SELECTED NON-METRIC MORPHOLOGY OF AN ARCHAIC PLAINS CEMETERY: THE GRAY SITE

by

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A THESIS SUBMITTED TO THE FACULTY
OF GRADUATE STUDIES IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE
DEGREE OF MASTER OF ARTS

DEPARTMENT OF ANTHROPOLOGY
UNIVERSITY OF MANITOBA

WINNIPEG, MANITOBA
AUGUST, 1980

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ABSTRACT

The Gray site represents a large sample of skeletons from Saskatchewan. With radiocarbon dates between 2915 and 5100 years B.P., these remains are assigned to the Plains Archaic and were found in association with Oxbow projectile points.

A number of non-metric variables structurally and functionally related to the vascular and nervous systems are described for a sample of 71 individuals. Sample frequencies for these traits are appended. Tests for association with age and sex are performed for all traits in order to screen out such biases.

The primary purpose of examining the morphological variability is to determine whether two or more distinct groups may have used the cemetery. The method used is a cluster analysis of the sample over 26 variables. The results indicate a single homogeneous group spanning more than 2000 years. Evidence also points to some females having been brought in from outside the population.

ACKNOWLEDGEMENTS

Many thanks to the members of my committee, Drs. Chris Meiklejohn and N. Arnason. Special thanks are due to my advisor, Dr. W.D. Wade. His insights into anthropology are valued as much as our friendship.

I must also thank Kathryn Norman atthe computer centre and my fellow graduate students in the department. Of these, Linda Fraser, Sid Kroker and Peter Lambert bore the brunt of the many incoherent discussions. Their support throughout is greatly appreciated.

Pat Hartney and Jerry Melbye started me along the path to this peculiar brand of anthropology. I am pleased to have had such good teachers.

Finally, I wish to acknowledge the support given me by my family; Bree, whose stories aremmore delightful than the following, and Robin, whose love may not withstand the mention once more of n**-m******.

This thesis is dedicated to my parents, Frank and Jean.

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CHAPTER I

INTRODUCTION

Little is known of the skeletal biology of the people inhabiting the Plains in the Archaic. The largest collection of human remains comes from the Gray site, a cemetery in southwest Saskatchewan. Extensive description and analysis of the skeletal material and the site has followed the series of excavations directed by J. Millar ('72, '78). The lack of large comparative collections has hindered the formulation of models to express morphological relationships and variation.

Part of the Oxbow Complex of the Plains Archaic, the Gray site is a piece of this puzzle stretching from Alberta to Manitoba and as far south as Wyoming and South Dakota. The major concentration appears to be southern Alberta and Saskatchewan. Identified mainly by tool types, both Oxbow and Mckean, another Complex within the Plains Archaic, overlap in time and space. Little in the way of skeletal remains relates the people to the tools and other evidence of material culture. The area covered by the tool complex and the span of two millenia (Millar '78) and possibly more (Callaghan '80) at the Gray site argues for high levels of population interaction, be it high mobility, actual migration or trade.

Much of this thesis is descriptive and exploratory. The paucity of comparative material, as well as the unsettled state of non-metric description precludes a more synthetic approach. Hypotheses of variation and population movement must await more information. The use of cluster analysis for structuring populations for inspection of evolutionary relationships usually proceeds from the sample frequencies of non-metric traits (Ossenberg '76, Zegura '75), or from raw metric data, amenable to regression techniques to 'fill in the blanks'. No cluster analysis has been performed, to my knowledge, using non-metric traits and the individual as the basic unit of analysis.

My major interest then, is the multivariate structuring of the sample, and the validity of the results. The only specific question to be entertained will be whether there are two or more morphologically distinct groups as suggested by Vyvyan ('77), and if they can be meaningfully coordinated with the hypothesis of temporally distinct groups (Millar '78). Visual inspection of the skeletons and associated artefacts gives no clue to these groupings. Indeed, the cultural material is highly variable and overall patterns are difficult to discern.

Research involving non-metric traits has followed a pattern much like that of metric or pathologic analysis of skeletons. Anthropological investigations early in the century started a systematic use of morphology to compare populations. Although much was anecdotal in nature, research quickly focused on the inherent population variation of non-metric variables (Oetteking '30) and the possibilities of phylogenetic studies as well (Wood-Jones '31).

The works of Grüneberg ('63) and Berry and Berry ('67) began an upsurge of interest in non-metric analysis. Even though a standard set of variables to be used has not been settled upon, non-metrics have increasingly been included in osteological research. Methodological problems are also given much attention. Studies of replicability (Molto '78), dependence upon age and sex (Akabori '33, Corruccini '74, Ossenberg '69) and intertrait correlation (Molto '79, Corruccini '74) have increased our knowledge of how these traits are affected. Many specific results are conflicting, but general concordance is found in many instances. Statistical treatment of these variables has evolved alongside a deeper understanding of biasing factors.

It is by no means clear to what degree environmental plasticity obscures the genetic control of non-metric variables. While a general genetic model entailing a threshold effect (Grüneberg '63) has probably been overstated, it makes sense to assume a large degree of non-genetic influence. Cheverud <u>et al</u>. ('79) have shown that growth and development play a much larger role in determining the final adult morphology than was suggested by earlier workers. The study of deformed crania has also shown that some traits are greatly affected by deviation from normal development.

In this light, qualitative variables can be no worse than quantitative characters and under such an assumption should provide for a more sound interpretation of variation when taken in concert with metric results (not to mention demography and pathology).

The first section details the traits used and their structural relations. Attention is then focused on the various possible associations with sex, age, side and between traits. After suitable manipulation, a cluster analysis is performed for a variety of samples. The results are interpreted in light of the metric analysis (Vyvyan '77), the chronology, and population variability in the Archaic.

CHAPTER II

MATERIALS

The Gray site is found in southwestern Saskatchewan, eight km. northwest of the city of Swift Current. Lying beside a now extinct lake, the site is made up of graves with from one to fourteen individuals in each grave. Apart from a tendency to bury infants by themselves, there is no obvious patterning by age, sex and/or number. Many different burial positions were used, no one major type being in the majority. The larger multiple interments resemble small ossuaries, although these may be the result of a number of different burials scattering the earlier remains. This is supported by a recent fluorine analysis (Callaghan '80).

Other cultural inclusions are red ochre, possible rock linings and bone, shell and stone artefacts. These latter suggest use of the cemetery in the Oxbow Phase of the Plains Archaic (Millar '72, '78). Nine radiocarbon dates span 2185 years, from 2915±85 (sample s-1449) to 5100±390 (sample s-647) years B.P. (Millar '78). At the time of excavation these dates greatly extended the duration of the Oxbow Phase.

There is no apparent spatial ordering of the cemetery by time. Nor does artefactual material suggest more than a single, homogeneous culture.

The preliminary demographic analysis of the Gray site (So and Wade '75) shows a steeply falling survivorship curve, with females at a higher risk from 15 to 25 years. This is followed by a reversal with males at higher risk from 25 years onward. The mean age at death is 15 years.

Disregarding the surface finds, the sample numbers 305, of which 113 are less than five years of age. Fully 57% of the sample is aged at less than 15. Subadults are not preserved, on the whole, nearly as well as adults. As a result, the sample used in the cluster analysis has only 13% (9/71) aged less than 12, while 42% (30/71) were adult female and 38% (27/71) adult male. The remainder are unsexed adults.

After the initial statistical analysis, four skeletons from other sites were added to judge their effect on the Gray site sample. Two skulls from the Skownan site on Waterhen Lake in the Interlake region of Manitoba were collected by Sid Kroker and subsequently reported upon (Kroker '77, Lambert '77). The site is approximately 620 km. east north-east of the Gray site. The few artefacts found near the bones proved to be non-diagnostic and cultural affiliation was not proposed.

The other two skeletons were found across the river from each other in the Whiteshell Provincial Park, southeast Manitoba. This site is roughly 900 km. due east of the Gray site. The Bjorklund skeleton is an older adult female, while the Whitemouth Falls skeleton is a somewhat younger female. Both have been tentatively assigned to the Archaic and a full report on both these individuals is in preparation (Meiklejohn and Pardoe n.d.).

The basis for selection of the sample was completeness. Of the 26 variables used in the analysis, an individual was included only when more than 20 observations were possible. Anything less than 75% completeness would only reduce the resolving power of the clustering techniques.

The traits examined were eliminated if there were very few observations made on the sample of 71 individuals. Of the original 47 variables, only 26 had sufficient observations to be included. The rest have been examined for correspondences between age, sex and side only.

The variants have been selected according to a single criterion: that they are morphologically related responses to variation in the circulatory and nervous systems, or as variation structurally related to the interaction between vessels and the surrounding bony structures. Interpretation of functional variation is beyond the scope of this research.

There are two reasons for using this one criterion as the basis for the collection and description of data.

1) It produces a more conceptually sound framework for the interpretation of non-metric traits in skeletal biology. Such a priori methods provide a more coherent outline for study than the usual 'shotgun' approach incorporating hyperostotic and hypostotic traits as well as variation in centres of ossification and foramina (as defined by Ossenberg '69 and Sjøvold '77).

2) By a fortunate coincidence, these traits are often those

with the clearest variation in expression. leading to increased precision in scoring. Most other traits are of the gradationally scored variety and are not generally amenable to comparison between the works of different researchers. To illustrate this point, the vertebral bridges may be observed as unquestionably present. On the other hand, the supraorbital torus may be graded on relative size within the population as well as on shape. This relative size may vary from sample to sample while the scores used to record it often stay the same. Quantification is therefore only internally consistent.

Much of the research done on non-metrics involves the dichotomization of variables. Ossenberg ('69,'76), Saunders ('78), Finnegan ('78), and Perizonius ('79), to name a few, have studied various features such as population differentiation, trait associations and laterality using population frequencies. The most elegant way of manipulating the data is to use present/absent classifications. Unfortunately, many distinct and real categories are lumped together. Some use the frequency of absence and include all other variability in the 'present' category, and vice versa. While it makes no difference in computation (Perizonius '79), the amount of information inherent in that variation is considerably reduced.

Using more categories, when appropriate, has been possible (see method) and provides no insurmountable problem to comparison with other studies. Care was taken to use variables that could ultimately be dichotomized to accord with other categorizations. For instance, the mylohyoid arch has four categories increasing from no marking to a fully ossified bridge. Fully present or fully absent frequencies may be easily derived.

The following discussion describes each variable examined in terms of the vessels, both vascular and nervous which are, in part, the ultimate source of morphological variability.

It would be superfluous to attempt to describe the position and appearance of each trait on the bony skeleton, and I have not tried. Accurate descriptions along with diagrams and photographs may be found in Ossenberg ('69,'74, '76), Saunders ('78) and Finnegan ('78).

