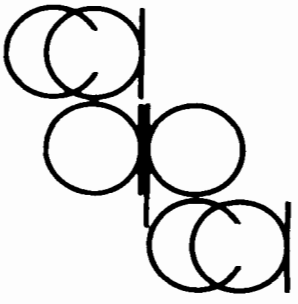
CANADIAN REVIEW OF PHYSICAL ANTHROPOLOGY

REVUE CANADIENNE D'ANTHROPOLOGIE PHYSIQUE

VOLUME 2 **NUMBERS 1-2** **1980**



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ISSN 0225-9958

The Skeletal Remains from the Taber Child Site, Taber, Alberta

ROBERT I. SUNDICK
Department of Anthropology, Western Michigan University, Kalamazoo, Michigan 49008

KEY WORDS Early Man • North America

ABSTRACT An analysis of a four to nine month old human infant with a possible date of at least 40,000 years, from Taber, Alberta, is presented. The specimen was found by A. MacS. Stalker in 1961 and has been reconstructed by the present author. The skeletal material derives primarily from the left side of the skull and face and, based on the degree of mineralization of the bone and the density of the matrix in which the material was embedded, it appears likely that the specimen is as old as has been suggested. The fact that only one side of the skull and face is present would indicate that erosion of the missing right side occurred before the specimen was embedded in the matrix. Loss of the right side after mineralization would have been unlikely because of the density of the matrix.

RESUME L'étude d'un enfant humain âgé entre quatre et neuf mois, associé à une date possible de 40,000 ans, provenant de Taber, Alberta, fait l'objet de cette communication. Le spécimen fut découvert par A. MacS. Stalker en 1961 et a été reconstitué par l'auteur. Les parties du squelette appartiennent principalement au côte gauche du crâne et de la face. Sur la base du degré de minéralisation de l'os et de la densité de la matrice lors de sa découverte, il semble possible que le sujet soit aussi ancien qu'on le suggère. Le fait qu'un côté seulement du crâne et de la face ait été préservé semble indiquer que l'érosion de la partie droite manquante a eu lieu antérieurement à l'ensevelissement du spécimen dans la matrice de sa découverte. La perte du côté droit après minéralisation aurait été peu probable en raison de la densité de la matrice.

The bones to be discussed herein are those which were discovered by A. MacS. Stalker and his field staff from the Geological Survey of Canada on July 11, 1961, near Taber, Alberta. Their find was made accidentally while Stalker and his colleagues were mapping surficial deposits in the area. At the time of the discovery Stalker was not aware that the small, fragmentary bones which were almost entirely embedded in a dense matrix were from *Homo sapiens* (Stalker '69). If this were known Stalker admits that a more diligent search of the area for additional bones would have been undertaken (Stalker '69), but this was not done and hence we have available for study only a very small sample of fragmentary infant skeletal remains. The bones were first sent to Mr. H. L. Shearman, of the National Museum of Canada who removed some of the surrounding matrix from the bone, but left all of the pieces together within the matrix. This lump of matrix with bone fragments extending from it was studied by Langston and Oschinsky ('63). Late in the 1960's the material was given to the present author by Dr. David Hughes, of the University of Toronto, for further study. I, in turn, brought the material to Dr. A. Gordon Edmund of the Royal Ontario Museum,

Toronto, Ontario, who very generously removed the entire skeleton from the matrix in which it was still embedded. Once the bone was removed from its matrix it was possible to reconstruct parts of the cranial vault and to identify additional parts of the skeleton which were included in the matrix.

This report is a review of the evidence for the antiquity of the material and a description of the skeletal material itself, based on the most complete reconstruction which has been undertaken to date. The material now resides in the National Museum of Man, National Museums of Canada, Ottawa, Ontario (Catalog No. XV-C5).

The site which yielded the material is located approximately 3 miles north of Taber, Alberta on the east bank of the Oldman River. More specifically it came from a cliff referred to as the Woodpecker Island Bluff (Stalker '69). Stalker has recently presented a number of arguments detailing the reasons why he believes in the great antiquity of this specimen (Stalker '69, '77), and concludes the following:

> "The Taber child is the most direct evidence for the presence of man on the Canadian prairies before retreat of the last Wisconsin glacier. It consists of the skull and some other bones from a four-month-old child, found in alluvial sand some 60 feet below prairie level at a fresh exposure along the Oldman River just north of Taber, Alberta. Because the sand beds lie beneath a classical Wisconsin till, the child is at least 18,000 years old. Further, the bones compare in mineralization and preservation with mid, or perhaps classical, Wisconsin bones recovered from near Medicine Hat to the east. Elsewhere the unit that contained them has yielded radiocarbon dates on wood of > 32,000 and > 49,000 years. The best estimate of their age is about 40,000 years." (Stalker '77: 135).

THE SKELETAL MATERIAL

The skeletal remains are those of an immature individual aged somewhere between four and possibly nine months of age. The early age is assigned on the basis of the fact that the two halves of the mandible at the symphysis menti are not yet fused together. This is generally thought to take place by six months of age. The older age is based on the degree of calcification of the lower, first and second deciduous molars. The bones recovered are primarily from the skull and are described below:

Parietals

The left parietal (fig. 1) is virtually complete, missing only the lateral anterior corner which articulates with the greater wing of the sphenoid. The bone measures 104 mm. along the sagittal suture and 92 mm. along the lambdoidal suture. It is 2 mm. thick at lambda and 1 mm. at bregma. There is a good deal of bossing at the parietal tuberosity, which would be expected in an individual of this age. The articulation between the two parietals and the occipital indicate that the posterior fontanelle is closed. This should occur in the first few months after birth. The inner surface (fig. 2) shows grooves for the frontal branch of the middle meningeal vessels, which are identical to those seen in modern day man.

The right parietal (fig. 3), less complete than the left parietal, consists of an 80 mm. section along the sagittal suture extending from lambda anteriorly. It extends laterally to the parietal tuberosity.

