are often removed from their associated village site(s), are fewer in number. Three of these ossuaries, Fairty, Orchid and Tabor Hill, have fairly large populations and would yield a more than adequate sample size.

This study will examine the Rice Lake Middle Woodland, the Early Ontario Iroquois Pickering and the Middle Ontario Iroquois ossuary populations as being representative of a preagricultural - incipient agricultural - pre-contact agricultural developmental continuum. The problem of whether bone quality, as indicated by cortical areas, decreases over time as a result of nutritional health stresses introduced by an increased proportion of maize in the diet at the expense of nutritional variety will be considered. Later protohistoric and historic samples (such as Uxbridge and Kleinburg) will not be investigated as they may exhibit metabolic insults and stresses as a result of contact with European diseases (Pfeiffer and King 1983).

CHAPTER II

PREVIOUS RESEARCH

Skeletal and dental tissues are sensitive to the environment. Therefore the study of these tissues yields information on the interaction of behaviour and environment as diet, disease, physical exercise and work leave marks on these tissues. Bone generally reacts to disease and trauma in two ways: additional bone tissue is produced and/or already existing bone tissue is destroyed. Pathological conditions in prehistoric skeletons reflect disturbances of growth and repair in bone, and can therefore be used to infer the environmental stressors that caused them (Huss-Ashmore et al 1982). Although stress cannot be directly observed in archaeological populations, the reactions to stress can be observed. A variety of osteological techniques provide direct estimates of the effects of stress on health in prehistoric populations; however the causative agents of stress cannot be identified with certainty. Huss-Ashmore and co-workers argue that:

> Many disturbances, by acting on the same process, may produce similar results, and the identification of a single causative agent may not be possible. This is particularly true in the case of nutritional deficiencies, in which the synergistic effect of multiple deficiencies, or of

> interaction with infectious disease, is a complicating factor (Ibid.:399).

Therefore the search for single diagnostic pathological lesions for single nutrient deficiencies has led only to the conclusions that stress markers in bone are non-specific, and that single nutrient deficiencies are relatively rare. However, the pattern and severity of involvement within the skeleton and the distribution of these lesions within the population may imply the presence of past nutritional deficiencies.

Food procurement and consumption systems form a direct interface for humans and their environment, and these systems are critical components of the human adaptive complex. Patterns of human growth and pathology can be used to investigate changing patterns of human interaction with the nutritional environment. The determination of nutritional deficiencies in archaeological populations is problematic as these populations contain few of the nutritional indicators that are available to living populations. However archaeological populations do often reveal indications of nutritional stress.

Garn (1970) argues that with continued caloric deficit, the rate of overall growth in the skeleton cannot be maintained. Growth in length and width continues but the amount of new bone added is insufficient, resulting in thinner bone cortices. Additionally, existing bone may be borrowed to maintain growth and remodelling. Nutritionally deficient diets can result in bone loss, slowed growth and increased bone turnover rates in humans. The most important and sensitive transverse measurements for the assessment of such stress are cortical thickness and per cent cortical area. Preadult cortical bone growth in skeletal series can be used as a marker of nutritional status as in modern populations; cortical bone mass is markedly reduced in populations experiencing nutritional deprivation. Even in adult samples, bone mass and cortical thickness exhibit greater porosity and earlier loss of bone in nutritionally stressed settings (Ibid.).

Dickerson and McCance (1961) noted that in animals experiencing protein-calorie malnutrition, bone turnover rates increased with the removal of bone exceeding bone deposition. The humeri of piglets and the femora of cockerels were noticeably thin, although their length-width ratio remained the same. Garn and co-workers (1964) demonstrated that in Guatemalan children hospitalized for the treatment of protein-calorie malnutrition there was a significantly higher incidence of compact bone deficiency. Even during the recovery period, cortical thickness decreased as bone length increased. Himes and co-workers (1975) showed that children suffering mild to moderate protein-calorie malnutrition exhibited signs of delayed ossification and reduced cortical thickness. Although the children's bones on the whole were small and their growth was stunted, their cortical thickness and cortical area were reduced even relative to overall bone size. In a study of the femora of children from the Middle Woodland Gibson site and the terminal Late Woodland Ledders site from the Illinois Valley, Cook (1979) found a highly significant loss of cortical bone thickness during the age at which weaning could have been expected in the Ledders population. Cook interpreted this as evidence of a decrease in health status after the adoption of agriculture as a subsistence mode in the later population. Keith (1981), in a comparison of juvenile femoral cross-sections from Dickson Mounds, Illinois, to prehistoric Nubian and modern samples demonstrated that the prehistoric samples revealed deficiencies in relation to modern populations with good diets. Huss-Ashmore, in a study of 75 prehistoric Nubian juveniles, noted that diaphyseal lengths and diameters suggested normal bone growth and maintenance. However, she detected discrepancies in cortical thickness that indicated nutritional stress and subnormal standards. When compared to Garn's (1970) 'normals', per cent cortical area in the Nubians was maintained at a relatively low level throughout childhood. Huss-Ashmore suggests that long-bone growth in the Nubian sample was maintained at the expense of growth in cortical thickness (Huss-Ashmore et al 1982). In an analysis of juvenile tibiae from Nubia, Hummert (1983) demonstrated that per cent cortical area, endosteal resorption rates and amount of relative bone mass indicated abnormal growth patterns in some of the age groups examined.

Garn (1970) argues that per cent cortical area in adults is virtually the same cross-populationally. Therefore fluctuations in per cent cortical area can be used to assess cortical bone maintenance and change during adulthood. Dewey and co-workers (1969) took direct measurements at the femoral midshaft of three prehistoric populations from Sudanese Nubia and noted sexual differences in gross amounts of bone. Dramatic bone loss occurred at earlier ages in females within the series, and this was explained as a combination of inadequate calcium intake and extended lactation. Carlson and co-workers (1976) used measurements of cortical thickness, cross-sectional area and diaphyseal width to indicate age-related bone remodelling rates in a skeletal series from the Campbell site, Missouri. Martin and Armelagos (1979) noted significant gross and histological differences between males and females in osteoporotic bone loss in 74 adult femora from Sudanese Nubia. They suggest that premature osteoporosis in young adult females in this series may be a response to dietary deficiencies. Pfeiffer and King (1983) recorded low amounts of cortical bone for most individuals among two protohistoric Iroquoian populations. They suggest that this is the result of nutritional deficiencies brought about by a reliance on maize agriculture. In a similar study, Cook (1984) argued that the thinning of cortical bone in skeletal populations in the Lower Illinois Valley may be a sign of relative malnutrition in groups first adopting maize agriculture. Mensforth and Lovejoy (1985) noted that during the third decade, females from the Libben site, Ohio, exhibited a 6 to 12% reduction of bone cortex at the femoral midshaft. They suggest that this is due to increased demands for calcium during pregnancy and lactation.

CHAPTER III

ARCHAEOLOGICAL BACKGROUND

3.1 Developmental History

Middle Woodland

The date of the cultural transition from Early Woodland to Middle Woodland is uncertain. Spence and Pihl (1984) contend that this transition took place between 500 and 350 B.C., and that the start of the Middle Woodland period itself dates to 350 - 300 B.C. Three complexes from this period have been identified in southern Ontario: Western Basin in the extreme southwestern portion of the province; Saugeen in southwestern Ontario; and Point Peninsula in the southeastern portion of Ontario and in adjacent parts of western Quebec and New York state (Spence and Pihl 1984:38). The Middle Woodland samples used in this study are all from sites designated as being Point Peninsula from the Rice Lake area.

Point Peninsula culture (ca. 350 B.C. to ca. A.D. 800) encompasses the Lake Ontario - St Lawrence drainage area. Sites range from large stations located along major river and lake systems down to small campsites. These habitation sites were seasonal occupations of brief duration. During the spring and summer larger band groups would settle along major waterways intent upon the exploitation of aquatic resources, particularly fish. Major ceremonial - mortuary components are often associated with these sites. In the winter, these larger band settlements may have dispersed into the interior and fissioned into family hunting camps economically dependent on large mammal hunting and probably some utilization of dried plant foods (Spence and Pihl 1984; Spence et al 1984).

Evidence from these occupations suggests that most social units were probably small egalitarian bands. However, in both the Squawkie Hill Phase in western New York state and in the Rice Lake region of southeastern Ontario a more complex level of sociopolitical integration is suggested (Spence et al 1979, Spence et al 1984).

Towards the end of the Middle Woodland period in southwestern Ontario (ca. A.D. 500 - 800) a new cultural complex, Princess Point, had emerged. This complex has been defined by stylistic changes in ceramics and lithics as well as the introduction of maize agriculture (Stothers 1976, 1977). The origins of this complex are uncertain. Stothers (1977) suggests that it may have been an intrusive culture with origins in the Hopewellian Interaction Sphere from the south and west. Finlayson (1977) argues that Princess Point was a local development of the southern portion of the Saugeen culture. The Princess Point culture was important to the later development of the Ontario Iroquois tradition, as it was during this period that cultigens, particularly maize, were introduced into southern Ontario.

The Rice Lake Region

The physiography of Rice Lake is dominated by the Peterborough Drumlin Field. The tops of these drumlins were covered by a beech - maple dominant forest, while the interdrumlin areas were covered by marshes and swamp forests. There are three north shore rivers which feed the lake: the Otonabee (which is the principal inlet); the Indian and the Ouse. On the eastern shore of the lake is the Trent River outlet (Spence et al 1984:120).

The settlement pattern of the region is similar to the pattern established for the rest of the Point Peninsula culture: large semi-sedentary sites centered on major waterways in the warm weather months followed by a break-up for winter into a series of small, limited occupation hunting campsites in the forest interior (Pihl 1978:pf.78). Some of the larger sites consist of a group of mounds and an associated habitation area, usually recognizable by an extensive shell midden. Mounds within a particular group are successive, not contemporaneous, indicating that family groups would join together again for the spring and summer at a preferred location (Spence et al 1984). Some of the burial mounds around Rice Lake are part of the mortuary ceremonialism associated with the Hopewell Interaction Sphere; however, the Rice Lake bands' participation in the Hopewell Interaction Sphere was marginal and highly selective (Spence et al 1984). Each mound in a group, or each addition to a mound, probably represents a burial episode that involved the entire community, not just a segment such as a lineage.

The Rice Lake bands were comprised of internally ranked bands of between 50 to 100 people. Each band had a distinct social identity which persisted over time, and the hierarchical internal structure of the band was based on some degree of ascribed status (Spence et al 1984). Since these bands seasonally fragmented, it is unlikely that this level of society had ranked corporate lineages. Nor were these bands distinct social units. Rather, there appears to have been a high degree of interaction among bands (Spence et al 1979; Spence et al 1984).

Late Woodland

The Early Ontario Iroquois period (ca. A.D. 800-1300) is characterized by two regional complexes developing in relative isolation from each other. In a restricted area to the southwest of the province was the Glen Meyer complex; a development of the Saugeen and Princess Point cultures.

More widely distributed in the southeast was the Pickering culture; an in situ development of the Point Peninsula culture (Wright 1966; Patterson 1984). Both branches utilized maize as part of their subsistence base and both, particularly the Pickering branch, relied upon hunting and fishing. Both also possessed the rudiments of other diagnostic cultural elements that define the later Ontario Iroquois: the longhouse, palisaded villages and multiple secondary burials (Molto 1983). The Glen Meyer settlement pattern is dominated by larger villages, whereas Pickering sites tend to be widely dispersed villages with numerous camp sites.

While the Glen Meyer chronological sequence is fairly well understood, the Pickering sequence is a bit confused. In a recent reanalysis of Iroquoian radiocarbon dates, Timmins (1984) states that:

> Interpretive problems with the Pickering sequence stem from the small number of radiocarbon dates and uncertainties in the application of ceramic seriation ... [and] ... Given the inadequacies of the data base, it is impossible to produce a reliable absolute chronology for the Pickering branch on the basis of the radiocarbon evidence alone (pf.89).