Table 1: Categorization of variables

TRAIT		CODE: 0	1	2	3	4
R FRGR L FRGR	* FRONTAL GROOVES	absent	present			
R SUOR L SUOR	* SUPRAORBITAL MORPHOLOGY	absent	1 foramen	2 foramina	1 notch	2 notches (5=both)
R ETFO L ETFO	EXTRA ETHMOIDAL FORAMEN	absent	1	2	3	4+
R ETPO L ETPO	ANT. ETHMOIDAL FOR. POSITION		suture	frontal	ethmoid	
R OPFO L OPFO	OPTIC FORAMEN		single	spur	divided	
R INOR L INOR	* INFRAORBITAL FORAMEN		1	2		
R ZYFO L ZYFO	* ZYGOMATICO-FACIAL FOR.	absent	1	2	3	4+
R ZYOR L ZYOR	*ZYGOMATICO-ORBITAL FOR.	absent	1	2	3	4+
R ZYTE L ZYTE	*ZYGOMATICO-TEMPORAL FOR.	absent	1	2	3	4+
R PAFO L PAFO	*PARIETAL FORAMEN	absent	1	2	3	
R MAFO L MAFO	* MASTOID FORAMEN	absent	1	2	3	4+

* Traits used in the final cluster analyses.

Table 1: Categorization of variables

TRAIT		CODE: 0	1	2	3	4
R MAPO L MAPO	* MASTOID FOR. POSITION	absent	occipital	mastoid-occipital	mastoid	parietal
R METE L METE	* MEDIAL TEMPORAL ARTERY	absent	groove on temporal	groove on parietal		
R POCC L POCC	* POSTERIOR CONDYLOID CANAL	absent	present			
R ANCC L ANCC	* ANTERIOR CONDYLAR CANAL		single	spur	divided	
R INCC L INCC	* INTERMEDIATE CONDYLAR CANAL	absent	incomplete	canal		
R STMA L STMA	* STYLOMASTOID FORAMEN		1	2		
R OVSP L OVSP	* OVALE-SPINOSUM	single	spur	divided		
R FOOV L FOOV	* FORAMEN OVALE		single	spur		open to petrous fissure
R FOSP L FOSP	* FORAMEN SPINOSUM		open to petrous fiss.	present		
R VEFO L VEFO	* VESALIAN FORAMEN	absent	present			
R PTBA L PTBA	* PTERYGOBASAL FORAMEN	absent	spur	foramen		

* Traits used in the final cluster analyses.

Table 1: Categorization of variables (cont.)

TRAIT		CODE: 0	1	2	3	4
R PTSP L PTSP	* PTERYGOSPINOUS FORAMEN	absent	spur	foramen		
R SPBA L SPBA	* SPINOBASAL FORAMEN	absent	spur	foramen		
R PTPL L PTPL	PTERYGOID PLATE FORAMEN	absent	present			
R PTPA L PTPA	PTERYGO-PALATINE CANAL	absent	groove (on sphenoid)	canal		
R PLFO L PLFO	* ACCESSORY PALATINE FOR.	absent	1	2	3	4
R CLCL L CLCL	CLINO-CLINOID BRIDGING	absent	spur	bridge		
R CACL L CACL	CAROTICO-CLINOID BRIDGING	absent	spur	bridge		
R MEBR L MEBR	* BRIDGING OF A. MENINGEA MEDIA	absent	incomplete	present		
SAGS	* SAGITTAL SINUS DIRECTION		right	left	common	indistinct
R MYAR L MYAR	* MYLOHYOID ARCH	absent	groove	notch	foramen	
R MNFO L MNFO	ACCESSORY MANDIBULAR FOR.	absent	1	2		

* Traits used in the final cluster analyses.

Table 1: Categorization of variables (cont.)

TRAIT		CODE: 0	1	2	3	4
R MEFO L MEFO	* ACCESSORY MENTAL FOR.	absent	1	2		
R SUSC L SUSC	SUPRASCAPULAR NOTCH	absent	notch	foramen		
R CISU L CISU	A. CIRCUMFLEX SULCUS	absent	present			
R SUAR L SUAR	GROOVE FOR SUBCLAVIAN A.	absent	present			
R SUVE L SUVE	GROOVE FOR SUBCLAVIAN V.	absent	present			
R CCDI L CCDI	FOR. TRANSVERSARIUM DIVIDED (C3)	single	spur	divided		
R CDDI L CDDI	C4	single	spur	divided		
R CEDI L CEDI	C5	single	spur	divided		
R CFDI L CFDI	C6	single	spur	divided		
R CGDI L CGDI	C7	single	spur	divided		
R FOTR L FOTR	FOR. TRANSVERSARIUM POSITION	through C7 not T1	through T1 not T2	through C6 not C7		

* Traits used in the final cluster analyses.

Table 1: Categorization of variables (concl.)

TRAIT	CODE:	0	1	2	3	4
R POBR L POBR	POSTERIOR BRIDGE OVER VERTEBRAL A.	absent	spur	bridge		
R LABR L LABR	LATERAL BRIDGE OVER VERTEBRAL A.	absent	spur	bridge		
R RANO L RANO	RETROARTICULAR NOTCH	absent	spur	foramen		

FRONTAL GROOVES [FRGR]

Frontal grooves result from the impression of the supraorbital vessels upon the outer table of the frontal bone. The supraorbital artery, vein and nerve are a common bundle from the upper margin of the orbit outward. They diverge rapidly and make an absolute correlation with the grooves impossible. Dixon ('04) suggested the grooves were formed by differential growth of the nerve and the frontal bone. The position of the grooves is variable; from the temporal line to as far medially as the inner margin of the orbit. Frontal grooves are rarely bridged and occasionally arise directly from the diploe. In the latter case, the variation was scored present for two reasons. First, other studies using this trait do not make the distinction. Second, it is not impossible for the diploic vessel to actually be a branch of the supraorbital.

SUPRAORBITAL FORAMEN [SUOR]

Although this variable is fairly obviously related to passage of the nerve, artery and vein of the same name, variation of the supratrochlear groove can be confused with the supraorbital. The nasofrontal vein can also cause problems in discerning the probable vessel involved. Care was taken to discount the supratrochlear groove when distinct and close to the inner angle.

EXTRA ETHMOIDAL FORAMEN [ETFO]

Situated in a very fragile portion of the skull, these foramina reflect the distribution of the anterior ethmoidal vessels. The posterior foramen is consistent and ignored for counting purposes. The anterior may be absent, single or multiple. In the present study, only two cases were found of more than two foramina. No observations yielded an absent anterior foramen.

ANTERIOR ETHMOID FORAMEN POSITION [ETPO]

While the preceding variable described the number of foramina, ETPO documents the relationship of the larger (if multiple) anterior foramen with the associated bones. The vessels may be surrounded by the frontal or ethmoid bones, or may lie in the suture.

OPTIC FORAMEN [OPFO]

The optic foramen may occasionally be divided by a bar of bone, or more commonly, exhibit incomplete spurs. Division of the canal presumably reflects ossification between the optic nerve and the opthalmic artery, the only vessels found therein.

INFRAORBITAL FORAMEN [INOR]

The foramen contains the infraorbital nerve, artery and vein, as well as the orbital and zygomatic branches of the maxillary fifth cranial nerve and an anastomosis between the inferior ophthalmic vein and the pterygoid plexus. It may be divided by a bar of bone. This effectively separates the vessels at one point. More rarely there are two canals originating from the infraorbital groove in the middle of the orbital floor and exiting some distance apart on the maxilla. No distinction was made for these two possible variations encountered in the Gray site sample.

There are two other canals derived from the infraorbital canal, However, it is not likely that they are related to the extra canal. They transmit some of the dental vascular and nervous vessels and are probably not subject to large variation.

ZYGOMATICOFACIAL FORAMEN [ZYFO]
ZYGOMATICOORBITAL FORAMEN [ZYOR]
ZYGOMATICOTEMPORAL FORAMEN [ZYTE]

The zygomatic nerve and artery branch from the infraorbital and lacrimal vessels respectively. They enter the zygomaticoorbital foramen with the exception of an occasional twig communicating with the lacrimal nerve through an accessory foramen. After entering the zygomatic bone the vessels branch into the zygomaticofacial and zygomaticotemporal, which exit through their named foramina.

PARIETAL FORAMEN [PAFO]

Also referred to as an obelionic foramen, it is found on the parietal close to the sagittal suture and slightly anterior to lambda. The parietal emissary vein exits here, and occasionally a meningeal twig of the occipital artery. When present, the latter is accompanied by a branch of the greater occipital nerve.

MASTOID FORAMEN [MAFO]

This variable is found near the mastoid-occipital suture. One or more of the foramina will rarely be found on the parietal. The emissary veins passing through the foramina connect the sigmoid sinus and the posterior auricular or occipital veins (Gray '74).

MASTOID FORAMEN POSITION [MAPO]

The position of the above foramen can be considered to vary along a line perpendicular to the mastoid-occipital suture. The largest (or only) foramen is judged to lie on the suture or one of the bones.

MEDIAL TEMPORAL ARTERY [METE]

I have recorded this variable somewhat differently than did Ossenberg ('69). Of the arteries supplying that portion of the scalp and muscle, Ossenberg recorded the frequency of an anomalous artery arising internally from the middle meningeal. The most common arteries found there are the parietal ramus and the medial branch of the superficial temporal. The variable examined is the grooving pattern of any of these arteries, although I will show that our methods and definitions are basically the same.

The absent category has no grooves. The [1] category is the presence of a groove on the temporal formed by the parietal ramus or the medial branch, but excluding the posterior branch, of the superficial temporal artery. There may be a continuation of the groove onto the parietal, but it is disregarded.

The last category [2], grooving of the parietal, is only relevant if there is no groove on the temporal squama. The frequencies for the last category are somewhat higher than other Plains groups examined by Ossenberg ('69) and could be methodologically biased. I would accept a groove with no obvious style shield as well as a rather common case where the groove is clearly associated with a middle meningeal artery, but has entered the diploe and exited the skull from 2-4cm. superior to the parietal-temporal juncture.

POSTERIOR CONDYLOID CANAL [POCC]

Another emissary vein, the posterior condyloid connects the sigmoid sinus with the suboccipital and vertebral plexuses (Ossenberg '69). An observation was deleted if the condyles had undergone extensive arthritic lipping and if the area of exit internally was unobservable.

ANTERIOR CONDYLAR CANAL [ANCC]

It is also named for the hypoglossal [cranial XII] nerve which is the major traversing vessel. The ascending pharyngeal artery also sends a meningeal branch through the foramen (Gray '74). Bridging of the canal occurs between the two major bundles of the twelfth cranial nerve, which commonly join only after passing through the canal.

INTERMEDIATE CONDYLAR CANAL [INCC]

The vein lying in the groove lateral to the occipital condyles connects the emissaria of the anterior and posterior canals. As with many variables, INCC can be trichotomized to complete, incomplete and absent; the former being a bridge anywhere along the length of the groove.

STYLOMASTOID FORAMEN [STMA]

Postero-lateral and adjacent to the styloid process is the stylomastoid foramen. It is constant and often double. The structures transmitted are the stylomastoid artery and vein and the facial nerve. This artery supplies much of the tympanic area. The associated vein drains into the posterior auricular vein, as does the mastoid emissary vein.