Occipital

The squamous part (fig. 4) of the occipital bone is fairly complete. The superior median fissure is fused. The mendosal suture or the line of union between the upper and lower parts of the squama cannot be observed on either side. Grooves on the inner surface for the superior sagittal venous sinus and the transverse sinuses are deep and easily discernible. The superior sagittal venous sinus turns into the right transverse venous sinus to drain eventually into the right sigmoid venous sinus of the temporal. A small portion of the right exoccipital including the posterior two-thirds of the occipital condyle is present. There is no posterior condylar canal.

Temporal

The left temporal (fig. 5) is intact except for a portion of the squamous part anterior to the squamomastoid suture and posterior to the zygomatic process. Maximum length of the bone in the sagittal plane is 56 mm. The posterior limb of the tympanic ring is fused to the petrous part through its entire length, while

only the most superior part of the anterior limb is fused to the squamous part. There is a small growth of bone extending down from the most superior part of the anterior limb toward the posterior limb, forming a foramen of Huschke. This stage of development corresponds to stage 4 in Anderson's ('62) report on the development of the tympanic plate. The incus and malleus are present on this side.

Frontal

The frontal bone consists of two fragments from the left side. One piece measuring 67 mm. by 39 mm. articulates with the left parietal and includes part of the edge of the anterior fontanelle. The other piece, a fragment of the orbit, extends from the sphenofrontal suture medially to a point just past the depression for the lacrimal gland. The zygomatic process of the frontal bone is present.

Maxilla

A barely recognizable fragment of the left maxilla is present. The alveolar sockets for the lateral incisor, permanent and deciduous canines, first and second deciduous molars are exposed as the external surface of the alveolar border is missing. There is a small part of the nasal process of the maxilla present.

Mandible

The left half of the mandible is present and complete (fig. 6). Fusion has not yet occurred at the symphysis menti. The height of the bone at the symphysis menti is 13 mm. and its depth is 10 mm. A single mental foramen is present below the anterior root of the first deciduous molar. The lateral and central deciduous incisors and the deciduous canine are missing. The crown of the lateral permanent incisor is present but cannot be observed. The first and second deciduous molars are present in their sockets. The first molar can be seen to be at a stage where one-fourth of its root is developed. An X-ray of the second molar shows it to have a completely calcified crown. The respective ages for these teeth according to 50th percentile standards for development of deciduous teeth by Fanning ('61) would be between 0.57 and 0.92 years for the first molar and 0.83 and 0.88 years for the second molar. These standards are based on X-rays of contemporary Boston children and the applicability of the standard to this specimen is questionable.

Vertebrae

The left lateral mass of the atlas and two neural arch halves from the cervical or thoracic region are present.

Clavicle

The left clavicle with a midshaft circumference of 14 mm. is present. A small segment of the medial end is broken off and missing.

Tibia

A very small segment of the proximal end (31 mm. maximum length) of the right tibia is present.

Other small fragments of bone are present which cannot be positively identified. One fragment, however, appears to be a nonhuman vertebral body.

Table 1 is a tabulation of the bones which are now identified and those which were identified by Oschinsky ('63). As can be observed there is a discrepancy between this report and the earlier one and I believe that this can be attributed to the fact that when Oschinsky studied the material it was still embedded in its matrix. He has, in fact, mistakenly identified a tibia as being a femur and skull fragments as being a scapula. This points out that we should make every attempt to clean and reconstruct our skeletal material before analyzing it in order to prevent errors from occurring and persisting through time in the literature.

Additionally it should be noted that the bones of the face and skull came almost entirely from the left side with only a fragment of the right parietal present. This indicates to me that the skull was most likely intact at the time of its deposition and that differential preservation has led to the destruction of the right side. This could have occurred if the right side were exposed to the elements before the cementing of the bones together into their dense matrix. I think it is unlikely that the destruction took place recently during the exposure of the deposits in which they were found, because of the extremely dense nature of the matrix which almost completely surrounded the bone.

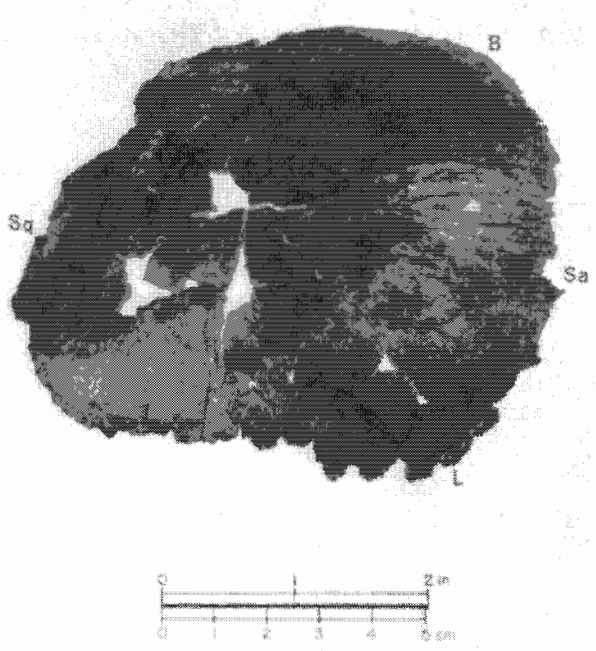


Fig. 1 Left parietal external surface (B-bregma, Sa-sagittal suture, L-lambda, Sq-squamosal suture).