Two points about the Pickering sequence are suggested, though. The first is that the existing Pickering dates do not support an extension of the Pickering period as far back as ca. A.D. 700 as some researchers have suggested (Timmins

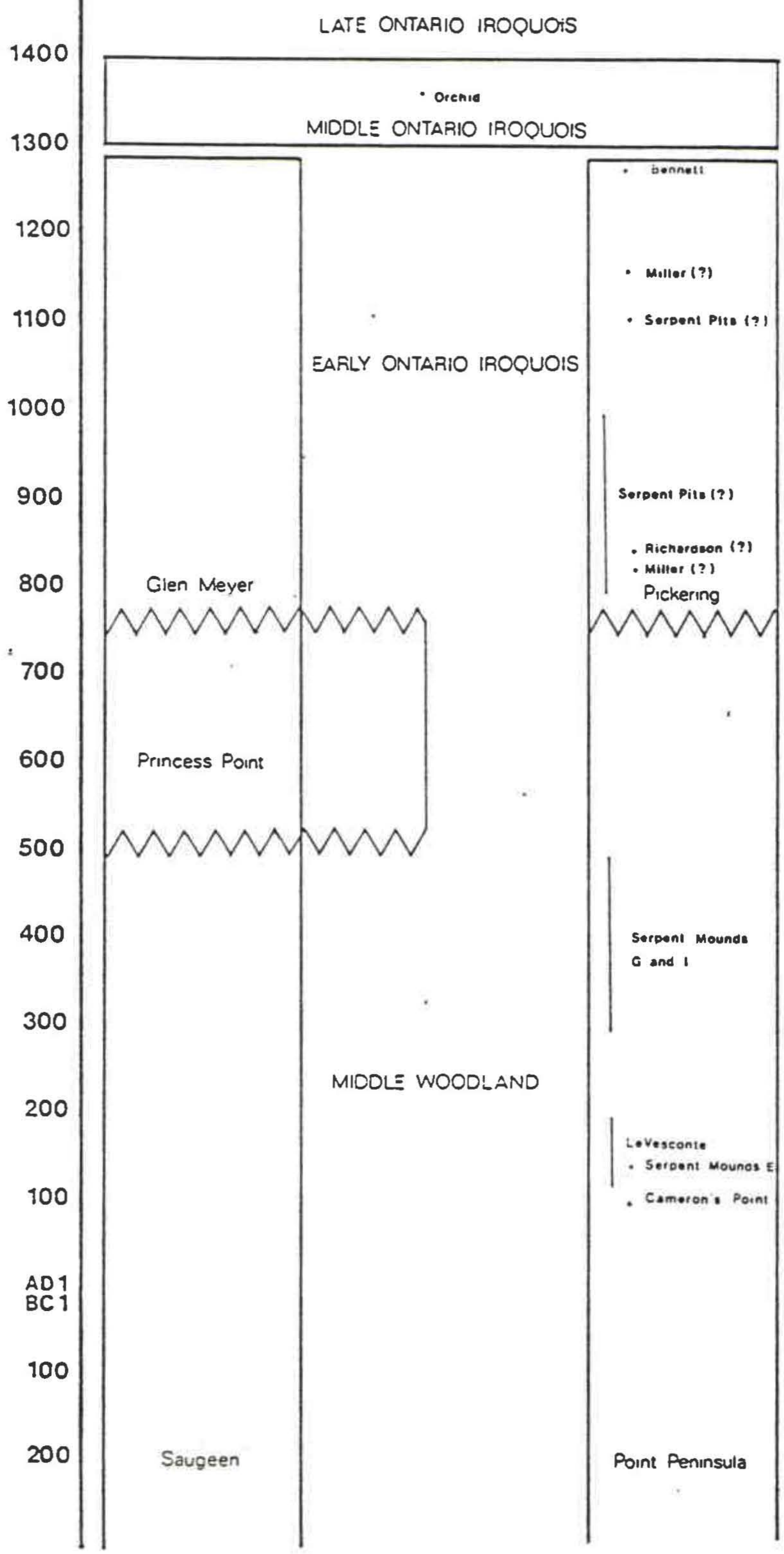
1984). The second is that no matter what the chronological ordering, there have been no suggestions that the sites designated as being of the Pickering branch are anything other than Pickering. The Early Ontario Iroquois skeletal samples used in this study are all from the Pickering branch.

By about A.D. 1300, the Glen Meyer and the Pickering branches merged into a relatively homogenous cultural horizon across southern Ontario. Wright (1966) suggested that this horizon, known as the Middle Ontario Iroquois stage, was the 'product of the uninterrupted cultural development of the Pickering branch and the conquest and absorption of the Glen Meyer branch by the Pickering branch' (Wright 1966:54). The conquest model explaining this fusion has since been questioned (Noble 1982; Rozel 1979), but whatever the mechanisms involved the Middle Ontario Iroquois stage appears to have been a period of cultural homogeneity.

Wright (1966) identified two substages in the Middle Ontario Iroquois stage: Uren, which lasted from A.D. 1300-1350 and Middleport, which lasted from A.D. 1350 - 1400. However, in current analyses, the integrity of the Uren substage has been questioned and the two substages have been subsumed under the Middleport horizon (Noble 1975; Kapches 1981).

This period can be characterized by a growth in

Fig. 3.1 Chronology of Southern Ontario and of sites used in study



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longhouse size, the further development of ossuary burial and 'perhaps an increase in population, in response to an improved horticultural base' (Warrick 1984:11). The settlement pattern is dominated by a small number of large village sites and numerous widely dispersed fishing and hunting camps (Patterson 1984).

3.2 Changes in the Subsistence Patterns of the Pre-Iroquois and the Iroquois

Both chemical analysis of bone (Katzenberg 1985; Schwarcz et al 1985) and archaeological data (Noble 1975) suggest a shift beginning in the seventh and eighth centuries A.D. from a diffuse economy where a wide variety of resources were utilized, towards an agricultural subsistence base with an increasing reliance on maize cultivation in southwestern Ontario. The people of the Middle Woodland period exploited a broad economic base with large mammals as the probable primary food source, supplemented by a diverse assemblage of small mammals and fish with a wide variety of wild plant foods rounding out the diet (Fecteau 1985). There is no suggestion that agriculture was being practiced. In the Rice Lake region, the distribution of larger sites and natural resources indicates that the exploitation of wild rice may have been of major significance. This has yet to have been tested by recent excavation and most of the prior excavations around Rice Lake took place before the advent of reliable recovery techniques such as water flotation of soil samples (Spence et al 1984; Pihl 1978).

Pihl (1978) has suggested the following subsistence strategy for the Rice Lake bands: in the warm weather months fish, shellfish, migratory birds and vegetal foods were available for exploitation; in the fall rice and nuts could be harvested; and in the winter when the bands dispersed inland, deer, other mammals and stored foods would be the basis of the diet.

Maize agriculture was introduced into Ontario during the Princess Point period (Stothers 1977; Fecteau 1985) and throughout the Early Ontario Iroquois period an increasing reliance on maize is demonstrated, although seasonal hunting and fishing activities remained important. The Glen Meyer people seem to have been more dependent upon maize agriculture than the Pickering branch. In his analysis of the cultigen history of southern Ontario, Fecteau (1985) found little evidence for cultigens on any Pickering site prior to A.D. 1100. By A.D. 1200 - 1300 the number of Pickering sites with cultigens increased and by the end of the Early Ontario Iroquois period all of the major cultigens (maize, beans, squash and sunflowers) were present in southern Ontario, although not all cultigens are present on each site in the archaeological record. Fecteau (1985) states that:

> the subsistence evidence from [the Early Ontario Iroquois] sites suggests the continuation of a diffuse economy to a shift to a focal economy with increased agricultural dependence . This is particularly noticeable on Pickering Sites. At this time Glen Meyer subsistence appears to be based on corn agriculture, supplemented perhaps by hunting and much fishing, while the Pickering peoples have broadened their agricultural base to include bean [Phaseolus vulgaris] (pf.137).

He goes on to suggest that the expansion of the Pickering branch and the increase in the number of Pickering sites may be due to an overall population increase, perhaps as a result of the inclusion of beans into the diet.

During the Middle Ontario Iroquois period, sites for which evidence exists suggest a focal economy based primarily on maize agriculture as well as the exploitation of other cultigens along with some hunting and gathering. Schwarcz and co-workers (1985) in their reconstruction of paleodiet by the analysis of stable isotopes in human skeletons of southern Ontario estimated the proportion of maize in the prehistoric diet. Maize is a C_4 plant relatively enriched in C^{13} whereas most native plants of Ontario are C_3 plants relatively low in C^{13}. By examining dC^{13} over time they proposed that by the end of the Middle Ontario Iroquois period, the proportion of maize as a 'primary component of the diet was probably never greater than 50% of the total carbon intake' (Schwarcz et al 1985:200).

As a foodstuff, corn is relatively high in phosphorous, potassium and vitamin A. It is deficient in the minerals calcium and iron and it also lacks the B vitamins thiamin, riboflavin and niacin. As a source of protein, corn by itself is not adequate because it is deficient in the essential amino acids lysine and tryptophan. Because of these deficiencies Fecteau (1985) states that without a cooking technique which combines lime and heat with corn, complete dependence on corn produces serious nutritional deficiencies.

Beans are a good source of the vitamins A and C, thiamin and riboflavin as well as the minerals calcium and iron. Its major dietary significance is its high protein content in the form of dry seeds. However bean protein, as in most legumes, is of low nutritional value because of a lack of sulphur-bearing amino acids such as methionine and cystine. Corn is relatively rich in methionine and when combined with beans, which are rich in lysine and tryptophan, produces a protein of higher biological value (Fecteau 1985). Beans can also remedy corn's deficiency in the B vitamins, riboflavin and nicotinic acid.

Recent studies (Katzenberg 1984; Schwarcz et al 1985; Schwarcz and Katzenberg 1986) suggest that although bean protein is considered to be important, there is no evidence suggesting a decreasing emphasis on animal protein throughout time in southern Ontario. Schwarcz and co-workers state that: 'The introduction of beans into the native diet about A.D. 1100 should have caused a decrease in the $d^{15}N$ content of human bone collagen because legumes are deficient in this isotope with respect to meat and fish' (Schwarcz et al 1985:188). No such shift in $d^{15}N$ of bone collagen was detected, leading the authors to conclude that:

> Based on these data, beans do not appear ever to have been an important source of protein for these people. On the contrary, it seems that the people of southern Ontario were able to continue utilizing their traditional sources of [animal] protein uninterrupted during a period in which they were shifting their carbohydrate source to a large extent from native, wild foods to a mixture of maize and squash (Ibid.:202)

They caution that the protein content per gram of beans is significantly less than for meat. Therefore a larger amount of beans by weight may have been consumed and yet remain undetected by their analysis. Up to one-sixth of the total protein content in the diet may have come from bean protein.

Thus it appears that although the later Iroquoians were heavily dependent upon maize as a part of their diet, this diet was supplemented by various other foodstuffs. The nutritional variety of the later Iroquoian diet does not appear to have been compromised.

3.3 The Samples

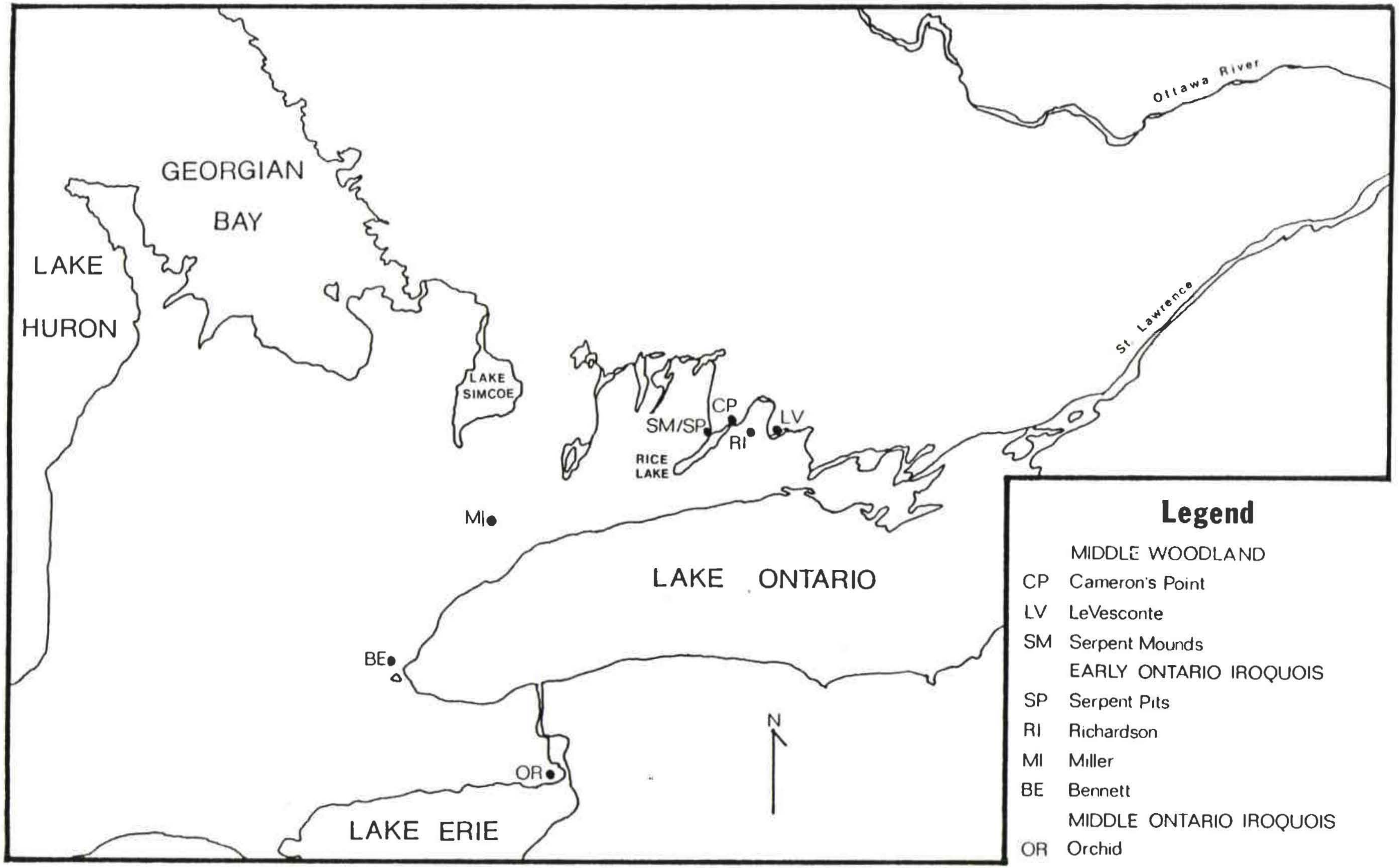
Middle Woodland

Cameron's Point

The Cameron's Point site (BbGm-1) is located on Lot A, Concession I, Asphodel Township, Peterborough County. It projects from the east end of the north shore of Rice Lake at the head of the Trent River. The site consists of three mounds (lettered A - C) and a midden ares. It was excavated in the summer of 1952 by J.R. Harper, who put test pits into Mounds A and B and extensively excavated Mound C. In 1958, R.B. Johnston salvaged a burial from Mound A (Spence and Harper 1968).