OVALE-SPINOSUM [OVSP]
FORAMEN OVALE [FOOV]
FORAMEN SPINOSUM [FOSP]
VESALIAN FORAMEN [VEFO]

These four variables are best considered together as they deal with the same structures. Wood-Jones ('31) attached phylogenetic import to the vessels and their associated foramina in the area of foramen lacerum medium, or the spheno-petrous fissure. The three foramina of interest; ovale, spinosum and vesalian, represent specializations of the primitive condition of a single large fissure. Foramen ovale transmits the mandibular portion of the trigeminal [cranial V] nerve, the petrosal nerve and a small meningeal artery (Gray '74), as well as an emissary vein connecting the cavernous sinus and the pterygoid plexus.

In humans, it is the emissary vein that varies to produce a vesalian foramen by separation from the rest of the foramen ovale bundle. Foramen spinosum carries the middle meningeal artery and vein and the mandibular nerve, meningeal branch (Woodburne '76).

OVSP is scored as single, indicating non-separation of the foramina, or as divided. Partial division of these two foramina is also taken into account. FOOV may sometimes be anteriorly spurred, possibly indicating incomplete separation of the vesalian foramen. It may also be open to the petrous fissure. FOSP is also observed for continuity with foramen lacerum, or the petrous fissure. The vesalian foramen can be found some distance from the anterior end of ovale and is scored as present or absent. There is some overlap between FOOV and VEFO in this respect. The anterior spurring of foramen ovale may be the incipient separation of the emissary vein. This is not anatomically correlated however, and could be explained by subdivision of the bundle within foramen ovale.

PTERYGO-BASAL FORAMEN [PTBA]

The foramen is formed by the ossification of a ligament from the lateral pterygoid plate to the lateral side of foramen ovale. The resulting foramen transmits the vessels of foramina ovale and spinosum and other vessels in a manner guaranteed to confound agreement among anatomists. It is however, generally agreed that all or most branches of the mandibular nerve pass through this foramen (Chouké '46, Le Double '03, Wood-Jones '31).

PTERYGOSPINOUS FORAMEN [PTSP]

Often confused with the above variable, this is formed by ossification of the pterygospinous ligament. The ligament attaches medial to foramen ovale. While it is possible that no vessels pass through the resulting foramen, most often mention is made of medially directed branches of the mandibular nerve (Ossenberg '69, Wood-Jones '31) and some veins of the pterygoid plexus (Chouké '46).

SPINOBASAL FORAMEN [SPBA]

Occasionally, spurs or a complete bridge will be found, which form one or more foramina inferior to the foramina ovale and spinosum. Of the many vessels traversing these two foramina, it is not known if there is any consistency between the exiting vessels and the spinobasal bridges.

PTERYGOID PLATE FORAMEN [PTPL]

The lateral pterygoid plate can have a foramen near the posterior border (not to be confused with spinous and basal bridging). Ossenberg ('69:136) lists a branch of the mandibular nerve, a branch of the internal maxillary artery and a venule emptying into the pterygoid plexus as possible vessels to be 'trapped' by the development of the plate.

PTERYGOPALATINE CANAL [PTPA]

These grooves run parallel and lateral to the vomer. The pterygopalatine artery and vein, and the pharyngeal nerve, may be covered by bone to form a canal.

ACCESSORY PALATINE FORAMEN [PLFO]

These are accessory foramina which transmit lesser branches of the descending palatine artery and vein. The blood vessels are accompanied by branches of the maxillary portion of cranial nerve V.

The major palatine foramen is consistently present, and is not included in the counting.

CLINOCLINOID BRIDGING [CLCL]

CAROTICOCLINOID BRIDGING [CACL]

Supralateral to the seat of the sella turcica are the anterior, middle and posterior clinoid processes. These are sites of attachment for dura mater and can ossify to produce foramina. The ossification process would appear to begin quite early and may reflect structural variation rather than ossification of the dura, *per se* (Ingalls '35); that is, the vessels may develop within the preforming cartilage and give rise to a normally developing bridge, instead of one formed by anomalous osteoblast activity.

The clinoclinoid bridge joins the anterior and posterior processes, while the caroticoclinoid bridge joins the anterior and middle processes. Given the interpretation of Keyes ('35) and Ingalls ('35), the main structures, the internal carotid artery and the optic [cranial II] nerve, as well as the attendant minor vessels, do not change their position. The position of the preforming cartilage is the underlying variable.

BRIDGING OF A. MENINGEA MEDIA [MEBR]

This well known endocranial vessel scores the parietal after egress from the parietal-sphenoid diploe. Once open to the internal skull it may be covered at some position on any of its many branches. Generally a bridge will be found at the posterior limits. The incomplete category underlines the continuity of the variable and is defined herein as the case where 1) no bridge is present, and 2) the surface width is less than the maximum diameter of the groove.

SAGITTAL SINUS DIRECTION [SAGS]

The direction of major blood flow away from the vein depends on the three main incoming vessels and the two transverse sinuses which carry the venous blood out of the braincase. At the confluens of sinuses meet the superior sagittal, imprinted upon the internal aspect of the sagittal suture, the occipital and the straight. The latter flows from the central portion of the brain and makes no impression on the bone.

If the variation of the structure of the superior sagittal sinus is the observation of interest, then a distinction must be made between the common state, where it seems that blood flows equally to both transverse sinuses, and the indistinct state. I have included this latter condition as an acknowledgement of the fact that, in certain cases, what appears to be equal distribution to the transverse sinuses is actually unequal. The occipital and straight sinuses may drain to one side, the sagittal to the other. Therefore, the common category is defined as the situation where there are two distinct grooves superior to the internal protuberance and the sagittal sinus can be said to be bifurcate.

MYLOHYOID ARCH [MYAR]

The mylohyoid groove, on the medial mandibular ramus, may be bridged by ossification of the spheno-mandibular ligament (Le Double '06). The mylohyoid vessels and nerve are offshoots of the inferior alveolar vessels found entering the mandibular foramen.

I have categorized the variation into four parts rather than as present/absent. A groove is any impression of the vessels on the bone. A notch, on the other hand, is defined as with MEBR. The surface width of the notch must be less than the greatest diameter of the groove.

ACCESSORY MANDIBULAR FORAMEN [MNFO]
ACCESSORY MENTAL FORAMEN [MEFO]

As mentioned above, the inferior alveolar vessels enter the mandibular foramen. Occasional divisions are found and these are counted exclusive of the major foramen. As those vessels supply the alveolus and teeth, there is a switch-back from the median plane (i.e. central incisor) and the mental nerves and vessels, the remnants of the inferior alveolar vessels, supply part of the face. The method of counting the accessory mental foramina is the same as for MNFO.

SUPRASCAPULAR NOTCH [SUSC]

When present, the notch, or foramen, is found on the superior border of the scapula. The notch is covered by the transverse ligament (Woodburne '76) and allows passage of the suprascapular nerve.

CIRCUMFLEX ARTERY SULCUS [CISU]

Also found on the scapula, this trait is on the postero-lateral border. "The narrow upper portion for the teres minor is crossed about 3cm. from the edge of the glenoid cavity by a groove for the circumflex scapular artery and vein" (Woodburne '76:56).

GROOVE FOR SUBCLAVIAN ARTERY [SUAR]

GROOVE FOR SUBCLAVIAN VEIN [SUVE]

The subclavian vessels pass between the clavicle and the first rib. Although no impression of these major vessels was found on the clavicle, the artery and less commonly the vein, had clearly marked the superior surface of the rib with broad, well defined grooves. The venous marking is anterior and medial to the arterial groove and they are separated by a rugged, triangular area inserted by m. scalenus anterior.

FORAMEN TRANSVERSARIUM DIVIDED, C3-C7

The vertebral artery is accompanied by the vein which forms a plexus through the cervical area. This is the basis for division of the foramina. The less common occurrence of division in C7 can be explained by the exit of the vein between the sixth and seventh cervical vertebrae.

FORAMEN TRANSVERSARIUM POSITION [FOTR]

The normal, or most common condition seen is a foramen through all seven cervical vertebrae. The variability of the vessels and the transverse processes of the vertebrae can result in the final foramen being found on C6 or the first thoracic.

POSTERIOR BRIDGING OF THE VERTEBRAL ARTERY [POBR]

As the vertebral artery ascends through the foramen transversarium, it twists sharply on the superior surface of the atlas vertebra. It then may be covered by a spur or bridge of bone connecting the superior articular mass and the posterior arch. The artery then ascends through the foramen magnum.

LATERAL BRIDGING OF THE VERTEBRAL ARTERY [LABR]

Distinct from posterior bridging in that this bridge, when present, joins the superior articular mass and the transverse process. In cases where both are present, there may be other bridges connecting the two as a single covering punctuated by foramina. In these cases, only the two traits are recognized and scored according to the position of the bridge lateral to the artery.

RETROARTICULAR NOTCH [RANO]

First included in 'trait batteries' by Saunders ('78), this variable consists of a notch or foramen on the posterior surface of the atlas at the juncture of the posterior arch and the transverse process. It marks the passage of a vein of the vertebral venous system arising directly from the mastoid emissary vein and by anastomoses, from the occipital veins. The vessel marking this groove may also be the first cervical nerve as it courses posteriorly and inferiorly from between the vertebral artery and the arterial groove.

CHAPTER III

METHOD

Clustering techniques are sensitive to biases in the data as well as factors underlying the distributions of variables. The most common occurrence is clustering by sex, where dimorphism tends to separate males and females by size alone. Such is the case with a study by Vyvyan ('77). The individuals from the Gray site analysed by her clustered by sex into small groups within the larger subdivisions. (See also the comparison of the two studies in chapter IV.)

Correlations of traits with sex, age, side and each other must be examined prior to the use of multivariate techniques. Much of the recent literature on non-metrics has been devoted to these problems. Unfortunately, there has been very little in the way of consensus or synthesis of a general model to cover all human populations and the underlying factors affecting trait expression.

In fact, the only agreement has been to test each sample as a necessary prerequisite. Therefore, the following section discusses the correspondence of the traits with sex, age, side and each other.

The method used to discern associations among these variables is a test of the general hypothesis of independence in a two way frequency table. Biomedical programme (BMDP) 1F, measures of association (Brown '77), was used to generate the results. The two statistics examined are Cramer's V and the log likelihood ratio; the latter being analogous to Chi^2 (see Sokal and Rohlf '69). Cramer's V, the generalized n x n table equivalent of the Phi coefficient, campares the level of association in each test. No statement of probability about a hypothesis is made, although the relationship between it and Chi^2 varies only in whether sample size is accounted for.

The reason for using simple measures of association rather than testing for interactions is that Korey ('70) used a log-linear model on certain non-metric traits to determine the interaction of different populations, age, sex and side. All were consistently non-significant at a level of .05.

ASYMMETRY

All but one of the traits examined (sagittal sinus direction) are bilaterally expressed. The major source of error in multivariate techniques, following Sneath and Sokal ('73), is redundant information, or the unconscious weighting of variables. If both sides of all variables were to be used, the traits with the highest side to side correlation would have the relatively highest weight, and a unilateral trait might have as little as one half as much influence on the final result.