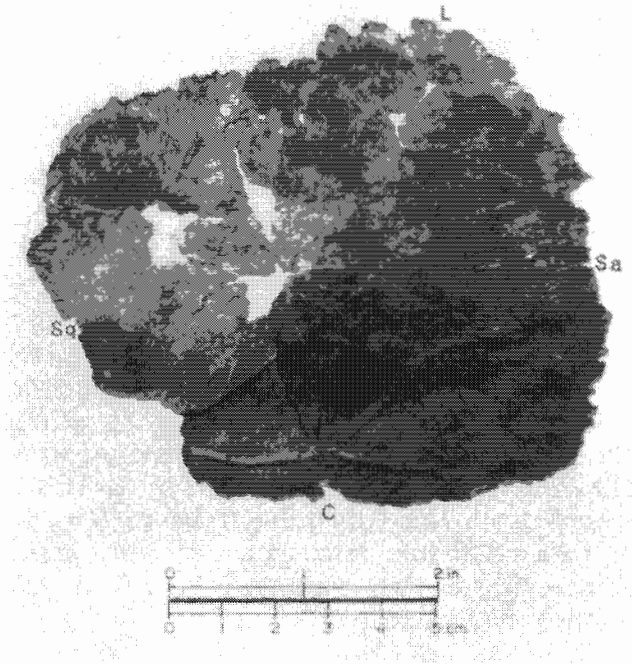


Fig. 2 Left parietal internal surface (L-lambda, Sa-sagittal suture, C-coronal suture, Sq-squamosal suture).

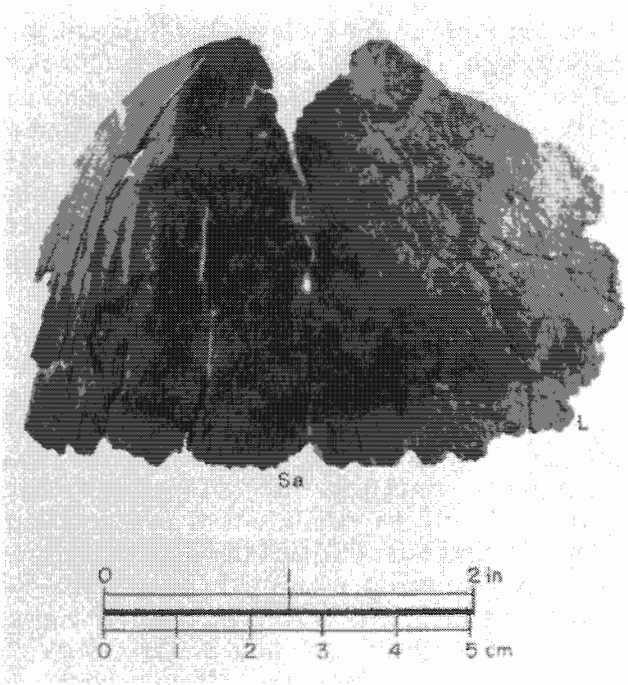


Fig. 3 Right parietal external surface (L-lambda, Sa-sagittal suture).

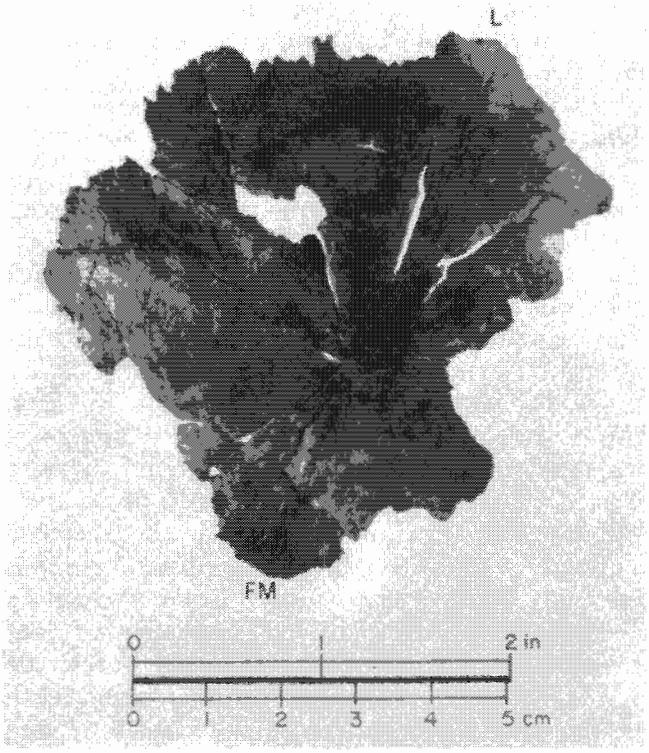


Fig. 4 Occipital bone external surface (L-lambda, FM-foramen magnum).

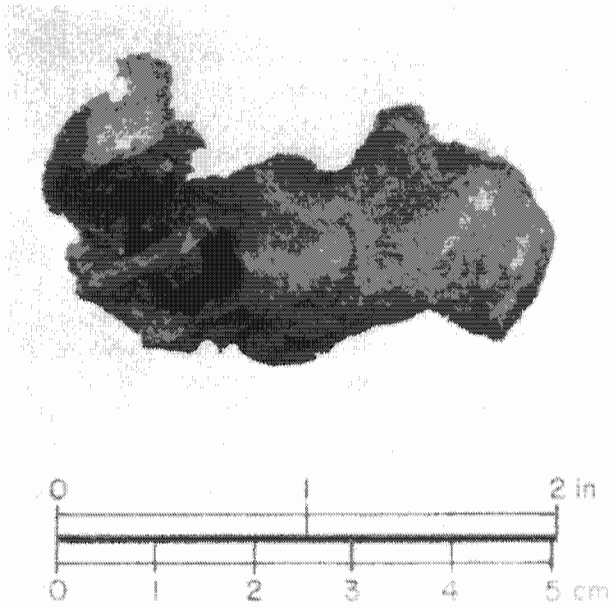


Fig. 5 Left temporal.