Mound C appears to have been erected in one stage. Construction probably was initiated by the death and burial of a high-ranking male individual, burial 37. The suggested date for the site is A.D. 100^{+}-55 (Spence et al 1979). The site report by Spence and Harper (1968) states that the minimum number of individuals included in Mound C was four infants, ten children and nine adults. In the disturbed portions of Mound C were found the remains of six infants (one of which was intrusive), four children and eight adults. The remains are very fragmented, and the total sample collected for this study consists of three infants,

Fig. 3.2 Location of the sample sites in Southern Ontario



SCALE: 1 inch = 32 km

Adapted from Spence et al (1979)

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Table 3.1 Summary Information of Sample Sites

Site	Location	Institution Housed	Total Sample Size	Date (A.D.)	Cultural Affiliation
Cameron's Point	Asphodel Township Peterborough County	University of Western Ontario *	14	100 ± 55	Point Peninsula
LeVesconte Mound	Seymore Township Northumberland County	Royal Ontario Museum	19	120 ± 50 230 ± 55	Point Peninsula
Serpent Mounds	Otonabee Township Peterborough County	Royal Ontario Museum	65	128 ± 200	Point Peninsula
Serpent Pits	Otonabee Township Peterborogh County	Royal Ontario Museum	31	1045 ± 60 1290 ± 60	Pickering
Richardson	Percy Township Northumberland County	Trent University	5	830 ± 80	Pickering
Miller	Durham Region	Royal Ontario Museum	13	1115 ± 70	Pickering
Bennett	Halton Region	National Museum of Man, Hull	5	1260 ± 130 1280 ± 100	Pickering
Orchid	Fort Erie Bertie Township	National Museum of Man, Hull	189	1380 ± 90	Middleport

* on loan from the Royal Ontario Museum

six children, two adolescents and three adults.

LeVesconte Mound

The LeVesconte Mound site is located six miles east of Campbellford on Concession I, Seymore Township, Northumberland County. The mound is situated on the edge of a high cliff some 40 feet above the Trent River (Kenyon 1986). The site consists of an isolated mound which was excavated in 1962 by a Royal Ontario Museum crew directed by W. Kenyon.

The mound is a 30 foot by 40 foot oval that is three to four feet high. It was built by accretion, with two layers added successively to the original structure and is situated on a prepared floor. Two radiocarbon dates obtained from bone samples yielded dates of A.D. 120^{+}- 50 and A.D. 230^{+}- 55 (Kenyon 1986:40) Patterson (1984) reports that approximately 50 individuals were represented. The total sample collected for this study was two infants, eleven children and six adults.

Serpent Mounds

The Serpent Mounds site (BbGm-2) is located on the southern portion of Roach's Point on the north shore of Rice Lake, Otonabee Township, Peterborough County. The mound group is situated along the edge of a grassy and nearly flat-topped drumlin (Johnston 1968b). This group consists of nine mounds (lettered A - I). These were first investigated by H. Montgomery in 1908. From 1955 to 1959, excavations were carried out by the Royal Ontario Museum on four of the mounds: E, G, H. and I. Mound H, which had been disturbed, was selected for test trenching in 1955. The sample used in this study comes from Mounds G, I, and E (Johnston 1968b).

Mound E (the 'Serpent Mound') is composed of several lateral extensions added sequentially over time to a smaller original mound and does not appear to have been a definite attempt to produce a serpentine form. There is a high degree of genetic homogeneity amongst the population represented in Mound E which suggests that the construction of the mound was accomplished over a relatively restricted time period (Spence et al 1979). Mound E dates to approximately A.D. $128^{+}-200$. Spence and co-workers suggest that 'some of the less elaborate mounds of the Serpent Mounds site (for example, Mounds G and I) might be placed in a later period, dating to the fourth to sixth centuries' (Ibid.:117).

The burial patterns within the mounds are quite varied. The mode of individual burial could take the form of single or multiple flexed and bundle burials in separate or common graves, single mass graves (in Mounds G and I), burials in pits or cremations (Johnston 1968b). The Serpent Mounds sample used for this study consists of seven infants, 14 children, six adolescents and 38 adults.

Early Ontario Iroquois - Pickering Branch

Bennett Site

The Bennett site (AiGx-1) is located 13 miles northwest of Hamilton on Lot 14, Concession I, Halton Region. It is situated on a small knoll and covers an area of 2.5 - 3 acres. It was excavated in 1961 by a University of Toronto crew directed by J.N. Emerson and in 1962 by a National Museum of Canada crew directed by J.V. Wright. Excavations uncovered a double palisaded village with four probable and three confirmed longhouses as well as 13 burials involving 15 individuals (Wright and Anderson 1969). Radiocarbon dates obtained for this site are A.D. 1260^{+}-130 and A.D. 1280^{+}-100 (Timmins 1984).

Anderson noted that the high incidence of caries and the moderate degree of dental attrition suggest an agricultural economy. He suggested that the closest biological affinity of the Bennett population was with the population from the pit burials from the Serpent Mounds site. Flexed, bundled and dismembered varieties of internment were found (Wright and Anderson 1969). The Bennett sample used in this study consists of one child, one adolescent and three adults.

Miller Site

The Miller site is located near the town of Pickering on Concession III, Durham Region. It was excavated from 1950 to 1961 by W.A. Kenyon. The site consists of six longhouses surrounded by a single palisade. Seven burials were uncovered both within and without the palisade (Kenyon 1968). The site has been radiocarbon dated to A.D. 1115^{+}- 70. (Timmins 1984) although several archaeologists have suggested a date of ca. A.D. 800 based upon ceramic seriation (Kenyon 1968; Noble 1975 in Johnston 1979).

The burial pattern consists of multiple secondary burials in six of the seven graves uncovered. Most of these included the remains of three to four individuals, while one contained the remains of 13 individuals (Johnston 1979). Ossenberg examined the human skeletal material from the site and concluded that the Miller population was closely related to the pit population at the Serpent Mounds site (Ossenberg 1969). The burials yielded the remains of ten juveniles, four adolescents and 18 adults. The total sample size used in this study is one infant, one child, two adolescents and nine adults.

Richardson Site

The Richardson site (BbGl-4) is located at the east end of Rice Lake in Percy Township, Northumberland County.

Test excavations were undertaken in 1969 by Trent University. In 1976 detailed excavations directed by R.J. Pearce were completed. Two separate palisades, two longhouses, a midden and two burial pits were uncovered. Faunal analysis suggests a year-round occupation at Richardson, from which 'excursions were made to base camps to exploit the available food resources' (Pearce 1978:22). There is a radiocarbon date of A.D. 850^{+}80 for Richardson, but Timmins (1984) argues that ceramic evidence suggests that the site seriates later than this mid-ninth century date.

The two burial pits were found along the north wall of House 1. One pit contained a single bundle burial while the other was a small ossuary - type grave containing five disarticulated individuals (Pearce 1978). The total sample from Richardson used in this study is five adults.

<u>Serpent Mounds - Pit Burials</u>

Three burial pits (numbered 1 - 3) were found at the Serpent Mounds site, located in a field north of the mound group roughly 170 feet from the eastern end of Mound E (Johnston 1968b). Rim sherds found in the pits indicate an Early Ontario Iroquois origin. Radiocarbon analyses date Pit 1 to A.D. 1045^{+}- 60, Pit 2 to A.D. 1440^{+}- 60 (which Johnston rejects as being too recent) and Pit 3 to A.D. 1290^{+}-60 (Johnston 1979).

A total of 69 individuals were excavated from the pits. Johnston noted that there was not a single instance of articulation found, and that this 'foreshadow[ed] similar, later and more elaborately developed Iroquois [ossuary] practices' (Johnston 1968a:27). The total sample from the Serpent Mounds burial pits used in this study consists of four children, four adolescents and 23 adults.

Middle Ontario Iroquois

The entire sample from this time period comes from the Orchid ossuary (ArGf-1), which is located on the first terrace above the present Niagara River level on Lots 1 and 2, Fort Erie. It was excavated in 1964 by M. White. Two distinct units were uncovered: Unit A which is the ossuary itself and Unit B, a series of individual burials (White 1966). The archaeological affiliation of the site is not known with any certainty. The only cultural material recovered from the site comes from the terminal Point Peninsula culture. No Iroquoian material was recovered from the ossuary or from the level over the ossuary. Nor was there any prehistoric village in the vicinity of the site. This led White (Ibid.) to date the site to the terminal Point Peninsula period. This date has since been challenged. In an analysis of the infracranial material from Orchid, Melbye (1967) found that the Orchid population fit between the Early Ontario Iroquois population from

Serpent Mounds and the Middle Ontario Iroquois population from the Fairty ossuary. Molto (1983) also places Orchid in the Middle Ontario Iroquois stage. Radiocarbon analysis of bone samples from Unit A yielded a date of A.D. $1380^{+}-90$ (Cybulski 1986, pers. comm.). The mode of burial also suggests a later date than terminal Point Peninsula. Unit A consists of an ossuary of disarticulated individuals which is not a burial pattern associated with Point Peninsula cultures.

The minimum number of individuals from the site may never be known. Due to a 24 hour time limit placed on the excavation, some material was left in the ground. Additional material was removed by bulldozer. The minimum number of individuals from the collected sample is 379, estimated by a count of the temporal bone (Cybulski 1967). The sample from the Orchid site used in this study comes from Unit A, and is composed of 14 children, nine adolescents and 166 adults.

CHAPTER IV

MATERIALS AND METHODS

4.1 Sample Selection and Preparation

The skeletal samples used in this study were drawn from eight sites representing three time periods in southern Ontario prehistory. The sites span a period from ca. A.D. 100 to ca. A.D. 1380. Archaeological evidence indicates a shift from a diffuse hunter/gatherer economy towards a focal economy based upon agriculture during this period. The samples from the two earlier time periods, the Middle Woodland and the Early Ontario Iroquois stages, do not represent single populations. However, no collection from a single site is large enough to provide a reasonable sample for statistical analysis. Therefore the individual site samples within each of these two time periods were pooled in order to increase their respective sample sizes. The later time period, the Middle Ontario Iroquois stage, is represented by one site with a large sample size and can be considered to represent a biologically uniform group.

In a study of skeletal involution of the long bones, Van Gerven (1973) concluded that a 'sampling of more than one skeletal area provides only minor quantitative power'

(P.44). In order to economize both time and resources, only one skeletal site was chosen to be investigated, the femoral midshaft. The femur is a robust bone and is identifiable in archaeological populations even when preservation is poor. Additionally, the femoral midshaft has been the study area of previous investigations (Keith 1981; Huss-Ashmore 1981; Ruff and Hayes 1983a,b; Ruff et al 1984).

A total of 343 femora were obtained for analysis from the eight sites used in this study. Of these, one specimen shattered during sectioning and could not be reconstructed; another was omitted from analysis for reasons to be given in the next chapter. An enumeration of the specimens from each site is given in Table 4.1. Selection was based on the condition of the bone for cross-sectioning. Skeletons showing trauma or pathological change other than osteoarthritis were excluded from the study. Trauma can induce additional bone remodeling, such as the healing of fractures, whereas pathological bones indicate that the individuals were under additional stress and thus may not be representative of the entire population.