Inspection of paired comparisons, left and right side, yields fairly predictable conclusions: the hypothesis of independence is rejected for many variables. The 41 variables with enough observations to estimate levels of association using the likelihood ratio have a range in probabilities from .000 to .678 of being side independent. For heuristic purposes only, the overall level of association between sides measured by Cramer's V may be represented by the mean ± 2 S.D. The mean measure of association is .540±.421. The range is 1.000 to .083. Although the mean value is rather reassuring, the obvious spread in both statistics denotes wide variation in association.

Of the 41 traits, 11 (27%) have a probability of independence greater than .05. These traits are ETFO, OPFO, ZYFO, MAPO, ANCC, PTSP, PLFO, SUVE, CEDI, and CFDI. ETFO suffers from a small usable sample (n=14), as do SUVE(11), CEDI(6) and CFDI(6). In these four the association is visually, if not statistically, satisfying. The reason for independence of sides being accepted at p=.05 significance for OPFO and PTSP is that these traits are relatively invariant in the sample. The optic foramen is never found divided, although spurring of the foramen does happen occasionally. The same is true for PTSP.

Cases such as ZYFO and PLFO seem to be clearly spurious results. Here the categories are numerous and empty cells more common, resulting in a sample size too small to be effective. Inspection of the table of frequencies shows a definite relationship. MAPO is amenable to the same kind of interpretation.

ANCC is the final and only case that cannot be explained from a statistical or structural viewpoint. Korey ('70) found the hypoglossal canal to be the only trait that was side-independent among four North American populations.

All bilateral traits, with the exception of ANCC, can easily be collapsed to form a single variable that ignores side and the information contained about asymmetry. In this case it was decided to use the left side when observable, the right side otherwise. To collapse ANCC to a single variable is, on the one hand consistent with the rest of the traits and weightings, but on the other loses more information. Both alternatives have advantages and the choice to remain consistent is arbitrary.

AGE

Many non-metric traits, like continuous linear and angular measures, are found to be somewhat age-dependent. In the latter, change essentially stops with maturation, while the former can vary throughout life. Korey ('70) found SUOR, INOR, ANCC, FOOV, and MYAR to be significantly correlated with age. PAFO, POCC, OVSP, and SAGS were not.

Although not tested statistically, Ossenberg ('69) elicited age-dependent patterns among her classificatory scheme of traits. Those of direct relevance to this discussion are:

I Hypostotic traits. Foramen spinosum and f. lacerum are more often found separate with increasing age.

II Hyperostotic traits. PTBA, CACL, CLCL, MYAR and INCC all show a general increase in ossification with age.

III Foramina, canals and grooves for blood vessels and nerves. PAFO, OPFO, METE, SUOR and PTPL are, with the exception of OPFO, positively associated with increasing age. OPFO appears to undergo deossification with age.

IV Craniovertebral variations. ANCC is more often divided in older individuals.

Traits that exhibit stable or indeterminate variation with age are PTSP, FRGR, MEFO, PAFO (in some samples), VEFO and POCC.

Of the infracranial traits examined by Saunders ('78) and relevant to the present work (SUSC, CISU, RANO, POBR, LABR, and the division of foramen transversarium in cervical vertebrae three to seven), only RANO in one sample was found to be age dependent.

Other variables have been found to be age regressive (direction of change is ignored): atlas bridging (Selby et al. '55, Saunders et al. '76) and clinoid bridging (Saunders et al. '76). Corruccini ('74) found many traits to be age related in the Terry collection of Caucasian and Negro, male and female, but in an inconsistent fashion for each subdivision of the sample. Finnegan ('78), again using the Terry collection, reported only one significant association among scapular and cervical variables.

The overall pattern emerging is that individual variables and types of variables are somewhat associated with age change. This is obscured by the inconsistency between populations, researchers and methodologies.

Within the Gray site, there are more significant correlations between age and variable than would be expected for type I errors. One unilateral and 46 bilateral traits were examined. Nine of the 93 proved to be significant at, or below, the .05 level. Small sample size for the number of cells in the tables is probably to blame for some of the correlations. SAGS, LFOSP, LMEFO and RCEDI are all likely to be spurious, especially since their lateral counterparts nowhere approach p=.05. FOSP was found by Ossenberg ('69) to be age related, but given the fact that only one side shows any such relation, and that the sample size is small, I feel secure in retaining it as a variable (left and right sides combined) for the cluster analysis. The other three have been shown to be age stable in various populations and the sagittal sinus direction shows no pattern to the correlation. This is to be expected in a trait that cannot change in the two most common categories (flexes left or right).

The remainder, RSUOR, RINCC, LMEBR, RMYAR, and RCISU have difinite tendencies toward age relation, although none of the other sides of these traits approaches significance. A further test for age regression was performed on the collapsed variables (left and right sides combined) to determine how deleterious the effects of the significantly associated traits may be on the clustering programme. The reason for doing so is based on the concept of brain hemisphere and body side dominance.

Since the left side is the preferred side for observation, the collapsed variables should, in most cases, be less age dependent. This turns out to be the case. No variable has a probability of less than .05. The most significant is MEBR at .08.

Ossenberg ('69) has related side dominance to the expression of non-metric traits. Ossification may be slowed on the right side, in accordance with the slightly favoured innervation and blood supply (Torgersen '51). Different rates of growth then can delay the expression of traits and show a correlation with age.

MEBR is an exception to this pattern and may be caused by the reversal of dominance within the skull (*i.e.* left hemisphere dominance).

SEX

One of the oft expressed advantages of non-metric traits is the lack of association with sex of the individual. With respect to the Gray site, five traits (sides separate), or 5.6%, were significant at less than .05. As with the tests of age dependency, no trait was bilaterally associated with sex. Using sides combined, only ETFO, ZYTE, and CDDI proved to be significant. The latter was not significant after the application of Yates correction for continuity.

INTERTRAIT CORRELATIONS

Two methods were used to examine the relationship between traits. A non-probabilistic way involves the use of clustering techniques. Variables that tend to correspond would group more closely in the diagram than those that bear no relation to one another. The first attempt utilized left and right sides of all variables in Biomedical programme (BMDP) 3M (Brown '77). Surprisingly, only eight pairs of traits clustered closer to each other than to any other. The size of the dendrogram and the lack of a readily apparent pattern made a second attempt desirable. In this step, only 26 variables commonly observed and not highly biased by sex or age were used over the final skeletal sample (N=71). These were the combined traits and the results were somewhat more clear.

Those that clustered most closely were generally the more persistent foramina as opposed to those produced by bridging. Contrary to my expectations, neither hyperostotic nor hypostotic traits formed any consistent pattern. The overall level of correlation was low with no grouping and no outliers.

The second method summarizes the associations as a correlation matrix. The 26 variables used above produce a total of 325 product-moment correlation coefficients. Under the null hypothesis $\rho_{ij}=o$, 16 type I errors are expected when significance is set at $p=.05$; 3 are expected at $p=.01$.

In fact, 18 and 4 respectively were found.

Structural causes for association are few and tenuous. FOSP and MEBR transmit the same vessel, the middle meningeal artery. INCC, as outlined in chapter II, connects the anterior and posterior canals. Therefore, it is possible that the posterior and intermediate are structurally correlated, although the absence of POCC is in no manner a guarantee of the absence of INCC. The last case, mastoid foramen number and position, may be influenced by some other variable such as vault thickness.

DISCUSSION

The four factors examined in this section are inconsistent in their effects and interactions. The study of side associations is predictable in outcome. Sex and age dependencies may in turn be underlain by rates of bony growth that vary ontogenetically and from side to side. The dimorphism of sex may be an added disrupting mechanism, drastically changing these rates of growth.

Echoing Corruccini ('74), I would ascribe the trait interactions to a low level of correlation. Perhaps the best way to look at these is as being based ultimately on the general bony growth and modification rates.

The impact of the underlying factors of side dominance, age, sex and general low level correlation is deemed to be of minor importance for the end result. The inherent biases are difficult to screen out, given the state of the raw data. Such an attempt would also involve extensive manipulation, requiring biological, not to mention intuitive, interpretation.

The final sample of 71 individuals is examined using 26 variables, one variable representing both sides of the trait. These variables are fairly common, show some variation, and are not unduly influenced by age, sex, or other traits. I have indicated these variables in table 1 as well as in the appendix.

CLUSTERING TECHNIQUES

The rationale of cluster analysis is that simultaneous examination of many variables can assort cases into natural (Sneath and Sokal '73) or novel (Anderberg '73) patterns. Objective statistical techniques for measuring the validity of these patterns lag far behind the present capabilities and complexity of most analytical packages. The presentation of the results in a dendrogram can, however, provide a basis for fairly rigourous interpretation.

Occasional studies of skeletal material in this manner have been generally successful and interpretable within a larger analytical framework including metric and linguistic variables (Ossenberg '76, Rathbun '79). Non-metric variables are not often used to assort individuals in a sample.

Once all preliminary interactions had been examined, the individuals within the sample were compared to each other pairwise. The correlation was determined by the product-moment correlation coefficient (Pearson's r). The use of Pearson's r is appropriate for multistate characters and measures the strength of association between variables (in this case individuals). A separate correlation matrix was then derived through SAS76, procedure correlation (Barr et al. '76) for each of the Gray site sample, adults, males and females only, and the Gray sample including the four Manitoban skeletons.

The reason for inputting the correlation matrix rather than a raw data array is that the programme used, Clustan 1C release 2 (Wishart '77), will not accept missing values. These are ubiquitous in the skeletal material. An unfortunate effect of having a correlation matrix as input is that many of the procedures within the programme are not accessible.

Within these constraints, three hierarchical techniques were incorporated: single, complete and average linkage. Single linkage creates the first cluster from the two most similar individuals, thereafter linking individuals and clusters on the basis of the highest similarity. An individual will join an existing cluster at the similarity value of the most alike individual within the cluster. Two clusters will fuse at the value exhibited by the two most similar individuals within those clusters, i.e., nearest neighbours. In general, the criterion for grouping C with A, where A is a cluster composed of (A,B), is the maximum of r(CA), r(CB).

Complete linkage, or furthest neighbour, performs the opposite technique. Clusters are merged on the basis of the minimum correlation within the group. When an individual fuses with a cluster, it does so with the least similar group member. Average linkage uses the average within cluster similarity to merge with other clusters. When an individual joins a cluster, there is no minimum or maximum similarity value used, so that individual relationships with the cluster are not known.

Dendrograms are produced for each subsample with single, complete and average linkage. These are inspected visually and compared to each other and to other subsamples for age and sex dependency, stability, and temporal patterns. The results of these various techniques are considered in the next chapter.

CHAPTER IV

RESULTS

> The mechanical results derived from submitting a set of data to some cluster analysis algorithm are themselves devoid of any inherent validity or claim to truth; such results are always in need of interpretation and are subject to being discarded as spurious or irrelevant.
> (Anderberg '73:176)

In order to complete this research, I had to accept the severe restraints imposed upon the data, and the descriptive techniques. Much of the reasoning throughout the results and discussion will be inferential, not to mention convoluted. There are four basic facets of the study to be interpreted: the constituent subsamples of the Gray site, the total sample, the Gray material in relation to the Manitoban skeletons, and a comparison of the results of metric (Vyvyan '77) and non-metric descriptions.