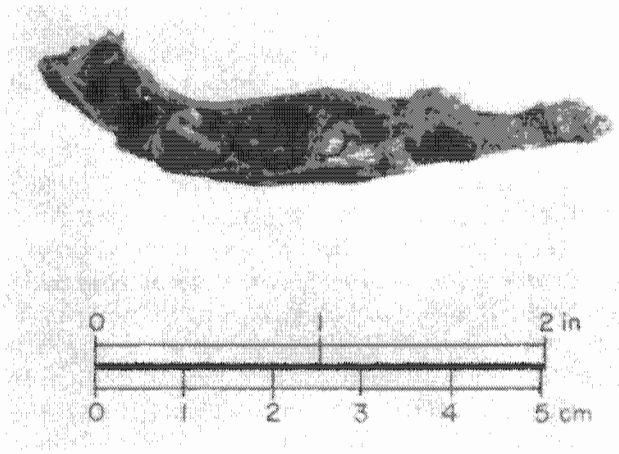


Fig. 6 Left mandible.

TABLE 1

A comparison of the Taber child skeletal material identified by Sundick and Oschinsky

Bone	Sundick	Oschinsky
Parietal	left and right present	fragments
Occipital	present	present
Temporal	present	absent
Frontal	two fragments from left side	fragment
Maxilla	fragment from left side	fragment – unrecognizable
Mandible	left – present	left – present
Atlas	left neural arch	absent
Vertebral neural arch halves	two present	two present
Clavicle	left	right
Tibia	right	absent
Scapula	absent	left
Femur	absent	left
Ribs	absent	two present

CONCLUSION

This specimen found by Stalker in Taber, Alberta is an extremely important one in delineating when man first arrived in the New World. Stalker, based on the geological evidence, is firmly convinced that the specimen is as old as 40,000 years, if not older. Jennings ('78) indicates that there was a land bridge connecting Asia to North America at this early time period, over which man could have travelled and Dragoo ('75) in a review of the evidence for man's arrival in the New World indicates that this arrival could have occurred more than 30,000 years ago. The specimen itself cannot be dated by the C-14 technique because there is so little of it and because it has been treated with an unknown preservative. The matrix surrounding the bone is unlike any that I have observed in more recent specimens and is probably consistent with an early date.

The fact that only this small sample is present should not be taken to indicate that man did not arrive in North America this early. I would presume that if man arrived in North America as early as 40,000 years ago that he arrived in small hunting bands, who would not have left significant amounts of skeletal or artifactual remains in one place for later discovery. It is probably not unreasonable to assume that in a group such as this, that if a four to nine month old infant were to die he would be left behind in some convenient area for nature to take its course. This, in fact, might lead to the type of preservation seen in the Taber specimen. It is hoped that further investigations in this region will lead to more definite evidence of man's early arrival in the New World.

ACKNOWLEDGEMENTS

I am grateful to Dr. A. Gordon Edmund of the Royal Ontario Museum, Toronto, Ontario, Canada who most graciously took the time and put the effort into removing this skeletal material from the matrix in which it was embedded. Without his help this material never would have been as completely reconstructed as it now is. I also express my thanks to Dr. Jerome S. Cybulski of the National Museum of Man, National Museums of Canada who made some of the information contained in the report available to me. The photographs were taken by Mr. John Glover of the University of Toronto.

LITERATURE CITED

Anderson, J. E. 1962 The development of the tympanic plate. Contributions to Anthropology 1960, Part I. National Museum of Canada, Bulletin No. 180.

Dragoo, D. W. 1976 Some aspects of Eastern North American prehistory: A review 1975. Am. Antiq. *41:*3-27.

Fanning, E. A. 1961 A longitudinal study of tooth formation and root resorption. New Zeal. Dental J. *57:*202-217.

Jennings, J. D. 1978 Origins. In: Ancient Native Americans. J. D. Jennings, ed. W. H. Freeman, San Francisco.

Langston, W. and L. Oschinsky 1963 Notes on Taber "Early Man" site. Anthropologica *5:*147-150.

Stalker, A. M. 1969 Geology and age of the early man site at Taber, Alberta. Am. Antiq. *34:*425-428.

——— 1977 Indications of Wisconsin and earlier man from the Southwest Canadian Prairies. Ann. New York Acad. Sci. *288:*119-136.

Etude Préliminaire de Certains Iroquoïens Préhistoriques du Québec [1]

ROBERT LAROCQUE et NORMAN CLERMONT
Département d'Anthropologie, Université de Montréal, Montréal, P.Q. H3C 3J7

MOTS CLES Iroquoïens Laurentiens • Variabilité Biologique

RESUME L'analyse de caractères métriques, morphologiques, discrets et odontologiques, de quatre échantillons de crânes attribués à des Iroquoïens préhistoriques de la vallée du St-Laurent, révèle une grande variabilité intergroupe. La présence possible de quelques individus non Iroquoïens, dans un ou deux échantillons, pourrait partiellement expliquer cette importante hétérogénéité. Il est d'autre part proposé que des facteurs environnementaux auraient pu favoriser la différentiation de ces groupes humains.

ABSTRACT Observations of metrical, morphological, discrete and odontological characters, on four samples of crania identified as prehistoric laurentian Iroquoians, show that these samples exhibit an important intergroup variability. This heterogeneity could partly be explained by the possible presence of a few non-Iroquoian individuals in one or two samples. On the other hand, it is proposed that environmental factors could have favoured the differentiation of these human groups.

INTRODUCTION

En 1860, des travaux d'excavation effectués au coin des rues Sherbrooke et Mansfield, à Montréal, ont mis au jour les restes d'un village iroquoïen. Un intérêt majeur de ce site a depuis toujours résidé dans le fait qu'il a été considéré comme étant celui d'Hochelaga, visité par Cartier en 1535. Cette possibilité peut en effet être envisagée, étant donné la situation géographique du site, et la présence d'objets de manufacture européenne, dans le matériel récupéré à l'époque, mais cette interprétation a aussi été contestée (Trigger et Pendergast, '72). Le matériel, maintenant éparpillé dans plusieurs musées, et les récits de Cartier, ont été étudiés par quelques auteurs, sans que la question soit pour autant définitivement résolue, et nous ne pouvons espérer trancher le débat à l'aide de l'étude des squelettes humains.