The left femora of males and females of all ages were obtained. However, the sample was not limited to one side. In cases when an individual was identified and the left femur was unsuitable for sectioning, the right femur was used. Following measurement of the maximum and

Table 4.1

Enumeration of Femora by Site

	Site	Infant		Child		Adolescent		Adult				N		
		≤1 year		>1 - <13 years		13 - <20 years		M		F				
		L	R	L	R	L	R	L	R	L	R	L	R	T
	Cameron's Point	3	-	6	-	2	-	2	-	1	-	14	-	14
Middle Woodland	LeVesconte[1]	1	1	9	2	-	-	2	1	3	-	15	4	19
	Serpent Mounds	7	-	12	2	6	-	23	2	13	-	61	4	65
	Serpent Pits	-	-	4	-	4	-	17	-	6	-	31	-	31
Early Ontario	Miller[2]	1	-	1	-	2	-	5	1	1	2	10	3	13
Iroquois	Bennett	-	-	1	-	1	-	1	-	2	-	5	-	5
	Richardson	-	-	-	-	-	-	1	2	-	2	1	4	5
Middle Ontario Iroquois	Orchid	-	-	14	-	9	-	103	-	63	-	189	-	189
	N	12	1	47	4	24	-	154	6	89	4	326	15	
	T	13		51		24		160		93		341		

[1] LeVesconte specimen LMB 40.48 shattered during sectioning and could not be reconstructed

[2] Miller sample B9 was omitted from analysis

physiological lengths and the transverse and sagittal midshaft diameters, each femur was cut transversely at midshaft and a section one centimeter in length was removed. The sections were cut so that the distal surface of each corresponded to the midpoint of the diaphysis from which it was removed to ensure uniformity between specimens. Femora that were damaged at their ends post-mortem were not excluded from sampling. These were lined up in series according to size and the midpoint of each was estimated using anatomical criteria. Following sectioning, the distal end of each specimen was lightly sanded in order to ensure a flat surface.

4.2 Methods

Past investigations of cortical bone have relied upon roentgenograms to determine bone thickness and areas (Garn 1970; Himes et al 1975). Several researchers have demonstrated that there are substantial errors inherent in this technique. Van Gerven and co-workers (1969) state that radiographic insensitivity to endosteal porosity may introduce substantial errors in measurements of cross-sectional areas, and that studies using roentgenograms are based on the assumption that medial and lateral wall thicknesses would be representative of the mean cortical thickness of the bone. In contrast to direct measurement of bone samples, it was demonstrated that:

> errors of up to 11.7% were produced by the inability of the x-ray process to distinguish compact from porous bone, while errors to 26.6% were produced by sampling bias resulting from the two-dimensional nature of the x-ray image allowing only two measurements of cortical thickness and one of periosteal diameter (Van Gerven 1973:pf.40).

Direct measurement of bone was used in this study.

The traditional method of direct area measurement follows that of Sedlin, Frost and Villanueva (1963). A grid of known area is superimposed over the bone section. The number of line intersects occurring over bone is then counted. The area is computed by multiplying the number of intersects by the total grid area, and dividing by the total number of possible line intersects in the grid. This method is time-intensive, especially when a large number of samples are being processed. In order to facilitate the measurement of the samples and reduce intraobserver error, a Kroton MOP Video-Plan Morphometric and Stereological electronic digitizer and the Video-Plan standard software package were used. Next, 1:1 images of cross-sections were placed onto the system tablet, and the subperiosteal boundary was manually traced three times with a stylus. After each individual tracing, the software programme computed the total subperiosteal area (TA) and the circumference of the sample. When the three tracings were completed, the programme averaged the three readings for both TA and circumference. Next, the endosteal boundary was traced three times. In each case, the programme calculated the medullary area (MA) and averaged the readings after the third tracing. The programme then computed the cortical area (CA) by subtracting MA from TA and calculated the per cent cortical area (PCA) using the formula: PCA = (CA/TA) x 100. A sample printout of the Video-Plan system is presented in Figure 4.1

Data concerning each sample (site, time period, sex, age, circumference, TA, MA, CA, PCA and side) were entered into a Vax computer terminal for statistical analysis using the Minitab statistical package. It would be ideal to know the sex and age for each sample. Whenever possible, macroscopic ageing and sexing techniques were utilized. However, the Orchid site sample comes from an ossuary, and the Miller, Bennett and the pit burials at the Serpent Mounds site are also multiple interments. This leads to several complicating factors. Ossuary burials are:

> large pits [which] yield the common graves of hundreds of individuals whose parts are incomplete and are totally dissociated and severely damaged. Demographic studies which depend on accurate determination of age and sex of individuals become not merely a challenge, but a complex jigsaw puzzle with many of the parts withheld from the player (Anderson 1964:29).

Figure 4.1
Video-Plan Printout of the Miller Site Sample
(Legend on next page)

CHAN	COUNT	AREA 1	PERIM 1	AREA 2	PERIM 2	AREA 3
5	1	624.42	91.82	636.22	93.10	626.92
4	1	562.43	89.95	559.46	89.79	558.67
5	2	569.83	88.59	562.50	87.68	558.82
5	3	642.19	93.48	643.11	93.66	630.73
2	1	148.90	44.29	143.97	43.88	146.47
5	4	504.03	84.43	500.76	84.24	500.94
4	2	540.94	88.46	532.87	88.38	532.59
4	3	441.14	78.03	441.20	78.07	440.53
4	4	515.65	83.40	515.65	83.14	509.56
5	5	554.66	85.24	553.23	85.16	545.07
5	6	657.41	95.00	654.50	95.12	657.88
1	1	31.46	20.29	29.56	19.76	28.92
3	1	411.94	74.20	410.99	74.54	420.49
3	2	485.42	79.71	488.95	80.36	491.73

CHAN	COUNT	PERIM 3	AREA 4	AREA 5	AREA 6	AVEPER
5	1	92.75	168.80	172.04	173.03	92.56
4	1	89.76	143.40	148.16	146.99	89.83
5	2	87.26	171.19	170.32	172.76	87.84
5	3	92.03	259.63	263.14	262.53	93.06
2	1	44.09	35.84	36.12	37.54	44.09
5	4	83.87	119.28	122.19	122.04	84.18
4	2	87.94	105.85	105.16	107.46	88.26
4	3	77.92	182.10	186.40	182.70	78.00
4	4	82.87	314.07	318.83	319.55	83.14
5	5	84.34	84.95	85.84	86.52	84.91
5	6	94.77	225.26	225.45	223.76	94.97
1	1	19.46	2.08	3.28	3.49	19.83
3	1	75.04	77.07	77.16	78.32	74.60
3	2	80.39	79.73	81.89	80.83	80.15

CHAN	COUNT	AVETA	AVEMA	CA	%CA
5	1	629.19	171.29	457.90	73.0
4	1	560.19	146.18	414.00	74.0
5	2	563.72	171.42	392.29	70.0
5	3	638.68	261.77	376.91	59.0
2	1	146.45	36.50	109.95	75.0
5	4	501.91	121.17	380.74	76.0
4	2	535.47	106.16	429.31	80.0
4	3	440.96	183.73	257.22	58.0
4	4	513.62	317.48	196.14	38.0
5	5	550.99	85.77	465.22	84.0
5	6	656.60	224.82	431.77	66.0
1	1	29.98	2.95	27.03	90.0
3	1	414.47	77.52	336.96	81.0
3	2	488.70	80.82	407.88	83.0

LEGEND FOR FIGURE 4.1

CHAN	- Storage area on disc for each specimen by age and sex: 1 = infant 2 = child 3 = adolescent 4 = adult female 5 = adult male 6 = adult of unknown sex
COUNT	- Number the computer assigned to each specimen as it was entered into each channel. The numbers were assigned consecutively.
AREA 1-3	- Total subperiosteal area (TA) recorded in mm^2 for each tracing of the periosteal boundary of each specimen.
PERIM 1-3	- Circumference recorded in mm for each tracing of the periosteal boundary of each specimen.
AREA 4-6	- Medullary area (MA) recorded in mm^2 for each tracing of the endosteal boundary of each specimen.
AVEPER	- Average circumference calculated as: (PERIM1 + PERIM2 +PERIM3)/3.
AVETA	- Average TA calculated as: (AREA1 + AREA2 + AREA3)/3.
AVEMA	- Average MA calculated as: (AREA4 + AREA5 + AREA6)/3.
CA	- Cortical area calculated as: AVETA - AVEMA.
%CA	- Per cent cortical area calculated as: (CA/TA) x 100.

In such cases, it is impossible to determine the age of every bone fragment and set a mean age. A working definition of 'adult', based on the complete closure of the epiphyses, was adopted.

Ruff and Hayes (1983b) have demonstrated that there are side and sex differences in cortical bone area. These authors suggest that there is a general trend to greater cortical bone area in the left femoral diaphysis than in the right. In females, midshaft cortical bone area is significantly greater in the left femur than in the right.

Due to sex differences in cortical bone area, it is desirable to separate the adult samples into male and female categories. To achieve this, Black's (1978) femoral midshaft circumference sexing technique was used. The results of this are reported in the following chapter.

The determination of the sex of subadults is difficult even when a complete skeleton is available for examination. Ubelaker (1978) suggests that in most cases, 'it is advisable to limit identification of sex to mature skeletons where the sources of error are significantly less' (p.42).

Infant bones are fragile, and their preservation is often poor. Thus, they are often under represented in archaeological populations. Additionally, during the Late Ontario Iroquois stage, infants were often excluded from ossuary burial. Instead, they were either buried inside the longhouse, or on or along pathways so that the souls of the infants could enter women's wombs as they passed by (Heidenreich 1978). Even when the sites within a time period were combined, the subadult categories do not contain enough samples to be statistically significant. Only the combined adult categories yielded statistically significant samples.

The loss of cortical bone is also age related. Dewey and co-workers (1969) found that bone loss due to age was significant among females in archaeological populations from Sudanese Nubia, but not among males from the same populations. In a study of 21 females and 19 males from the Campbell Site, Missouri, Carlson and co-workers (1976) found that:

> Both females and males tend to lose bone tissue, as measured by cortical thickness and cross-sectional area, throughout the length of the femur diaphysis with increasing age, with females losing the greater amounts (p.309).

Studies by Ruff and Hayes (1983b) and Mensforth and Lovejoy (1985) also point to decreasing cortical areas with age, particularly among females.

CHAPTER V

RESULTS

5.1 Femoral Midshaft Circumference Sexing

Pfeiffer (1979) states that in the analysis of a skeletal series: 'As long as males and females are mixed, the descriptive statistics have high coefficients of variation and sex-influenced differences in morphology are obscured' (p.55). As noted above (p.43), there is evidence of sexual dimorphism in cortical bone areas. In order to examine temporal changes in bone areas, some attempt must be made to divide a sample into males and females.

Black (1978) points out that: ' ... most of the techniques presently available for the sexual assessment of human skeletal remains can be used only on well-preserved bones from relatively complete skeletons' (p.227), and that few reliable methods for sexing poorly preserved, fragmentary or mixed skeletons exist. When intermingled in multiple interments, even well preserved bones can cause problems of sexing. Such is the case in this study where, of 253 adult femora available for sampling, only 52 individuals (32 M, 20 F) could be assigned sex by macroscopic methods. To divide the remainder of the sample, Black's femoral midshaft circumference sexing technique was used.

It is accepted that generally, males are larger than females and that male skeletons are more robust than those of females. Black states that male bones remain larger than female bones throughout adult life and that dimorphism in bone diameters is 'due to sexual differences in bone remodeling in the tubular bones during adolescence' (Ibid.). In particular, sexual dimorphism in the widths, circumferences and areas of the long bones often exceeds sexual dimorphism in bone lengths. Black's method is to take a skeletal sample of known sex and measure the circumference of the femoral midshaft. The male and female means for midshaft circumference are calculated and the midpoint between these means is used as the cut-off value for assigning sex. Based on a sample from the Libben site, Ontario County, Ohio, Black generated a cut-off value of 81.2mm. Individuals with a circumference greater than the cut-off value were classified as males, those with a lesser circumference were classified as females. The results of this simple analysis compared favorably with the results of the macroscopic sexing techniques used on the Libben site. When individuals of morphologically determined sex were tested, this method consistently assigned sex to 87.7% (50 of 57) of the males and to 82.0% (41 of 50) of the females.