The Gray Site

Figures 1-3 display the dendrograms plotted using the various techniques. Two observations are readily apparent. First, there is no consistent structure within the groupings. Second, there are individuals on the far right of each figure who generally cluster with the rest at very low levels of similarity.

The single linkage plot (fig.1) exhibits a chaining effect. As the threshold criterion is reduced, individuals

EXPLANATION OF FIGURES

Each individual listed on the following dendrograms is identified by a six digit code. The first two digits refer to the burial, or grave, number. The first season of excavation was different in the system of cataloguing from later seasons. Each grave was given a G(ray) B(urial) number; for instance G3B6. I have given these numeric values from 01 to 19 in keeping with the rest of the series. The corresponding burial numbers are:

G3B1	01	G8B2	08	G13B3	14
G3B2	02	G8B3	09	G13B4	15
G3B3	03	G8B4	10	G13B5	16
G3B4	04	G8B5	11	G13B6	17
G3B5	05	G8B6	20*	G13B7	18
G3B6	06	G13B1	12	G13B8	missing
G8B1	07	G13B2	13	G13B9	19

*This burial was reassigned in the field.

The next two digits signify the individual number within the burial unit. The last two, separated by a dash, are single digit codes for sex and age respectively. The designation for males is 1, females=2, and unknown=0.

Age grades are as follows:

foetal	1	13-17y.	5
0-3y.	2	18-20y.	6
4-6y.	3	21-35y.	7
7-12y.	4	36-55y.	8

Some of the individual numbers have been lost and the field catalogue numbers have been used instead. These are 5973, 5999, and 5420.

Blanks indicate the data are unavailable.

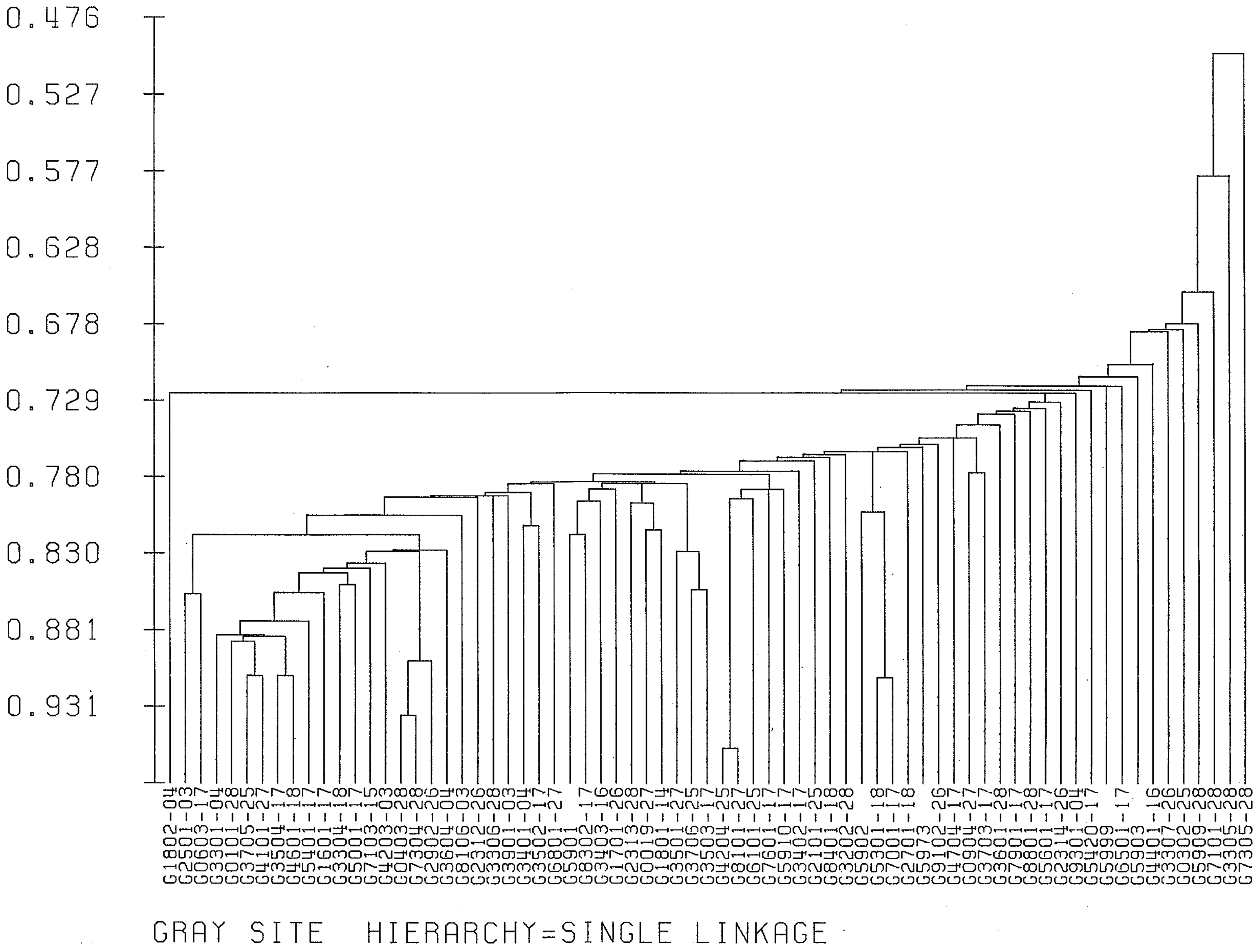
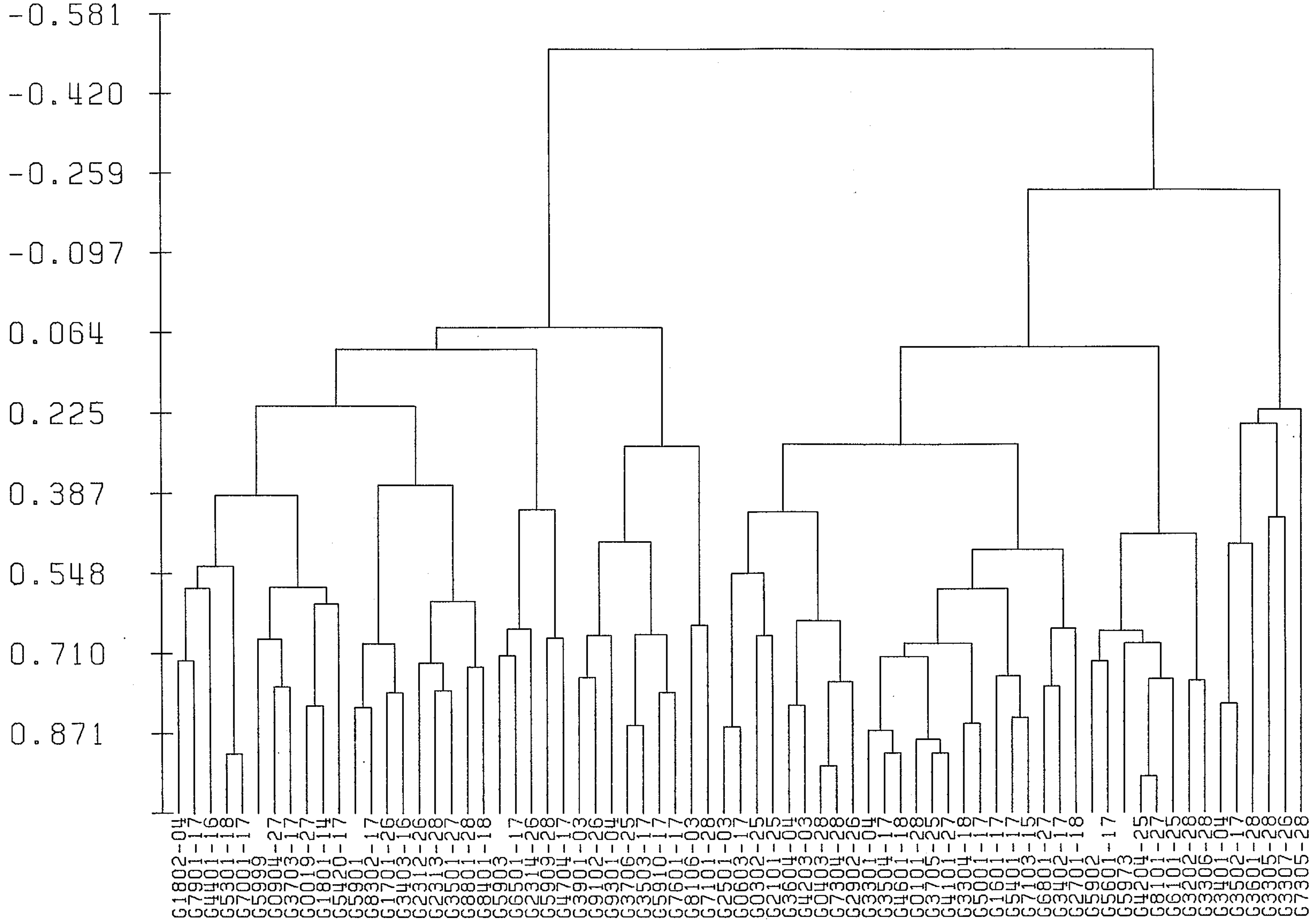
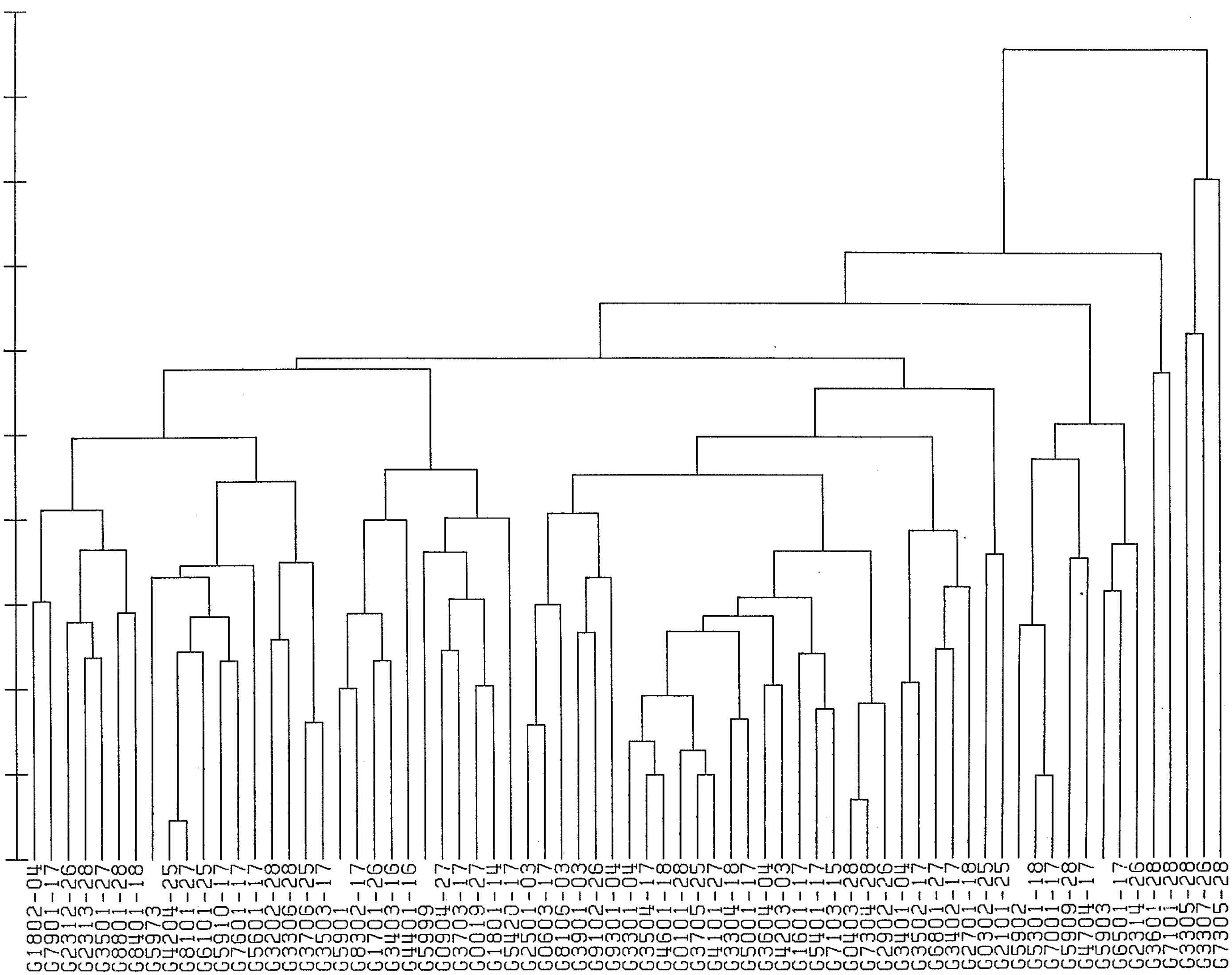