Il n'est peut-être pas si important de savoir que le site Dawson ait été ou non celui du village d'Hochelaga. Il est néanmoins évident qu'il doit être plus ou moins contemporain des séjours de Cartier au Nouveau-Monde.

Les études biologiques ont été jusqu'à récemment handicapées par l'apparente disparition d'une partie du matériel osseux recueilli par Dawson. Cette lacune vient d'être partiellement comblée, et c'est presque d'une toute nouvelle collection dont nous parlerons ici. Elle revêt d'autant plus d'intérêt que, depuis l'étude d'Anderson ('72), d'autres squelettes iroquoïens ont été mis au jour dans la vallée du St-Laurent. Ainsi, sommes-nous désormais plus en mesure de situer les Iroquoïens du site

[1] Ce texte est celui d'une communication présentée par Robert Larocque au 7e Congrès Annuel de l'Association pour l'Anthropologie Physique au Canada, Ste-Adèle, Québec, 1979. Il a été revisé par l'auteur, ainsi que par le Dr Norman Clermont, qui avait antérieurement fait une analyse préliminaire des échantillons des sites de Mandeville, de la Place Royale et de Lanoraie.

Dawson, sur la base de leurs caractères biologiques, par rapport aux autres groupes d'Iroquoïens de la vallée du St-Laurent.

HISTORIQUE DE LA COLLECTION DU SITE DAWSON

Le site a d'abord été révélé par la découverte de squelettes humains. Dans deux publications de l'époque, Dawson a décrit quelques caractères métriques et morphologiques des 8 crânes les plus complets, laissant entendre qu'il y en eut plusieurs autres dans un plus mauvais état de conversation (voir Trigger et Pendergast, '72 app. 2 et 3). Au moins 20 squelettes auraient été dégagés, dit-il.

Il rapporte dans ses notes que les 8 crânes avaient une tendance à la dolichocrânie, une capacité crânienne importante, et qu'ils présentaient une grande variabilité dans les dimensions. Cette variabilité aurait été telle qu'il en vint à croire que l'échantillon représentait plus d'une tribu, ou que la population était métissée. Il signale aussi qu'en général, les dents étaient fort usées, et que plusieurs étaient cariées ou tombées *ante mortem*.

Au début des années '70, J. E. Anderson a repris l'analyse à partir des squelettes du musée McCord (Anderson, '72, pp. 311-323). En se basant sur les maxillaires et les mandibules présents, il estima à au moins 10 le nombre minimum d'individus de la collection, alors que 4 crânes seulement, plus ou moins complets, ont pu être observés. Aucun de ces crânes ne put être identifié comme l'un des 8 décrits par Dawson (ibid, p. 314). Une important partie des squelettes récupérés par Dawson était donc manquante.

Malgré la maigre collection dont Anderson disposait, il arriva à la conclusion que les individus étudiés pouvaient être considérés morphologiquement comme des Iroquoïens, et que le groupe d'Iroquoïens s'en rapprochant le plus était celui de Roebuck, site ontarien de la vallée du St-Laurent, datant de 1 390 ± 100 ans ap. J. C. Il nota aussi que certains attributs de la denture traduisaient un régime alimentaire basé à la fois sur l'agriculture et la chasse-cueillette (ibid; pp. 319-320).

Quant aux 4 crânes en parfait état de conservation, trouvés sur les flancs du Mont-Royal à Westmount, et dont Anderson fait mention (pp. 311, 314), on ne saurait les inclure dans la collection du site Dawson, auquel ils ne sont pas associés. De plus, il n'est même pas acquis qu'ils soient contemporains des habitants de ce site. Nous devons donc traiter ces 2 échantillons comme s'ils représentaient 2 groupes distincts.

Il y a quelques mois, l'un de nous a pu retracer d'autres pièces squelettiques, dans des musées affiliés à l'Université McGill. La collection comprend désormais au moins 19 boîtes crâniennes. Un vingtième individu, âgé d'environ 6 ans, est représenté par un fragment d'arcade alvéolaire.

Cependant, ces 20 individus ne sont pas tous associés de façon certaine au site Dawson. Seulement 10 le sont, les autres l'étant implicitement. Même parmi les crânes certainement trouvés au site Dawson, il demeure possible que certains soient ceux d'individus étrangers à la population locale.

Les considérations précédentes, relatives à l'identification de ces 20 individus à la population du site Dawson, nous obligent à entrevoir les 3 possibilités suivantes:

1. ils proviennent tous du site Dawson, et étaient tous membres de la communauté locale.
2. ils proviennent tous de ce site, mais certains étaient des étrangers qui furent ensevelis pour une raison ou une autre, sur la terre de la communauté locale.
3. ils ne proviennent pas tous de ce site.

Tant que nous ne saurons à laquelle des possibilités nous rallier, les 2e et 3e se réduisent en fait à une seule. Or, dans l'état actuel de la recherche, on ne peut dire laquelle de ces possibilités est la plus probable, car parmi le groupe d'individus qui ont certainement été trouvés au site Dawson, la variabilité est importante. On ne peut donc pas raisonnablement exclure de ce groupe, aucun des autres individus, sur la base de ses caractères biologiques.

En comparant les descriptions publiées par Dawson, à celles des individus présentement à l'étude, on réalise qu'il manque toujours des crânes de la collection originale. On arrive tout au plus à reconnaître 2 des 8 crânes décrits par Dawson. Dans quelques autres cas, les observations morphologiques correspondent, mais pas les observations métriques, ou le contraire. Une grande partie du nouveau matériel, s'il vient du site Dawson, serait vraisemblablement celui,

trop fragmentaire, que Dawson n'a pas cru bon de décrire. Même si on tient compte des impondérables reliés aux faits qu'il a pris ses mesures en pouces, et qu'il a fallu ensuite les convertir en mm, que les définitions de ses mesures pouvaient être différentes des nôtres, et qu'avec le temps, certains crânes ont pu être endommagés, on ne peut raisonnablement reconnaître plus de 4 des 8 crânes qu'il a observés et décrits.