The cut-off value generated by Black was applied to the individuals of morphologically determined sex used in this study. This time the results did not compare favorably. Although 96.9% (31 of 32) of the males were consistently assigned sex, only 55.0% (11 of 20) of the females were consistently assigned sex (Table 5.1). This was not unexpected as Black states that: 'It is unlikely that two biologically distinct populations would be correctly sexed by the same function' (p.230), and that a new cut-off value should be calculated for each population. Unfortunately, most of the sites used in this study have either too few or no adults of morphologically determined sex to compute a cut-off value based on femoral midshaft circumference for each. The exception to this is the Serpent Mounds site, which contains 28 adults of morphologically determined sex. This site yielded a cut-off value of 83.7mm. Since Molto (1983) suggests that there was genetic continuity between the Middle and Late Woodland peoples of southern Ontario, it is felt that in lieu of a cut-off value for each population, the Serpent Mounds cut-off value could be applied to the entire sample population.

When applied to the sample of morphologically determined sex, the Serpent Mounds cut-off value consistently assigned sex to 84.4% (27 of 32) of the males and to 80.0% (16 of 20) of the females (Table 5.1). Black

Table 5.1
Results of Femoral Midshaft Circumference
Sexing Compared Against Sample Whose Sex was Morphologically Determined

Cut off value	Percent Correctly Classified		
	Male	Female	Total
81.2mm (Black)	96.9	55.0	80.8
83.7mm (SM reference population)	84.4	80.0	82.7

Table 5.2
Breakdown of Adult Sample by Sex

	M	% M	F	% F	Total	% Total
MW	30	63.8	17	36.2	47	100.00
EOI	27	67.5	13	32.5	40	100.00
MOI	103	62.0	63	38.0	166	100.00
Total	160	63.2	93	36.8	253	100.00

suggests that 85 - 89% represents high accuracy for cut-off values using only one measurement; therefore these results demonstrate a fair degree of confidence in the cut-off value computed here. The breakdown of the adult sample by sex using the Serpent Mounds cut-off value can be seen in Table 5.2.

These results compare favorably with published reports on two of the sites used in this study. In his analysis of the later pit burials at the Serpent Mounds site, Anderson (1968) noted that of the 42 crania that were assigned sex, 71.4% (N=30) were male and 28.6% (N=12) were female. Using the femoral midshaft technique and the Serpent Mounds cut-off value, 74.0% (17 of 23) of the femora used in this study were sexed as male and 26.0% (6 of 23) of the femora were sexed as female.

Cybulski (1967) noted that of 197 reconstructed crania from the Orchid site that were assigned sex, 57.4% (N=113) were male and 42.6% (N=84) were female. As noted in Table 5.2 above, the adult sex ratio for the Orchid site, as derived by the femoral midshaft technique, is 62.0% male (N=103): 38.0% female (N=63).

Other femoral measurements such as maximum head diameter and maximum length have been used to assign sex to skeletal samples (Pfeiffer 1979). However in order to maximize sample size in this study, it was necessary to include fragmentary femora which could not always be reconstructed to permit measurements and diagnostic features such as the femoral head were sometimes broken off and lost. Therefore it was necessary to use a technique for the determination of sex that would work with fragmentary remains and with individual bones.

5.2 Results of Analysis

Tables 5.3 - 5.5 and Figures 5.1 - 5.3 present the descriptive statistics and plots of the subadult samples used in this study. As can be seen, in most cases the sample sizes are not large enough to be tested statistically. Also, as there is rapid growth of bone during the subadult years which can cause rapid changes in bone areas (Garn 1970; Hummert 1983), the use of gross age categories may obscure possible secular trends in bone areas within each age category. In studies of bone loss in juveniles, Huss-Ashmore (1981) and Keith (1981) used age categories with one-year increments to demonstrate that there can be substantial changes in per cent cortical area in stressed populations of subadults. If such one-year increments were used in this study, sufficient sample sizes would not be reached. As noted in the previous chapter, only the adult sample reaches sufficient sample size.

Table 5.3
Descriptive Statistics of PCA of the Infant Sample

	N	$\bar{X}$	Median	Min	Max	S.D.	S.E.	V
MW	12	83.97	84.30	76.50	90.00	3.95	1.14	4.70
EOI	1	90.20	90.20	90.20	90.20	---	---	---
MOI	--	---	---	---	---	---	---	---

Table 5.4
Descriptive Statistics of PCA of the Child Sample

	N	$\bar{X}$	Median	Min	Max	S.D.	S.E.	V
MW	31	65.95	67.20	51.10	85.80	6.93	1.25	10.51
EOI	6	70.93	71.15	65.30	75.10	3.89	1.59	5.48
MOI	14	73.76	75.05	63.30	85.10	6.84	1.83	9.27

Table 5.5
Descriptive Statistics of PCA of the Adolescent Sample

	N	$\bar{X}$	Median	Min	Max	S.D.	S.E.	V
MW	8	70.14	73.95	41.00	83.50	13.59	4.80	19.38
EOI	7	78.61	81.30	70.60	83.50	5.81	2.20	7.39
MOI	9	78.29	78.30	69.60	84.60	5.31	1.77	6.78

Figure 5.1
Plots of Infant Sample PCA

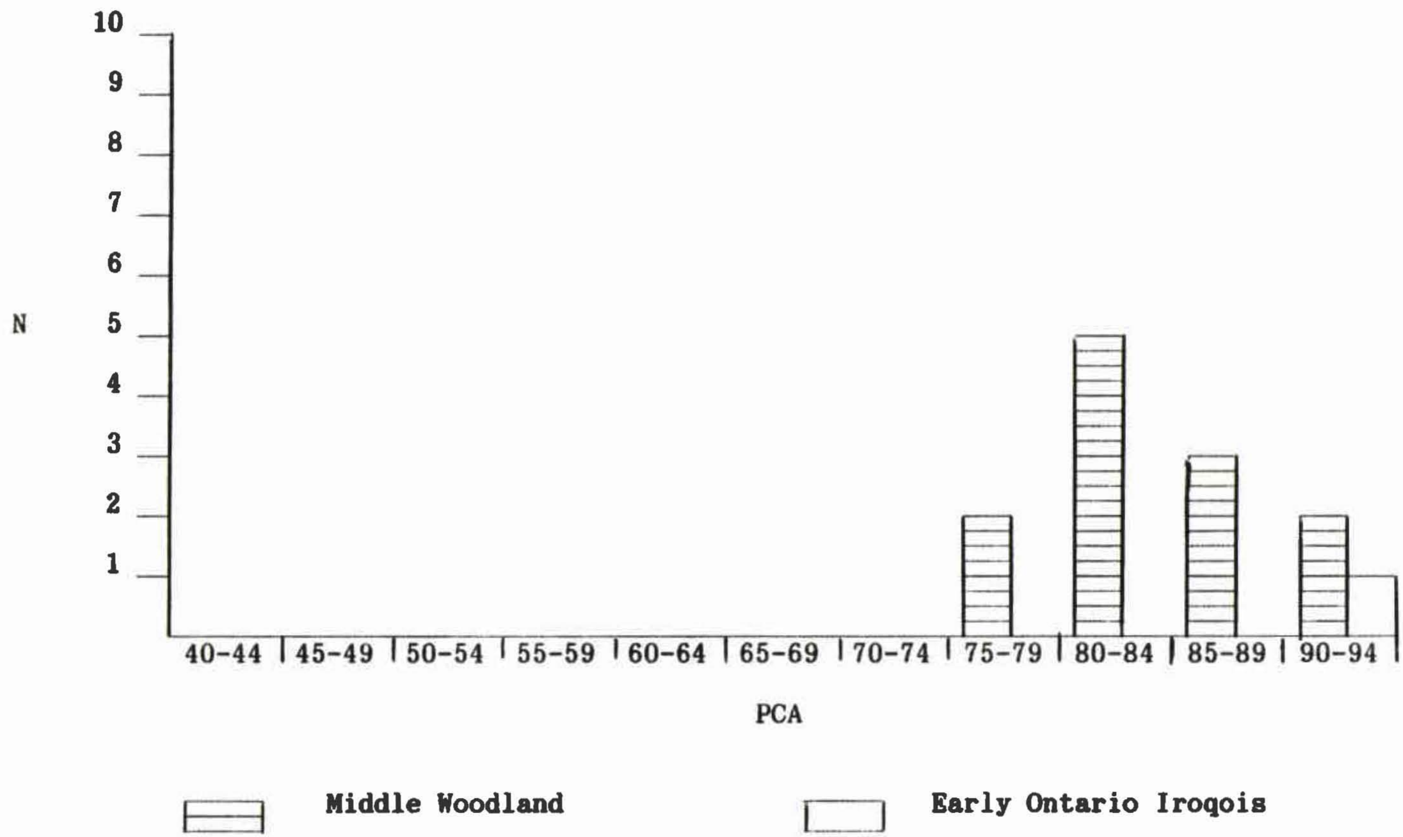


Figure 5.2
Plots of Child Sample PCA

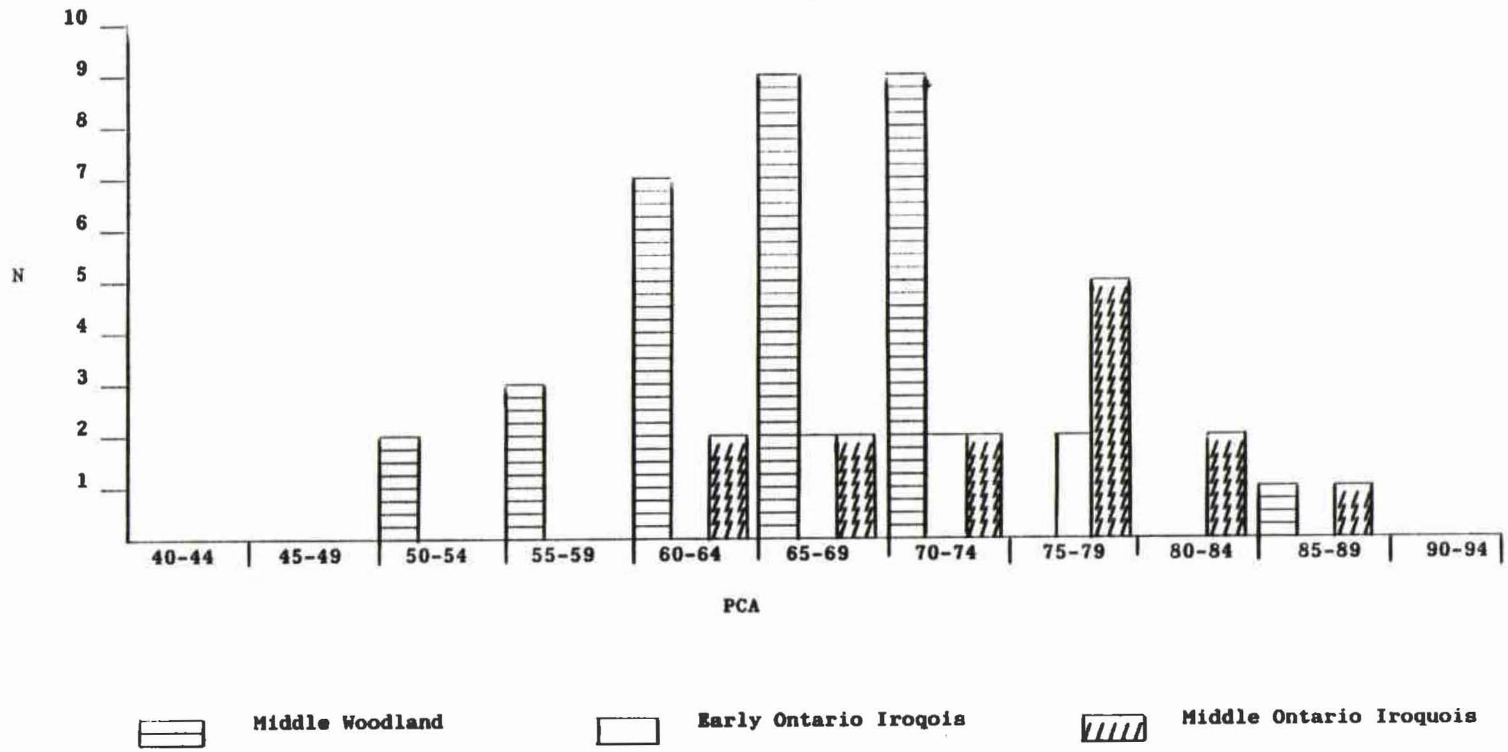
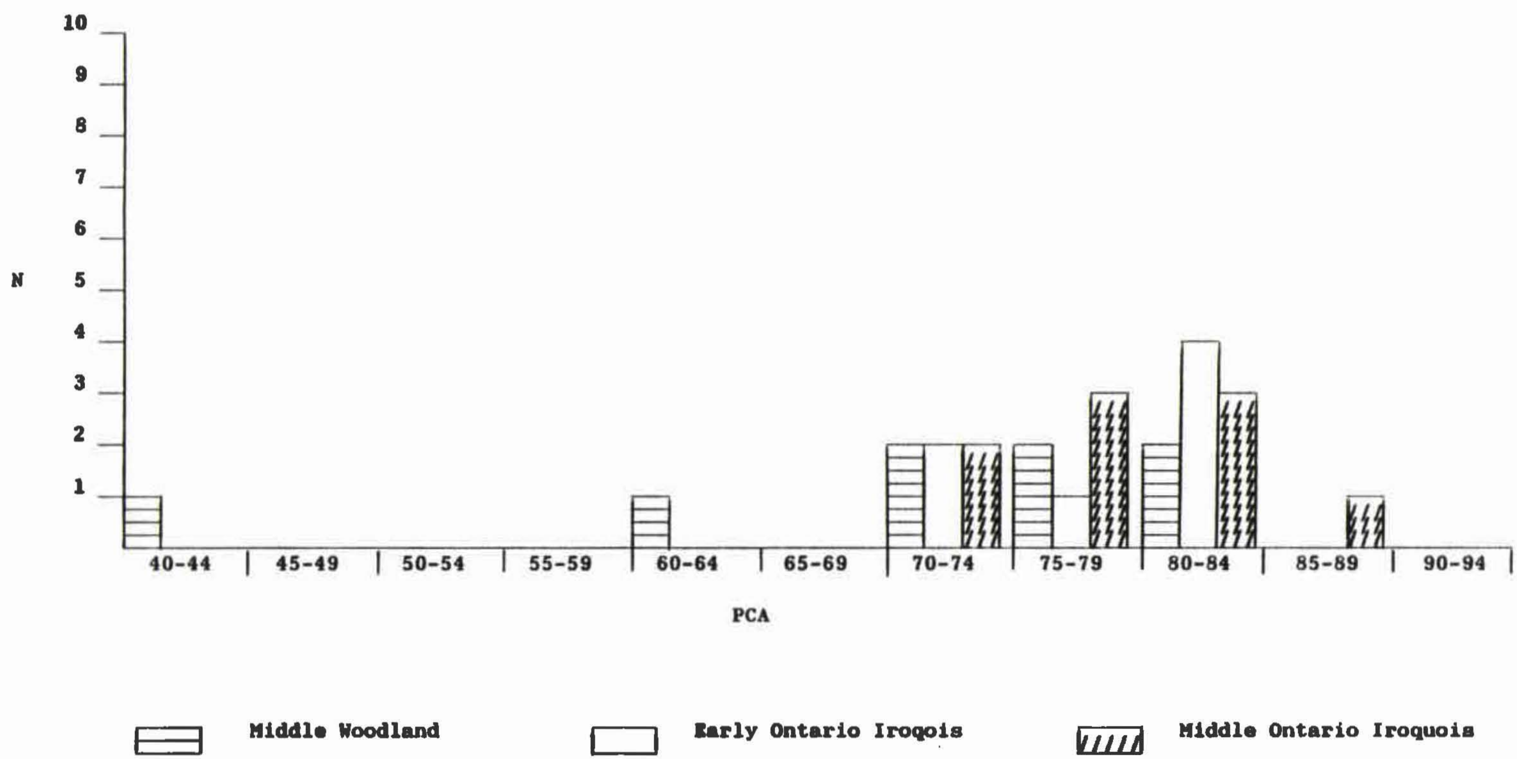