0.476
0.527
0.577
0.628
0.678
0.729
0.780
0.830
0.881
0.931
G1802-04
G2501-03
G0603-17
G3301-04
G0101-28
G3705-25
G4101-27
G3504-17
G4601-18
G5401-17
G1601-17
G3304-18
G5001-17
G7103-15
G4203-03
G0403-28
G7304-28
G2902-26
G3604-04
G8106-03
G2312-26
G3306-28
G3901-03
G3401-04
G3502-17
G6801-27
G5901
G8302-17
G3403-16
G1701-26
G2313-28
G0019-27
G1801-14
G3501-27
G3706-25
G3503-17
G4204-25
G8101-27
G6101-25
G7601-17
G5910-17
G3402-17
G2101-25
G8401-18
G3202-28
G5902
G5301-18
G7001-17
G2701-18
G5973
G9102-26
G4704-17
G0904-27
G3703-17
G3601-28
G7901-17
G8801-28
G5601-17
G2314-26
G9301-04
G5420-17
G5999
G6501-17
G5903
G4401-16
G3307-26
G0302-25
G5909-28
G7101-28
G3305-28
G7305-28
GRAY SITE HIERARCHY=SINGLE LINKAGE

Figure 1



GRAY SITE HIERARCHY=COMPLETE LINKAGE

Figure 2



GRAY SITE   HIERARCHY=AVERAGE LINKAGE

Figure 3

link directly to the existing cluster. Were there two or more very discrete groups, separation would be effected as soon as a grossly dissimilar case was encountered. The final members to be joined, 7101, 3305, and 7305, do so at a lower level of similarity. I will return to these below.

The next figure (2) is produced by complete linkage. Immediately there is a disjunction obvious. The furthest neighbour, or complete linkage technique admits menbers to clusters on the basis of the most dissimilar existing member. The duality is artificially inflated in the final fusion by comparison of the most extreme individuals in the sample. This happens to be an individual in the 'major' cluster to the left and one of the outliers in the small cluster on the right. The small cluster, in the second last fusion, has to group with one or the other of the larger groups and forces a larger separation in the final fusion.

Among these procedures, average linkage probably best approximates the reality of morphological relationships. As with the rest, there is no sharp change of similarity values from 70 clusters to one. No major groupings are evident. However, the anomalous individuals remain more or less regularly outside the rest of the sample.

The overall stability of these dendrograms is evident only with small clusters of 7 to 20 individuals. Within these groups relationship changes are minimal. Whole clusters may exhibit different linkage patterns in every technique. The diagrams as a whole are not stable. The reason for this is probably the homogeneity over all variables as well as the lack of flexibility in computation brought about by the fact that each case is compared to each other on the basis of a single number, without the possibility of going back to the raw data.

The individuals that consistently cluster with no other groups present an interesting anomaly. 7305, 3307, 3305, 3601, and 7101 are all adult female. Two interpretations are possible for these outlying females. It may be pure chance that five individuals of one sex exhibit some of the limits of non-metric variation. That is, these skeletons possess many of the less frequent expressions of the traits observed and may be from the same gene pool. On the other hand, they may represent the presence of non-homogeneous individuals within the sample.

Given the accuracy of sexing, these individuals represent a more divergent segment of the sample. This may reflect some of the variability between groups or societies. An argument against such a conjecture is that none of these females resembles each other any more than they do the Gray site as a whole. On the other hand, they may not all have come from the same population.

GRAY SITE MALES, FEMALES, AND ADULTS

Various sub-sets of the sample, assorted by age and sex, were useful in the interpretation of the complete sample. Removing the young individuals (less than 17 years) can help determine the pattern with respect to sexes. Associations among variables on account of sex differences have been shown to be acting at a very low level. This is further borne out by the cluster analyses. To test whether the cluster analysis has an underlying bias in grouping by sex, a Chi^2 test of maximally clustered adults was performed. By this I mean only combinations of pairs were counted. The frequencies of association by sex could be expected by chance alone ($X^2 = 1.53$, $0.5>p>0.1$).

The group of dissimilar females was also removed, resulting in a more homogeneous dendrogram. As with the complete sample, similarity coefficients decrease in a linear fashion (from n clusters to one), indicating the lack of grouping within the sample.

The lack of distinction between the analyses including and excluding the sub-adults leads to the conclusion that age has little or no bearing on the expression of non-metric traits in such a multivariate study..

The separated male and female samples reiterate the findings so far. Each type of hierarchical method examined has few changes of the groupings between the total sample and a single sex. The final fusion of all individuals in single linkage is at a similarity coefficient of .499. Males group at .627 and females at .473. For complete linkage, total group similarity is -0.508 versus 0.011 (males) and -0.508 (females).

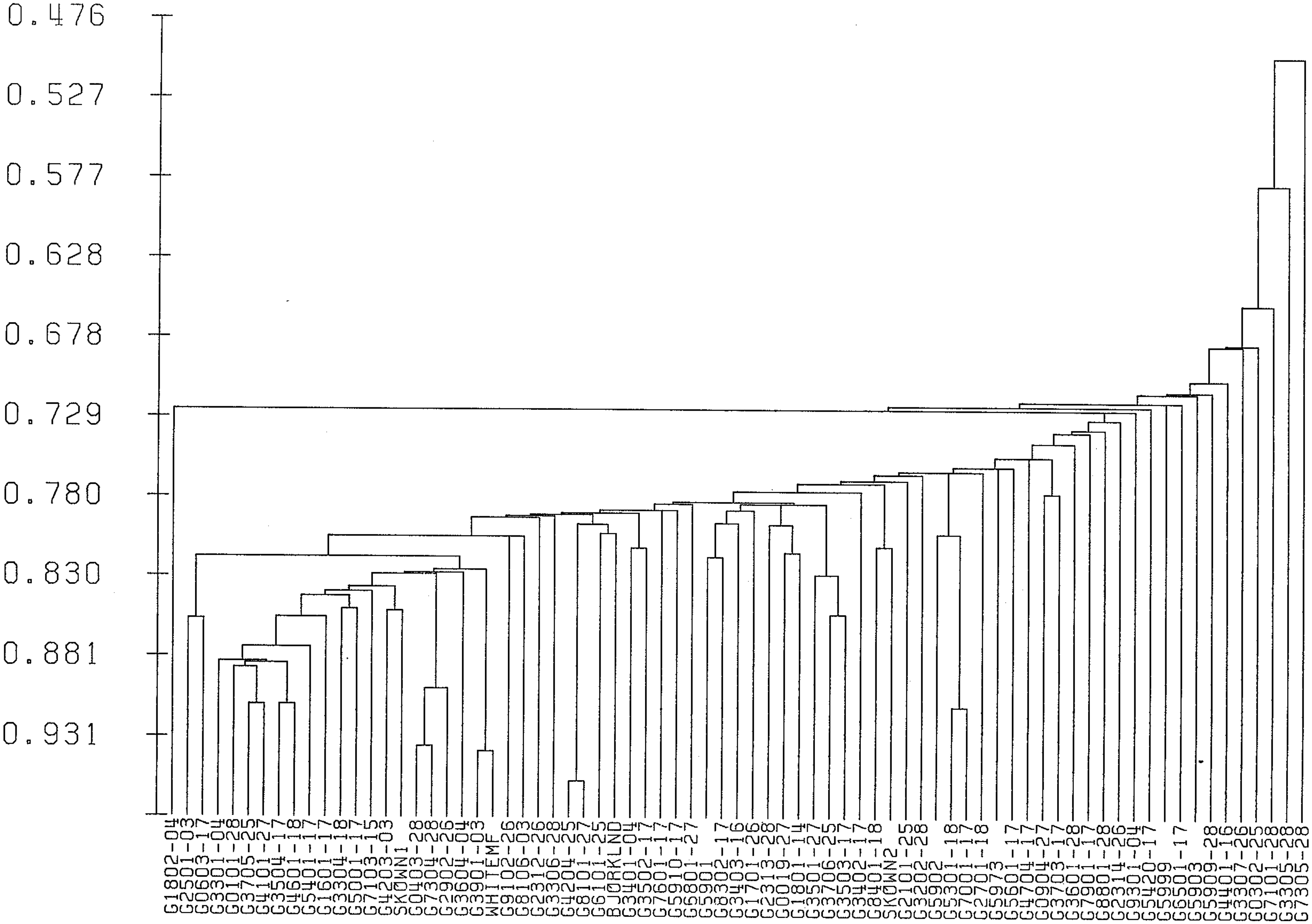
Males are more tightly clustered than females only because four of the latter (3305. 3307, 5909, and 7305) make up part of the anomalous group noted above. If these are excluded, females cluster at 0.000, about the same as for males. Group averaging gives generally identical results.

INCLUSION OF THE FOUR MANITOBAN SKELETONS

Some relationships were expected between the Gray site and these skeletons, but not on the scale shown (figures 4-6). The two Skownan skeletons are male. Skownan 1 joins 4203, an unsexed 4-6 year old, at .852 (1.0 indicates complete correspondence). Skownan 2 pairs with an older adult male at a coeffieicnt of .811. These values for all linkage patterns are high. The complete sample only fuses at a value of .499 (single) and .131 (group average).