Quant à la collection étudiée par Anderson, elle fut retrouvée presque intégralement, sauf quelques fragments.

DESCRIPTIONS DES COLLECTIONS

Dawson

Des 20 individus, aucun n'est représenté par un crâne complet. Quelques-uns ne le sont que par la calotte ou un fragment de calotte. La détermination de l'âge et du sexe de ces derniers reste délicate et sujette à caution, mais ils ont aussi permis peu d'observations, et influencent donc peu les résultats. Les âges et sexes se répartiraient comme suit:

- 2 enfants (6 et 12 ans), 8 jeunes adultes, 5 adultes d'âge moyen, et 5 adultes âgés.
- 3 individus de sexe indéterminé (dont les 2 enfants), 11 mâles (3 sont discutables), et 6 femelles.

En première analyse, un attribut immédiatement évident de cet échantillon est sa grande variabilité morphologique et métrique. On peut souvent dire d'un échantillon de crânes d'une même population, qu'il s'en dégage un "air de famille", tels ceux de Mandeville ou de Westmount, qui seront décrits plus loin. Mais tel n'est pas le cas de l'échantillon de Dawson. Il est en effet plus difficile d'en dresser une diagnose. Aussi, quelques individus tombent en dehors du type iroquoïen décrit par Anderson, pour certains caractères. Les individus sur lesquels sont basées ces constatations sont pourtant certainement associés au site Dawson, et parmi les plus complets.

Le dimorphisme sexuel paraît aussi plus important que celui observé dans les autres collections, et en conséquence il a été relativement plus facile de déterminer le sexe des individus les plus complets. Le volume de la boïte crânienne notamment, était très discriminant, celui des mâles étant en moyenne très grand. Les mâles ont de plus un profil aux lignes plus arrondies, celui des femelles étant plus anguleux, vu l'aplatissement davantage marqué de la région post-bregmatique et de la région sus-lambdoïde, ou un degré de courbure plus prononcé entre ces 2 régions (fig. 1).

Parmi les quelques tendances ou constantes qui ressortent, signalons un relief sus-orbitaire modéré chez les mâles, et atténué chez les femelles. Il est en forme de V dans presque tous les cas. Le front est bas, et même chez les mâles, il est relativement bien bombé, quoique moins anguleux comparé à celui des femelles. Sur plus de la moitié des sujets où l'observation était possible, on remarque une dépression ou un aplatissement de la région post-bregmatique. La région sus-lambdoïde est aplatie sur la majorité des crânes, et l'occipital est très généralement bombé.

La *norma posterior* montre une pente biparietale prononcée. En conséquence, les bosses pariétales sont relativement basses, ainsi que les euryons, et surmontent des murs tombant plutôt droit. Même si les types ovoïdes tendent à dominer, en *norma superior,* on en relève quelques-uns de type plus ovalaire, mais qui se distinguent entre eux par la largeur maximum du crâne, relativement à la longueur maximum ou au développement latéral du frontal.

Sur les caractères de la face, il y a peu à dire, deux sujets seulement ayant une face bien conservée. Cette lacune est moins grande pour les mandibules, plus nombreuses et mieux conservées, dont on parlera à l'occasion des comparaisons entre les collections.

Notons que, des 3 tendances qui avaient été notées par Dawson, deux d'entre elles ont aussi été relevées sur l'échantillon présent, à savoir la grande capacité crânienne et la grande variabilité individuelle. Quant à l'indice crânien moyen, il indique bien, à 74, 6, une tendance à la dolichocrânie comme le disait Dawson, mais contradictoirement, les crânes auxquels il se référait alors avaient un indice moyen de 77, 6.

Westmount

La collection de Westmount a aussi des origines obscures. Seule la localisation géographique est indiscutable, bien qu'elle soit imprécise. Les 4 crânes qui se trouvent aujourd'hui au Musée National de l'Homme, à

Ottawa, et qui sont identifiés au catalogue du musée comme étant des "Hochelagans and Mohawks from an ancient Iroquois site at Westmount, Montreal" (Anderson, '72, p. 314), auraient été trouvés dans un cimetière près du réservoir situé le long de la Côte-des-Neiges, sur le flanc ouest du Mt-Royal (ibid, p. 314, note 1). Il est permis de douter qu'ils viennent tous de cet endroit, d'autant plus que de nombreux autres crânes ont été trouvés à Westmount (Lighthall, 1898, 1899, '24). Un cinquième crâne, qui aurait aussi été trouvé à Westmount, est actuellement dans les collections du musée McCord.

Ces découvertes sont presque totalement dépourvues de témoins culturels. Seuls les modes de sépulture et les caractères biologiques permettraient d'identifier éventuellement la population d'origine de ces 5 crânes. Or, les modes de sépulture ont été qualifiés d'algonquiens par Lighthall ('22, pp. 73-75), qui avait cependant d'abord cru qu'ils étaient iroquoïens (1899, p. 206). De son côté, Anderson les range dans son type iroquoïen (p. 314). Les moyens de datation font aussi défaut, si ce n'est l'absence d'objets de manufacture européenne, qui suggère que ces sépultures étaient antérieures à la période du contact.

Sauf celui du musée McCord, auquel il manque la mandibule, tous ces crânes sont complets. Ils sont en général beaucoup plus semblables entre eux que ne le sont ceux de Dawson. On y peut identifier 4 mâles adultes et une adolescente.