Figure 5.3
Plots of Adolescent Sample PCA



One specimen from the adult sample was excluded from analysis. Miller B9 registered a per cent cortical area of 38.2, which is over three standard deviations below the mean for Early Ontario Iroquois adults. In her report of the skeletal material from the Miller site, Ossenberg (1969) noted that B9 was found in the same grave as the remains of a second individual, B8. Both were identified as being females in their 30's. Only one vertebral column was found in the grave, and Ossenberg was unable to determine to which individual it should be assigned. The vertebrae of the column are osteoporotic and it is felt that, given the amount of endosteal resorption exhibited in the femoral cross-section of B9, the vertebral column could be assigned to B9.

The appearance of this cross-section is similar to the description of a particular condition reported by Mensforth and Lovejoy (1985). In a study of the skeletal correlates of the aging process, these authors note that with increasing age, both males and females from the Libben site experienced endosteal resorption and increasing intracortical porosity. 'The ultimate result of continued endosteal and intracortical bone resorption is a cortical shell' (op. cit.:95). Such a condition was found in only two Libben females aged 55+. Mensforth and Lovejoy published an illustration of the midshaft femur cross-section of one of these individuals (Ibid.:96, Fig.8, specimen h) and this cross-section and that of Miller B9 are remarkably similar. Given these similarities, it might have been possible to conclude that the initial age assessment of B9 was incorrect, and that an age of 50+ may be more appropriate. However, upon re-examination of the entire skeleton, an age assessment of 30 years based on morphological criteria is still appropriate for B9. Thus the extensive bone loss exhibited is probably pathological and not age-related. As noted in Chapter IV, pathological individuals were to be excluded from sampling; therefore Miller B9 was removed from the sample before statistical analysis.

Male and female descriptive statistics for cortical bone area (CA), medullary area (MA) and total subperiosteal area (TA) at the femoral midshaft for each time period are shown in Table 5.6. The data here demonstrate that in all but one case, there are significant differences in bone area distribution between the designated sexes. These differences are not unexpected, as Ruff and Hayes (1983b) also demonstrated sex differences in bone area distribution in their Pecos Pueblo sample.

A series of analyses of variance were performed on each cross-sectional area for each sex. These are summarized in Table 5.7. None of these cross-sectional

Table 5.6

Sex Differences in Bone Areas[1]

	Male								Female							
	N	$\bar{X}$	Median	Min	Max	S.D.	S.E.	V	N	$\bar{X}$	Median	Min	Max	S.D.	S.E.	V
CA																
MW	30	431.66[2]	429.09	333.12	507.86	41.15	7.51	9.53	17	349.20	347.30	206.90	465.00	59.40	14.40	17.01
EOI	27	438.20	452.70	356.70	556.50	54.70	10.50	12.48	13	351.40	372.30	257.20	435.50	62.00	17.20	17.64
MOI	103	446.26	449.33	290.08	568.42	49.12	4.84	11.01	63	361.74	360.10	292.27	459.74	35.29	4.45	9.76
MA																
MW	30	140.82	137.39	84.17	290.21	40.40	7.38	28.69	17	123.90	108.00	61.80	258.10	51.20	12.40	41.32*
EOI	27	157.40	149.60	85.50	280.00	52.00	10.00	32.62	13	116.30	107.70	57.30	214.50	44.00	12.20	37.83**
MOI	103	138.08	132.07	62.66	254.97	41.13	4.05	29.79	63	103.42	97.61	49.44	183.99	31.39	3.95	30.35
TA																
MW	30	572.50	569.50	482.30	700.00	59.10	10.80	10.32	17	473.10	466.80	395.30	660.50	61.60	14.90	13.02
EOI	27	597.60	577.50	501.90	748.00	65.80	12.70	11.01	13	467.70	484.00	345.80	560.20	54.60	15.20	11.67
MOI	103	584.34	583.60	494.03	695.25	45.82	4.51	7.84	63	465.18	462.19	376.95	535.66	37.09	4.67	7.97

[1] All sex differences significant at 0.001 level except: * not significant (p=0.25); ** significant at 0.011 level

[2] In mm^2

Table 5.7
Summary of ANOVAs of Cross-Sectional Areas
for Sex by Time Period[1]

	Male				Female		
Source	df	MS	F	Source	df	MS	F
				CA			
Between	2	2731	1.15	Between	2	1380	0.69
Within	157	2376		Within	90	1997	
Total	159			Total	92		
				MA			
Between	2	4893	2.65	Between	2	3210	2.29
Within	157	1849		Within	90	1403	
Total	159			Total	92		
				TA			
Between	2	4483	1.64	Between	2	424	0.21
Within	157	2725		Within	90	2019	
Total	159			Within	92		

[1] No significant differences noted

areas exhibited significant differences over time. As can be seen in Table 5.6, variation in all cross-sectional areas in the Middle Woodland and the Early Ontario Iroquois female samples is greater than in the Middle Ontario Iroquois female sample. The two earlier male samples show greater variation in total subperiosteal area than the Middle Ontario Iroquois male sample. Although these are not significant differences, these are suggestive of a greater number of older individuals contained in the samples of the two earlier time periods.

Bone is constantly added to the periosteal surface with increasing age in both sexes, with a resultant increase in total subperiosteal area (Ruff and Hayes 1983b). In females, endosteal resorption of bone with age is rapid and the rate of resorption appears to exceed the rate of subperiosteal expansion. A great amount of cortical bone is lost; thus cortical area is diminished. These age-related differences in cross-sectional areas are reported to be significant (Ruff and Hayes 1983b; Carlson et al 1976; Van Gerven 1973). In males, cross-sectional areas also exhibit age-related differences. Ruff and Hayes (1983b) report that TA and MA exhibit significant change with age. However, they and several other authors report that there is no significant age-related change in CA (Ruff and Hayes 1983b; Carlson et al 1976, Van Gerven 1973).

The lesser variation in all cross-sectional areas in Middle Ontario Iroquois females and the lesser variation in TA in Middle Ontario Iroquois males suggest that this sample may have a larger number of younger adults. In his study of the demography of the Orchid site, Cybulski (1967) indicates that this population had a generally short life span. Using multiple aging criteria (epiphyseal fusion of long bones, the development and change in the skull, the development and wear of the dentition and the pubic symphysis) only 5.7% of the Orchid ossuary population survived past the age of 50. Furthermore, the highest per cent of mortality of individuals who had reached the age of 20 had occurred within the 25 to 35 year range, with more than one-half of all adults dying by the age of 35. However as Garn (1970) demonstrated, in studies of bone loss per cent cortical area (PCA) is a more useful measure, for although TA, MA and CA may differ, adult PCA should be very similar in various populations. Therefore, variation in PCA between populations may indicate differences in stress loads.

Tables 5.8 and 5.9 and Figures 5.4 and 5.5 present the descriptive statistics and plots of the per cent cortical areas for the adult samples.

A one-way analysis of variance was performed comparing the mean per cent cortical areas of the three time periods for each sex. For the males, the F was not statistically

Table 5.8
Descriptive Statistics of PCA of the Adult Female Sample

	N	$\bar{X}$	Median	Min	Max	S.D.	S.E.	V
MW	17	74.00	76.60	44.50	86.50	9.81	2.38	13.26
EOI	13	75.05	76.50	55.70	88.40	9.17	2.54	12.22
MOI	63	77.88	78.60	63.40	90.30	5.89	0.74	7.56

Table 5.9
Descriptive Statistics of PCA of the Adult Male Sample

	N	$\bar{X}$	Median	Min	Max	S.D.	S.E.	V
MW	30	75.63	75.75	58.50	83.70	5.17	0.94	6.83
EOI	27	73.54	75.90	59.00	85.50	7.13	1.37	9.70
MOI	103	76.41	78.30	54.70	88.30	6.68	0.66	8.75

Table 5.10
Descriptive Statistics of PCA of the Combined Adult Sample

	N	$\bar{X}$	Median	Min	Max	S.D.	S.E.	V
MW	47	75.04	76.30	44.50	86.50	7.14	1.04	9.51
EOI	40	74.03	76.10	55.70	88.40	7.77	1.23	10.50
MOI	166	76.97	78.30	54.70	90.30	6.42	0.50	8.34