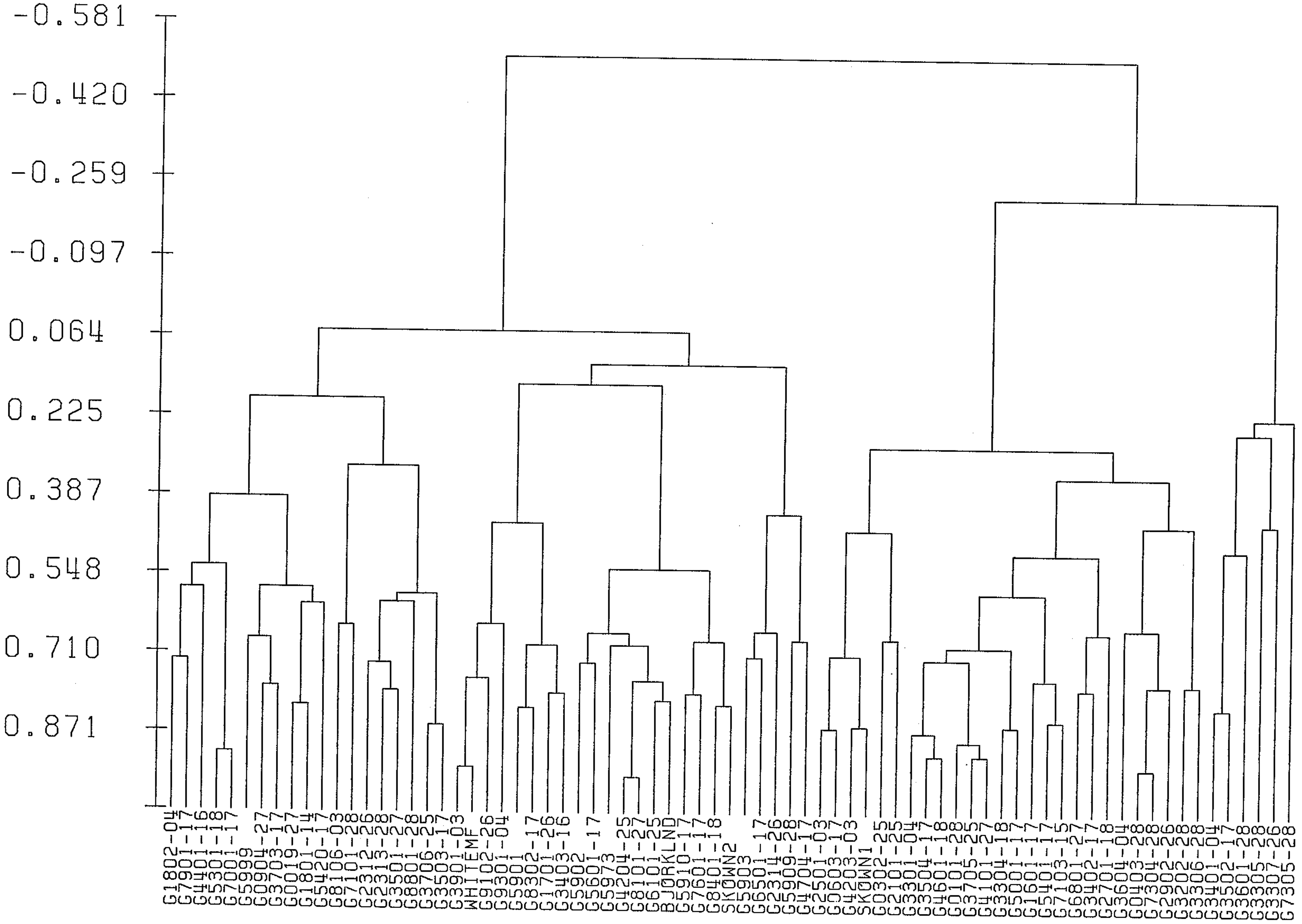
Much the same is true for the Bjorklund and Whitemouth Falls females. The former cleaves to 6101, a 13-17 year old female, at a coefficient of .803. The latter unites with 3901 (4-6 years, unsexed) at .940; making these two of the most similar pairs encountered.

The effect of these four individuals on the rest of the material is minor. As stated before, most of the smaller



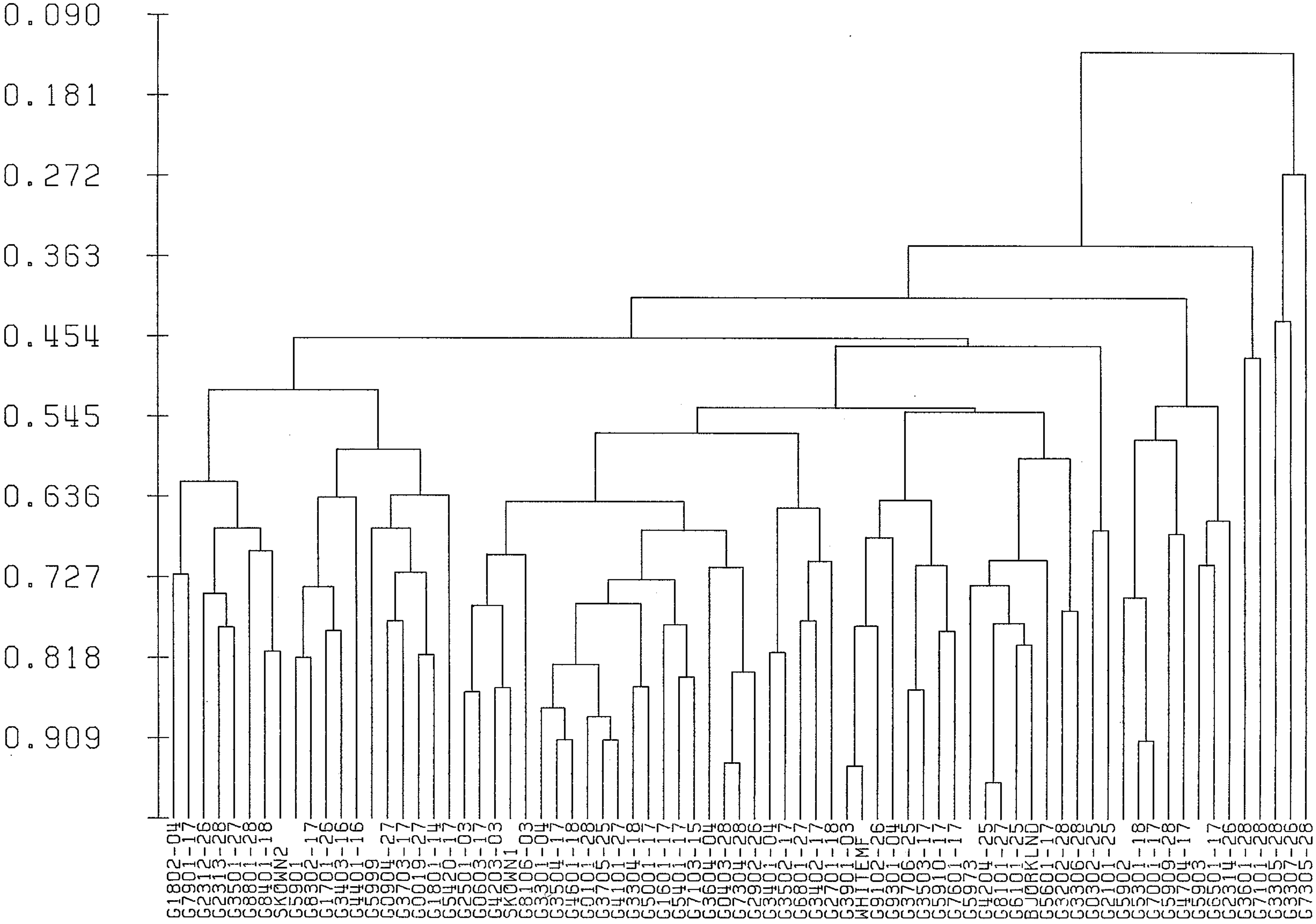
GRAY SITE PLUS FØUR MB INDIVIDUALS HIERARCHY=SINGLE LINKAGE

Figure 4



GRAY SITE PLUS FØUR MB INDIVIDUALS HIERARCHY=CØMPLETE LINKAGE

Figure 5



GRAY SITE PLUS FØUR MB INDIVIDUALS HIERARCHY=AVERAGE LINKAGE

Figure 6

clusters are quite stable. No radical changes of structure, whether association or similarity coefficient level, were observed.

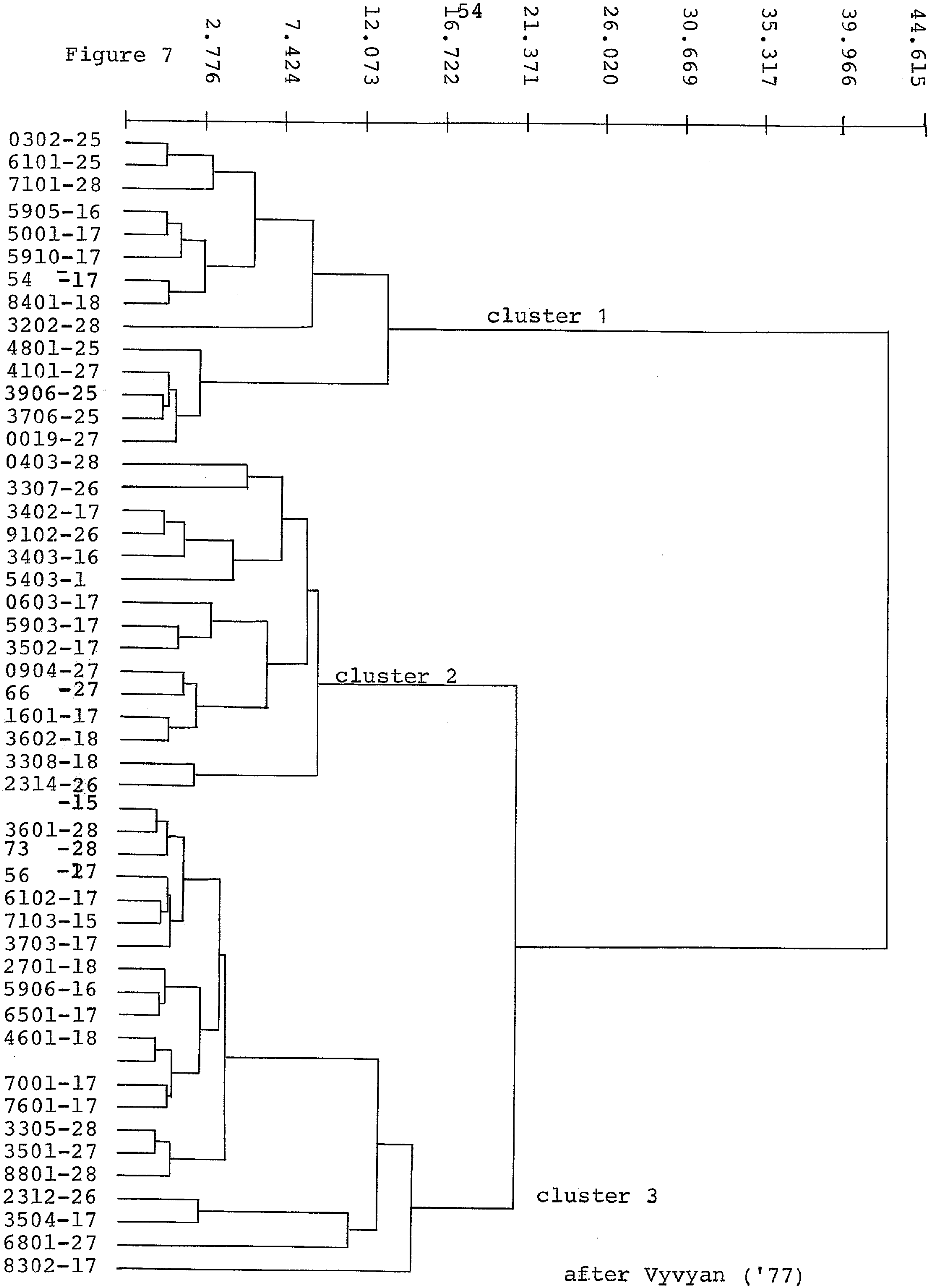
COMPARISON WITH THE METRIC STUDY

Different variable sets cannot be expected to give the same results when investigating what is probably quite small intra-population variation. Part of the reason stems from the factors underlying development of the skeletal system (sex, growth rate, laterality). Another part is dependent upon technique. An unfortunate aspect of the non-metric study is that an exact replication of the method used by Vyvyan ('77) in her metric analysis of the Gray site is impossible.