Les capacités crâniennes diffèrent très peu l'une de l'autre, même en incluant l'adolescente, et sont en moyenne bien inférieures à celles des individus du site Dawson. Le relief sus-orbitaire, en V, et la fuite du front, sont modérés. En *norma lateralis,* on distingue 2 formes de calottes: celles où le frontal est plutôt fuyant et le vertex nettement dégagé, et celles où le frontal est plus droit et le vertex difficile à localiser (fig. 2). Si dans la collection de Dawson des types semblables existent, on ne trouve cependant pas dans celle de Westmount le type de calotte régulièrement arrondie, qui caractérise quelques individus du site Dawson.

Les bosses pariétales sont à la fois plus développées et relativement plus élevées que sur les crânes du site Dawson. La *norma superior* révèle qu'ils sont plutôt brachycrânes, avec un indice moyen de 77,7, s'éloignant ainsi de ceux de Dawson dont l'indice moyen était de 74,6. La largeur maximum est aussi relativement plus reculée, et le front paraît plus étroit par rapport à la largeur maximum. Les boîtes crâniennes sont donc plutôt de forme ovoïde que de forme ovalaire.

Les arcades zygomatiques sont proéminentes, et cela explique en partie que la face soit large, l'indice facial supérieur étant inférieur à 50. Les orbites sont relativement larges et disposées horizontalement, plutôt qu'inclinées vers les côtés, tandis que le nez est étroit. Le palais est large et tend à épouser la forme d'un U.

Mandeville

Le site de Mandeville est situé sur la rive ouest du Richelieu, près de son embouchure. Ce site iroquoïen de la fin du Sylvicole supérieur a été fouillé à diverses reprises au cours des années '70, sous la direction de Girouard et Barré. Il a livré 6 fosses funéraires, 2 simples et 3 doubles, dont le contenu était dans un état de conservation médiocre (Clermont et Falardeau, '77).

La collection de crânes est composée de 9 individus: 5 mâles adultes, 1 femelle adulte, 2 femelles subadultes, et un jeune enfant. Ici encore, ils sont beaucoup plus homogènes que ceux de Dawson, et le dimorphisme sexuel est réduit. Le relief sus-orbitaire, en V, est modéré. Le front est généralement bas chez les 2 sexes, et chez les mâles il est plus fuyant qu'il ne l'est dans les autres collections. Le profil présente, chez les 2 sexes, des lignes adoucies (fig. 3). La calotte est, en aucun cas, pyramidale, contrairement aux les collections précédentes. Le toit du crâne est aussi moins élevé. L'aplatissement sus-lambdoïde et le bombement de l'occipital sont tous deux plus faibles. Malgré ces observations, aucun individu n'a un profil arrondi comme il en existe parmi les sujets du site Dawson.

Par rapport à la largeur maximum de crâne, le front est plus large. L'indice crânien de 76,4 les rend légèrement brachycrânes, et le crâne, vu en *norma superior,* est ovoïde.

Les observations sur la face sont trop peu nombreuses pour qu'on s'y attarde. Seuls 2 individus ont la face presque complète, et l'un d'eux est affecté d'une déformation.

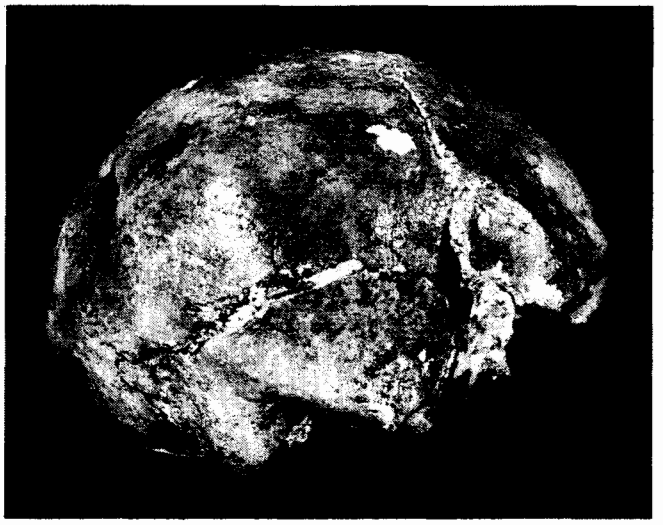
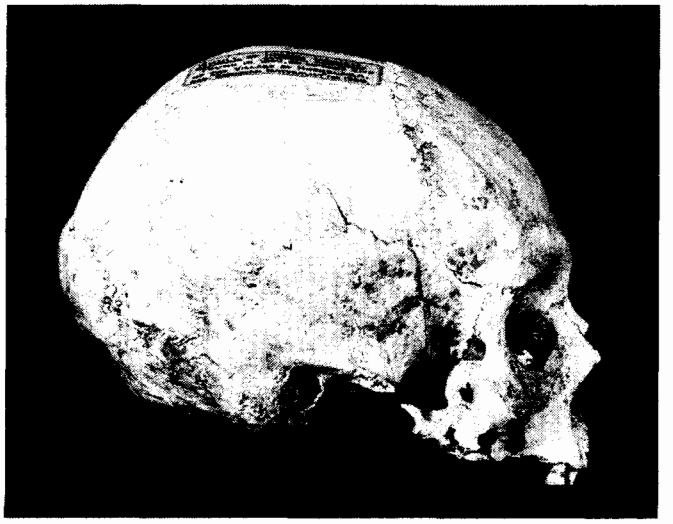


Fig. 1 Site Dawson. A) Un des crânes de mâles qui ont, en *norma lateralis*, une forme plutôt arrondie.



B) Un crâne femelle, au profil plus anguleux et au front plus fuyant.