Figure 5.4
Plots of Adult Female Sample PCA

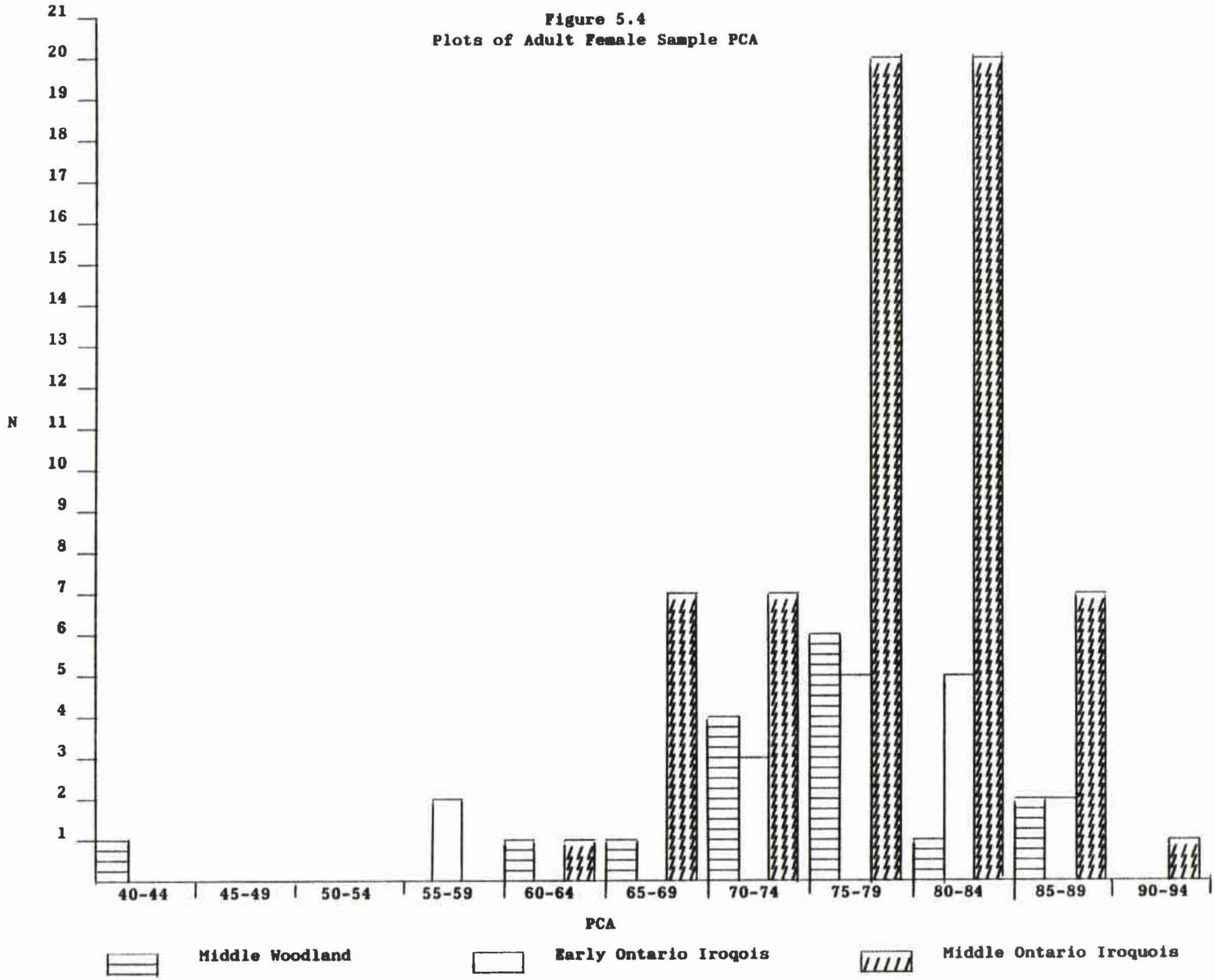
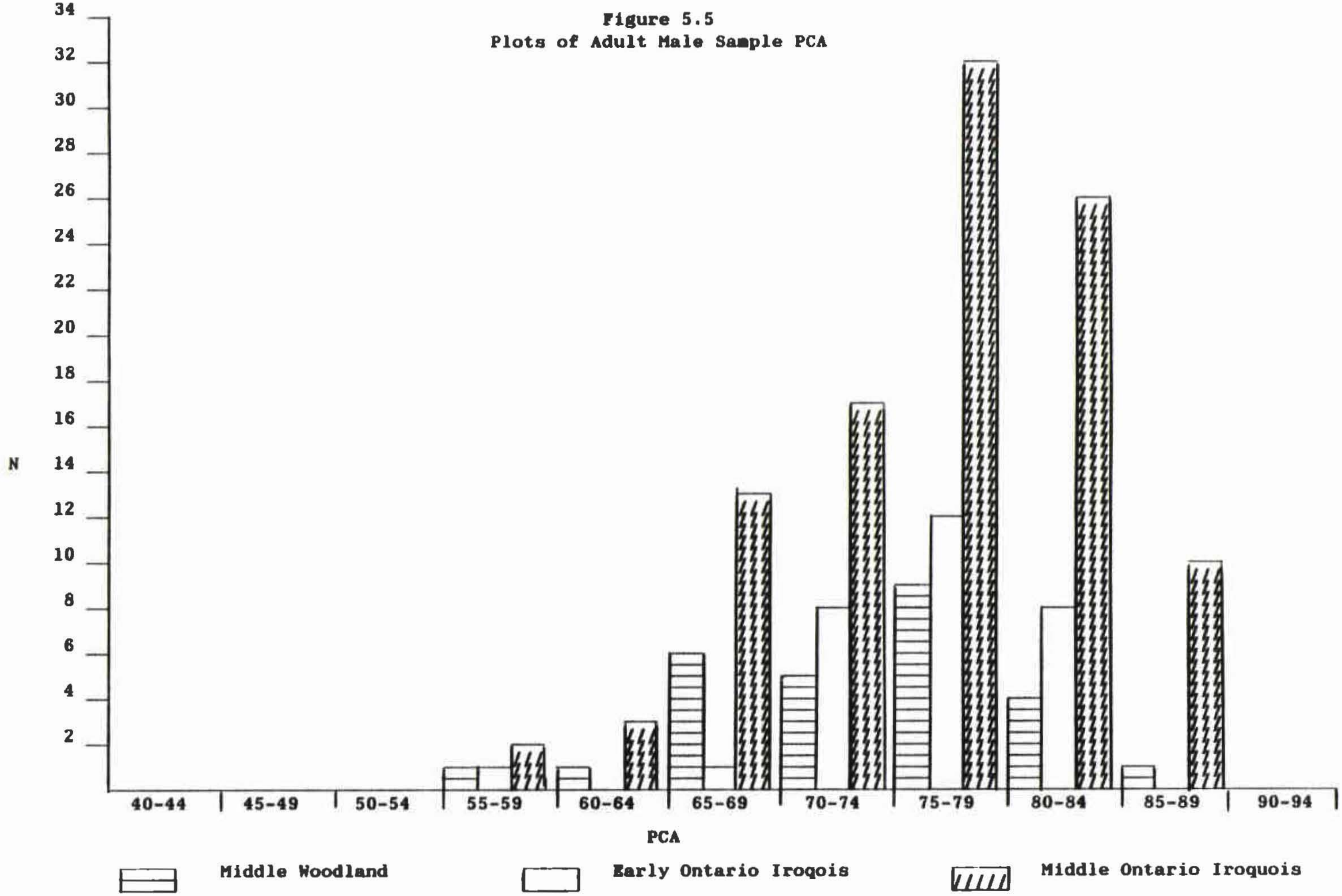


Figure 5.5
Plots of Adult Male Sample PCA



significant ($F=2.09, df=2,157$, ns). The strength of the effect, as indexed by eta^2, was .026. For the females, the F was also not statistically significant ($F=2.36, df=2,90$, ns). The strength of the effect, as indexed by eta^2 was .050. Both of these eta^2 values show only a weak relationship between time period and per cent cortical area.

A series of t-tests was performed comparing the mean per cent cortical areas of males and females for each of the three time periods. For the Middle Woodland samples, the t was not statistically significant ($t=0.64, df=21.1$, ns) indicating that the mean score for males (75.63) did not differ significantly from the mean score for females (74.00) at the 0.05 level. For the Early Ontario Iroquois samples, the t was not statistically significant ($t=-0.52, df=19.3$, ns) indicating that the mean score for males (75.63) did not differ significantly from the mean score for females (75.05) at the 0.05 level. Finally, for the Middle Ontario Iroquois samples, the t was not statistically significant ($t=-1.48, df=143.9$, ns) indicating that the mean score for males (76.41) did not differ significantly from the mean score for females (77.88) at the 0.05 level. Eta^2 for each of the three time periods (0.020, 0.014 and 0.015 respectively) supports a weak relationship between the variables sex and per cent cortical area.

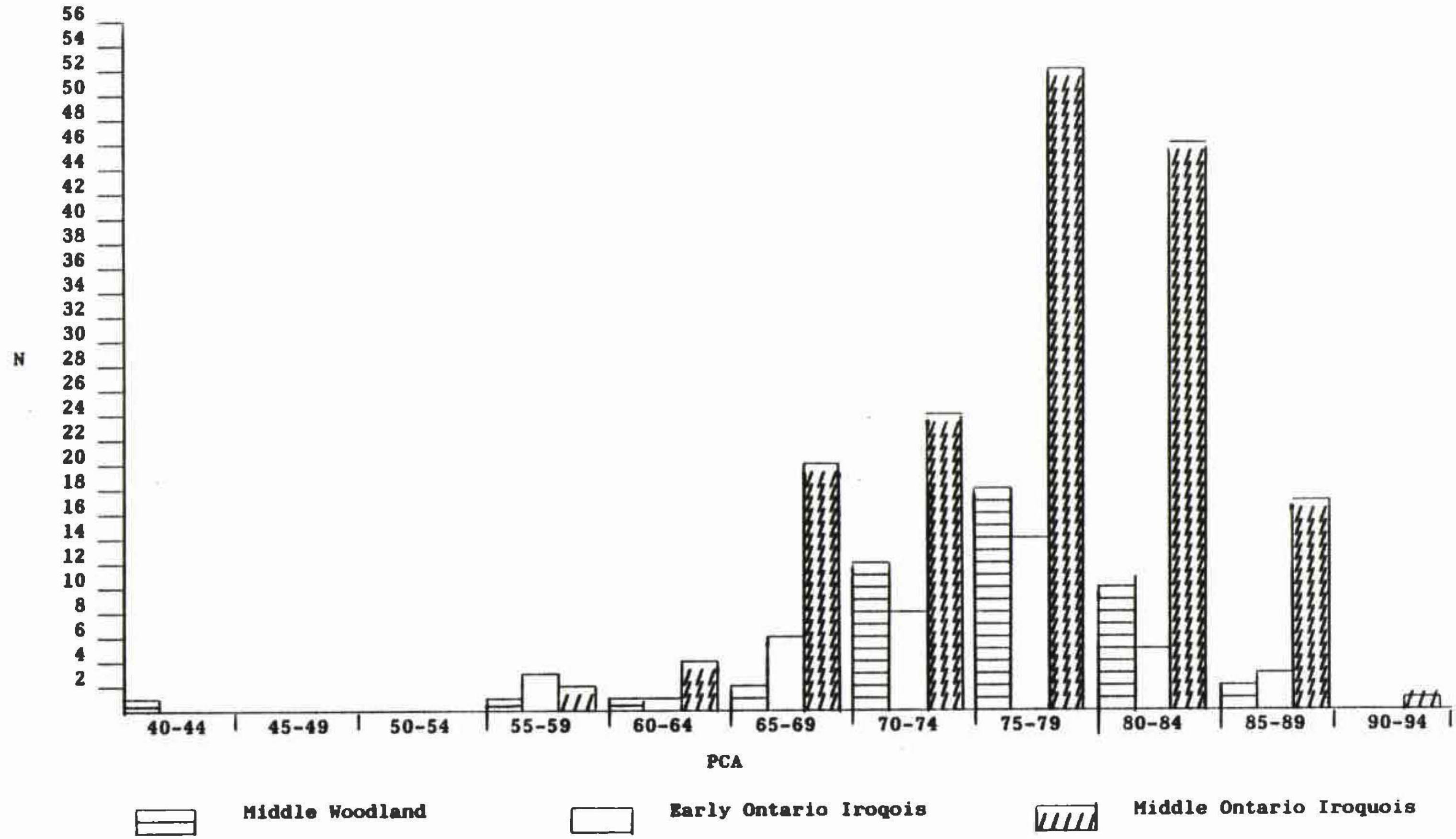
Since no statistical difference in per cent cortical area between males and females was demonstrated in this study, the adult samples within each time period were combined. Table 5.10 and Figure 5.6 present the descriptive statistics and plots for the per cent cortical area for the combined adult samples. A one-way analysis of variance was then performed comparing the mean per cent cortical areas of the three time periods for combined sex. The F was statistically significant ($F=3.79, df=2,250, p<0.05$). An HSD test was performed and indicated that the mean score for the Middle Ontario Iroquois sample (76.968) was statistically significantly different from the mean score for the Early Ontario Iroquois sample (74.030). The mean score for the Middle Woodland sample (75.040) did not differ significantly from either of these groups. The strength of the effect, as indexed by eta^2, was 0.029. This represents a weak relationship and indicates that only 2.9% of the variation in per cent cortical area is associated with time period.

The assumptions that underlie both a t-test and an ANOVA are:

1) normal distribution of scores;
2) homogeneity of variances and
3) independent and random samples.

These samples are moderately skewed to the left, and homogeneity of variances is not demonstrated. However, Jaccard (1983) suggests that both of the above tests are relatively robust to violations of these assumptions,

Figure 5.6
Plots of Combined Adult Sample PCA



especially when the number of observations is greater than or equal to 10.

As a check of the above results, nonparametric tests were performed. These tests make no assumptions about the nature of population distribution, although they are less statistically powerful. A Mann-Whitney U-test (the nonparametric counterpart of a t-test) was performed comparing the mean per cent cortical area of males and females for each of the three time periods. In all cases, the null hypothesis could not be rejected at alpha = 0.05.