A comparison of the resultant dendrograms (figures 1-3 and figure 7) reveals some interesting discordances. The overall structure of the metric-based diagram is much different from the results presented herein. Three clusters are visible, two of them 'tight', or well differentiated. Of the identified individuals from the earlier study, there is no tendency for grouping in the dendrograms based on non-metrics. Even the individuals of the most distinct, smaller cluster (figure 7) assort themselves throughout the non-metric diagram.

At least part of the reason for the evident dissimilarities lies in the measures used. Size variables were used

Figure 7



after Vyvyan ('77)

by Vyvyan ('77); probably accounting for most of the low level clustering by sex. The very distinct group, her cluster 1, contains five of the six subadults (13-17y.). These are all female, while the remaining subadult, 7103, is male and is in cluster 3.

In the sample used (n=49, I have deleted 7101 in her cluster 1 as there is a mistake in sexing), 22 are female, or 45%. Vyvyan's cluster 1 contains 64% females (9/14); cluster 2,40% (6/15); and cluster 3, 33% (7/20). Such a distribution by sex, while the confidence limits for each cluster's percentage for females embraces the total sample percentage, indicates that the clusters are assorted along a gradient of size. Sex and age are seen to be two components of that gradient.

It seems reasonable, then, to assume that if size effects were dispensed with, or the subadults deleted from the metric analysis, much of the heterogeneity of the sample would disappear.

CHAPTER V

DISCUSSION

The exploration of human variation can yield clues to specific questions in terms of pursuing the history of the Gray site. The non-metric variation evident has been used as a tool to describe the morphological structure of the population and to relate it to our present knowledge of the Plains Archaic.

The methodology was developed as an investigative device, to examine its applicability to skeletal studies in general. At the same time it has opened up the possibility of ordering some of the vast amounts of information contained in the skeletal material allowing questions to be asked within a more coherent framework. Some of these have been raised in the results chapter and will be discussed below.

It has become apparent to me that population analysis must be tempered by individual analysis not only to pursue certain problems, but as a preliminary to further comparison. To this end, cluster analysis is admirably suited. The result of such a study is a discussion of individuals the basic unit of osteological research.

In order to study the population and the individuals composing a part of it, variables had to be selected and themselves examined. Unlike measures of size and shape, qualitative variables may be assorted into a number of categories. Those dealing with the relationship between the skeleton and the vascular/nervous systems can be profitably separated from traits involving muscular robusticity, joint variation or changes in bony deposition. I have found the former to be easily and consistently defined. Furthermore, my preliminary investigations have shown them to be biased by age and sex in an inconsequential way.

Unfortunately, this does not appear to be true for all traits in all populations. It is probably necessary for these associations to be tested in every study, or recognized as possible biases in the results. I have found it impossible to discern any tendencies for bias in the results presented, although assuredly they are there.

In making left and right side observations the problem of laterality is encountered and I have followed the common procedure of reducing redundancy by counting only one side. There is a lot to be gained, however, by using laterality itself as an investigative tool. Variation in individual and trait asymmetry can chart differences in growth rates and are applicable to both between and within population comparisons.

CLUSTER ANALYSIS OF THE GRAY SITE

The homogeneity exhibited by the Gray collection extends over the full range of use; more than 2000 years. The few carbon dates available (Millar '78) show no grouping by date in the dendrograms. This is in accord with the archaeological data that suggests the presence of only one group. The lack of sharp distinctions in any Clustan procedure argues for morphological stability within the Gray site. While these results conflict with the metric study (Vyvyan '77), they are supported by the archaeological and chronological information. As was pointed out in the previous chapter, the metric study suffers from biases in age and sex. Using non-metrics has done away with such problems. The separate analyses of male and female, adult and subadult show a uniform variability, while the complete sample has been shown to have no obvious biases.

For the traits examined, the four individuals added to the cluster analysis from outside the Gray site are found to be extremely similar. The general morphology of these skeletons is visually close to that of the Gray site. It is evident that east-west movement would be greatly aided by the major river systems of the Plains. In that light it is reasonable to suppose the Archaic to be a time of routine migration and similarity. This interpretation is further aided by an analysis of the two skulls from the Skownan site (Wyman n.d.). Hierarchical clustering based on metric measures placed them consistently far from post Archaic skeletons that were excavated much closer to the Skownan site than is the Gray site.

The similarity of these four skeletons from outside

The Gray site leads to a discussion of the individuals so often referred to in the previous chapter. This anomalous group of females contains at least three and possibly as many as six adults. Between 10 and 20 percent of the females in the sample are represented by these few. In osteological studies that have attempted to discern social structure from relationships among groups and between sexes (Lane and Sublett '72, Spence '71), much has been made of the differences in homogeneity between males and females. Generally the findings coincide with a mode of woman exchange such as posited by Williams ('74).

Lane and Sublett ('72) hypothesized that a number of exogamous groups were arranged into a larger endogamous group. The females are found to be morphologically more alike than are the males. However, the movement of females only is not going to make males in each group more distinct after more than a few generations. To evade this problem of viewing a dynamic process (reproduction and genetic recombination) as a synchronic event, it is reasonable to suggest that if woman exchange is being practised, then some skeletons should directly reflect this fact. The sample frequencies of female traits should then be more similar because each is represented in the other sample.

I suggest that this is what is found with the outlying group of females in the Gray site. Of necessity, this hypothesis must await the application of cluster techniques to a larger and more widespread samples from the Plains.

Given the importance of exchanging women as a means of enhancing solidarity, it is not unlikely that such a comparatively large proportion of the females in the sample appears to have joined the people of the Gray site. It is curious however, that these individuals should be distinct even from the Archaic skeletons from Manitoba. A simple hypothesis that awaits testing is that these females have come from north or south, rather than east or west. In other words they are from outside the culture we call Oxbow.

In this thesis I have tried to accomplish two goals. The first task was to formulate a methodology to examine individuals within a population through multivariate structuring. This has been accomplished using cluster analytical techniques on non-metric variables. The second goal was to describe the Gray skeletal population using these techniques. By attempting to clarify intragroup morphological relationships, future comparisons within a broader context may bring our view of the Plains Archaic and its people into sharper focus.

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APPENDIX

The trait frequencies are presented for all traits examined during the course of study. Sides are enumerated separately. The codes [columns] may be interpreted with the aid of table I. Sample sizes [n] are on the far right.

Observations were only taken for bones directly assignable to a given individual.

TRAIT	0	1	2	3	4	5	n
R FRGR	66	23					89
L FRGR	66	24					90
R SUOR	4	30	17	33	4	22	110
L SUOR	1	37	13	45	2	19	117
R ETFO	0	10	8	1	1		20
L ETFO	0	10	7	0	0		17
R ETPO		3	11	0			14
L ETPO		3	8	0			11
R OPFO		36	2	0			38
L OPFO		37	3	0			40
R INOR		57	6	1			64
L INOR		58	6	1			65
R ZYFO	5	36	18	6	2		67
L ZYFO	10	34	19	7	2		72
R ZYOR	15	34	23	4			76
L ZYOR	8	39	21	0			68
R ZYTE	7	44	15	2	1		69
L ZYTE	14	42	9	3	1		69
R PAFO	61	50	2	1			114
L PAFO	62	51	2	0			115
R MAFO	6	30	21	13	7	1	78
L MAFO	5	29	22	16	6	3	81
R MAPO	6	3	14	48	2		73
L MAPO	5	6	12	49	3		75
R METE	38	22	11				71
L METE	35	28	16				79
R POCC	8	85					93
L POCC	3	96					99
R ANCC		73	10	11			94
L ANCC		74	4	14			92
R INCC	34	11	17				62
L INCC	29	15	14				58

TRAIT	0	1	2	3	4	5	n
R STMA		68	31				99
L STMA		74	30				104
R OVSP	1	5	75				81
L OVSP	2	3	80				85
R FOOV		61	4		4		69
L FOOV		73	4		2		79
R FOSP		17	59				76
L FOSP		20	61				81
R VEFO	14	48					62
L VEFO	12	47					59
R PTBA	47	19	3				69
L PTBA	51	21	3				75
R PTSP	21	48	1				70
L PTSP	24	46	1				71
R SPBA	57	10	7				74
L SPBA	51	19	7				77
R PTPL	13	2					15
L PTPL	11	1					12
R PTPA	4	20	7				31
L PTPA	4	23	1				28
R PLFO	2	23	21	5	1		52
L PLFO	1	14	22	12	2		51
R CLCL	27	11	6				44
L CLCL	28	9	12				49
R CACL	8	3	3				14
L CACL	9	3	2				14
R MEBR	92	8	11				111
L MEBR	101	6	9				116
SAG SIN		46	7	8	10		71
R MYAR	5	46	13	12			76
L MYAR	4	50	15	9			78
R MNFO	18	40	9				67
L MNFO	13	41	9				63

TRAIT	0	1	2	3	4	5	n
R MEFO	77	18	0				95
L MEFO	66	26	1				93
R SUSC	4	12	0				16
L SUSC	2	18	0				20
R CISU	13	15					28
L CISU	22	12					34
R SUAR	3	10					13
L SUAR	2	10					12
R SUVE	4	9					13
L SUVE	3	8					11
R CCDI	11	0	0				11
L CCDI	9	1	1				11
R CDDI	10	2	0				12
L CDDI	9	1	0				10
R CEDI	6	1	2				9
L CEDI	5	2	4				11
R CFDI	2	3	5				10
L CFDI	5	2	4				11
R CGDI	3	0	0				3
L CGDI	5	2	0				7
R FOTR	8	0	0				8
L FOTR	9	0	0				9
R POBR	21	1	1				23
L POBR	18	2	2				22
R LABR	15	2	0				17
L LABR	16	0	1				17
R RANO	11	9	1				21
L RANO	14	7	1				22