A Kruskal-Wallis test (the nonparametric counterpart of an ANOVA) was performed comparing the mean per cent cortical area of the three time periods for each sex. The H statistic was not significant for either males ($H=3.356, df=2, ns$) or females ($H=74.523, df=2, ns$). A Kruskal-Wallis test was then performed comparing the mean per cent cortical area of the three time periods for combined sex. This time the H was statistically significant ($H=7.624, df=2, p<0.05$). The strength of the effect, as indexed by eta^2, was only 0.022, showing again a weak relationship between per cent cortical area and time period.

CHAPTER VI

DISCUSSION

Cohen and Armelagos (1984) have edited a recent book on the correlations between the shift in subsistence strategy from a diffuse economy to a focal economy based on agriculture and health status. In this work, several authors (Cook 1984; Goodman et al 1984; Perizigian et al 1984) demonstrate higher frequencies of markers of poor health in agricultural populations as opposed to preagricultural populations. These results are not conclusive, as some authors (Rose et al 1984) have noted improvements in health with the adoption of agriculture. The general pattern, however, is towards a decline in health.

As an overall trend, this study suggests that there is little evidence of nutritional stress over time. The agricultural Middle Ontario Iroquois population studied here had the highest overall mean per cent cortical areas. As outlined in Chapter III, although southern Ontario prehistoric aboriginal populations underwent a shift in subsistence strategy, nutritional variety does not appear to have been compromised. Hodges (1987) notes that there was no decline in health with the intensification of agriculture in prehistoric Oaxaca, Mexico, and that this: 'may be related in part to the continuation of a diversified diet, a diet based on cultigens and wild foods' (p.229). The data presented here support Hodges' contention that;

> ...the development of agriculture was less detrimental to health in populations that raised a variety of cultigens than in populations in which the variety of cultigens was limited (Ibid.:230).

However, the Early Ontario Iroquois sample was statistically significantly different from the Middle Ontario Iroquois sample, and had the lowest overall mean per cent cortical area. There are several possible explanations for this.

The possibility that the Middle Ontario Iroquois sample being studied here is composed of younger individuals has been discussed in Chapter V. If an unequal age distribution biased towards younger individuals does exist in this Middle Ontario Iroquois sample, then possible differences in cross-sectional bone areas may be masked. A younger adult population would have higher cortical and per cent cortical areas and lower medullary and total subperiosteal areas than populations that included more elderly individuals. To see if such an event has occurred, the results of this study should be checked against other Middle Ontario Iroquois samples such as Fairty and Tabor Hill, which may have more elderly individuals in their respective samples. However, to be certain of this, the demographic breakdown of these samples should be re-examined (Jackes 1986). Conversely, the Early Ontario Iroquois samples used in this study may have an over representation of older people. This is harder to determine, as of the 40 adult individuals that comprise this portion of the sample, 23 could not be assigned a morphological age estimate.

The presence of more younger adults in the Middle Ontario Iroquois sample used in this study may reflect earlier mortality due to poor health. However in her dissertation, Clabeaux (1967) indicates that the Orchid site population was fairly healthy with low rates of occurrence of non-specific infection and metabolic and circulatory disorders. It is possible that the extant Orchid site population may be an artifact of sampling. At most, the excavated sample represents about one-third of the total ossuary population. Another third was destroyed by bulldozer activity and perhaps one-third could not be excavated due to time restrictions placed on the excavation (White 1966). Therefore the extant sample may not accurately represent the health status or demographic profile of the ossuary population.

Assuming a normal distribution of age classes, it is not surprising that the Early Ontario Iroquois sample had the lowest mean per cent cortical area. This was the period in which the transition from a diffuse subsistence economy towards a focal economy took place. Both the Pickering and Glen Meyer branches adopted maize into their floral assemblages, and the former broadened their base to include beans later in the stage (Fecteau 1985). If an unsupplemented maize diet puts populations under nutritional stress, one may expect to see a change in health patterns and bone quality during this stage. In the best of all possible worlds, one would hope to have securely dated sites that would allow one to examine skeletal series from early Pickering sites which have maize but no beans in the floral assemblage and later sites which postdate the inclusion of beans into the diet. However, as noted in Chapter III, Pickering dates are unreliable and one cannot say with any degree of certainty which sites predate the inclusion of beans and which sites postdate the inclusion of beans into the diet.

Buikstra (1984) noted that in the Lower Illinois Valley, the Late Woodland peoples had increasing amounts of maize in the diet after A.D. 800. Beans, however were 'conspicuously absent from the west central Illinois archaeological record' (p.226), but were found further south in the American Bottom region at about A.D. 1000. Cook (1984) notes that Mississippian peoples made more extensive use of maize than did Late Woodland peoples, and suggests that:

> ...because we have very little evidence for nutritional disease or stress among Mississippian peoples, this low-protein staple food [maize] does not in itself account for the apparent ill health of late Late Woodland peoples. The incorporation of maize into the continuing collecting and seed-horticulture economy seems ultimately to have been of biological benefit (p.261).

It may be argued that the inclusion of beans into the later diet made it nutritionally sound by off-setting the nutritional deficiencies in maize. This appears to be the same situation that occurred with the Pickering peoples.

There is a possibility that compact bone does not exhibit cortical involution as readily as trabecular bone. There are several considerations which weigh against the use of trabecular bone in this study. On a practical level, trabecular bone does not survive as well as cortical bone in an archaeological context. Additionally, cross-sections taken from areas of extensive cortico-endosteal trabecular bone are harder to trace on the digitizer, thus increasing the probability of observer error.

Trabecular bone and cortical bone are reported to react to physiological stress in similar ways (Martin et al 1985). However the magnitude of this reaction can vary. In a study of the loss of skeletal calcium in lactating women, Atkinson and West (1970) demonstrated a 3% loss of bone at trabecular sites and a corresponding 6% loss of cortical bone. On the other hand, Mazess (1979) states that:

> ...it seems reasonable to assume that trabecular

> bone could show a 50% greater difference than compact bone between patients and normals, and that the rate of change in the trabecular bone in patients could be five times greater than in compact bone (p.89).

Compact bone has also been used successfully in studies to demonstrate bone loss and maintenance (Dewey et al 1969; Martin and Armelagos 1979; Carlson et al 1976; Armelagos et al 1972). If a physiological stress is chronic, both trabecular and compact bone will be affected. Goodman and co-workers (1984) state that:

> Because cortical bone is in a constant state of remodelling by resorption and deposition, introduction of any stress which seriously affects metabolism may alter the rate of remodelling (p.20).

Therefore the use of compact bone in this study is justified.

Different levels and types of activity may have an effect on cross-sectional distribution of cortical bone over time. Ruff and co-workers (1984) have analyzed cross-sectional geometric properties of femora from preagricultural and agricultural subsistence strategy groups from the coastal region of Georgia, U.S.A. The authors report significant declines in almost every cross-sectional bone property in the agricultural group, and argue that this strongly suggests a reduction of mechanical loading of the femur in the agricultural group. However, when standardized for equivalent bone length, the relative cross-sectional area of bone remains the same. Thus the spatial distribution of bone area is different in the two groups, with the bone tissue of the agricultural sample being more tightly distributed around the centre of the sections.

Finally, there is the possibility that any nutritional stress experienced by prehistoric aboriginal populations in Ontario may not be severe enough to cause abnormalities in cortical bone remodelling rates. If this is the case, other markers of physiological stress, such as Harris lines, porotic hyperostosis and histological structures in bone, should be examined.

Comparative data for cross-sectional bone areas for aboriginal North American populations are scanty, with most reported values coming from biomechanical studies. Ruff and Hayes (1983a,b) examined 119 individuals from Pecos Pueblo, New Mexico, in a biomechanical study of cross-sectional bone geometry. As mentioned above, Ruff, Larsen and Hayes (1984) studied structural changes in the femur with the transition to agriculture in coastal populations of Georgia. Sumner (1984) examined size, shape and bone mineral content of the femur in a population from Grasshopper Pueblo, Arizona. The comparative data from these investigations as well as the data from this study are summarized on table 6.1.

In general, the Ontario groups have the highest values for cross-sectional areas. There are cases where the

Table 6.1

Mean Femoral Cross-Sectional Bone Areas: Comparative Data

Males

		CA		MA		TA		PCA	
	N	$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE
Middle Woodland	30	431.66	7.51	140.82	7.38	572.50	10.80	75.63	0.94
Early Ontario Iroqois	27	438.20	10.50	159.40	10.00	597.60	12.70	73.54	1.37
Middle Ontario Iroqois	103	446.26	4.84	138.08	4.05	584.34	4.51	76.41	0.66
Georgia Preagricultural[1]	8	420.00	24.90	147.80	16.10	567.80	20.30	74.00	---
Georgia Agricultural[1]	11	396.10	11.80	105.10	7.80	501.20	15.20	79.00	---
Grasshopper Pueblo[2]	7	385.00	---	---	---	---	---	---	---
Pecos Pueblo[3]	59	358.90	4.80	140.50	4.70	449.30	5.90	71.90	---

Females

		CA		MA		TA		PCA	
	N	$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE
Middle Woodland	17	349.20	14.40	123.90	12.40	473.10	14.90	74.00	2.38
Early Ontario Iroqois	13	351.40	17.20	116.30	12.20	467.70	15.20	75.05	2.54
Middle Ontario Iroqois	63	361.74	4.45	103.42	3.95	465.18	4.67	77.88	0.74
Georgia Preagricultural	12	326.20	16.20	162.20	17.30	488.50	13.80	66.80	---
Georgia Agricultural	9	264.20	12.60	100.40	8.00	364.70	17.30	72.40	---
Grasshopper Pueblo	6	301.00	---	---	---	---	---	---	---
Pecos Pueblo	60	292.40	5.70	121.60	6.60	414.10	6.80	70.60	---

[1] Ruff, Larsen and Hayes 1984 [2] Sumner 1984 [3] Ruff and Hayes 1983

values for other sites fall within the range of values established for Ontario, and there is only one case (TA for females in preagricultural Georgia) where the Ontario value is not the highest. Whether these differences are significant cannot be tested as the individual observations for each of these studies have not been published.

Brock and Ruff (1988) examined diachronic change in the femoral diaphysis in skeletal series from Mew Mexico. Although no significant differences in bone areas were found, the authors note that: TA remained constant or increased throughout time in both males and females; MA increased throughout time in males but decreased in females; and CA increased or remained unchanged between the two earliest time periods, but decreased in the last time period. However, the areas reported in the study have been standardized by dividing by bone length^2, so the results have not been included on table 6.1.

CHAPTER VII

CONCLUSIONS

This study has attempted to assess the nutritional health status of prehistoric aboriginal populations of southern Ontario by examining femoral midshaft cross-sectional bone areas, in particular per cent cortical area (PCA), from several skeletal samples from three time periods. The results presented here are suggestive of an overall maintenance of a nutritionally varied diet. This is reflected in the maintenance of cortical bone quality over the three time periods under study. Three of the cross-sectional bone areas, cortical area, medullary area and total subperiosteal area, exhibit expected differences on the basis of sex, with females having smaller bone areas. However, when examined for cross-temporal change in these bone areas for each sex, no significant differences were noted.

An examination of PCA demonstrated diachronic variation amongst the samples. The Early Ontario Iroquois sample had a mean PCA that was significantly lower than that of the Middle Ontario Iroquois sample. This may be interpreted as an increase in nutritional stress due to the changes in dietary regime during the Early Ontario Iroquois period. However, this difference may be more apparent than real as the later Middle Ontario Iroquois sample may contain a greater number of younger adults. Furthermore, the Middle Woodland sample did not differ significantly from either Ontario Iroquois tradition sample. Further studies in this area should include:

A) an increase in the sample sizes of Middle Woodland and Early Ontario groups;

B) more individuals of morphologically assigned age and sex so that greater control can be exercised over these variables;

C) failing the above, more individuals of morphologically assigned sex should be used as a test for the midshaft circumference sexing technique used here;

D) a greater number of subadults from all periods need to be sampled in order to improve the statistical robustness of these samples so that they may be compared with published reports (Huss-Ashmore 1981, Keith 1981);

E) another Middle Ontario Iroquoian sample should be tested as a check to see if the results of the Orchid site are anomalous;

F) Glen Meyer samples should be examined in order to see if there was any synchronic variation in per cent cortical areas associated with differing subsistence economies between the Early Ontario Iroquois cultures;

G) better dates for Pickering sites, so that pre-bean and post-bean patterns in percent cortical areas can be examined;

H) a prehistoric Late Ontario Iroquois population to examine any changes in health as the use of maize in the aboriginal diet increases (Hodge 1987); and

I) an examination of other markers of stress to see if these support the results of this study.

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