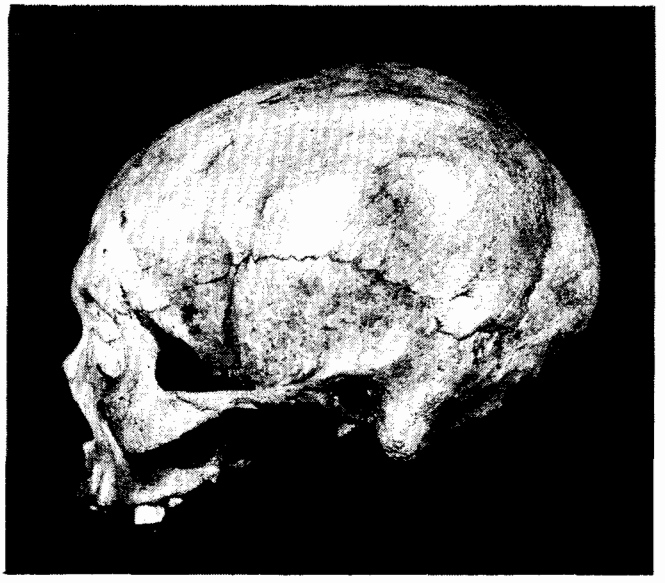
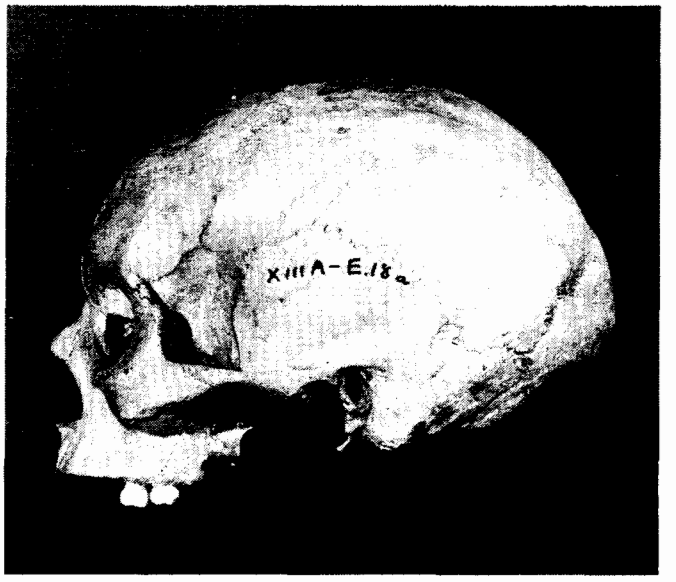


Fig. 2 "Site" Westmount. A) Un crâne de mâle, au toit de forme pyramidal.



B) Un crâne de mâle, dont le vertex est nettement moins dégagé.

Place Royale

Ce site du Sylvicole supérieur, situé dans la ville de Québec, a été fouillé en 1977 par Girouard et Mandeville. Il contenait, en deux fosses, les squelettes de 2 hommes et de 2 femmes adultes, et de 6 enfants de moins de 6 ans (Clermont, '78).

Pour fins de comparaisons, nous n'avons retenu que les adultes, dont l'état fragmentaire permet peu d'observations. On y peut toutefois remarquer un aplatissement sus-lambdoïde, une proéminence de l'occipital, un relief sus-orbitaire modéré et en V, et un relief musculaire marqué, surtout au niveau des crêtes temporales et des mandibules, ces dernières étant particulièrement robustes. Le seul individu dont on pouvait estimer l'indice crânien, serait nettement brachycrâne, l'indice se situant aux alentours de 80.

Fig. 3 Site Mandeville. Chez ce mâle, la *norma lateralis* montre des lignes adoucies, comme chez tous les individus de ce site, ainsi qu'un front très fuyant.

Enfin, signalons la présence, au Musée National de l'Homme, à Ottawa, des restes de deux adultes et d'un enfant trouvés près du village de Lanoraie, sur la rive nord du St-Laurent. Ils ont été offerts par Wintemberg, il y a quelque 50 ans. Le peu d'observations qu'on y peut faire permet néanmoins de confirmer l'identité iroquoïenne de la population qui occupa ce site. De même, les modes de sépulture s'apparentent à ceux d'autres Iroquoïens de la plaine de Montréal (Clermont, '79).

Que peut-on conclure de ces quelques observations faites sur les quatre premières collections? D'abord, que les quatre s'apparentent à des degrés sensiblement différents, au type iroquoïen d'Anderson. Mais ce qu'il faut surtout retenir, c'est que les groupes de Mandeville et de Westmount, spécialement le premier, présentent une variabilité intragroupe très réduite, alors que celui de Dawson est beaucoup plus hétérogène, et diffère globalement des 2 autres groupes. Nous comparerons maintenant les variables métriques et les variables discrètes, et pour terminer, les observations sur la dentition.

ANALYSE COMPARATIVE

Caractères métriques

Des échantillons d'effectif réduit empêchent généralement un test de t de déceler une différence significative entre 2 moyennes. Une même différence aura en effet d'autant plus de chances d'être significative, que les effectifs seront élevés. Nos comparaisons relèvent donc surtout d'une perception de type intuitif.

Dans le tableau 1 sont portées les moyennes de 12 variables qui traduisent le développement de la boîte crânienne chez les mâles. Pour toutes ces variables, les moyennes sont plus elevées chez les habitants du site Dawson que chez ceux des 2 autres échantillons, et parfois de façon nette. Ce fait est conforme à l'observation formulée plus haut, à savoir que les crânes mâles du site Dawson sont plus volumineux que les autres. Même si plusieurs de ces variables sont corrélées positivement, cela ne diminue en rien l'ampleur du phénomène.

Une autre variable s'inscrit dans cette tendance. Même s'il n'a été possible de calculer le module crânien que d'un seul mâle du site Dawson, il est supérieur de 6 et 8 unités aux moyennes des mâles de Westmount et Mandeville respectivement. Et ce mâle est, dans l'échantillon de Dawson, celui dont la capacité crânienne paraît être la plus réduite.

Malgré les contraintes posées par les effectifs réduits, le test de t a été appliqué aux variables dont l'effectif est au moins de 4 dans les échantillons de Dawson et Westmount. Sur ces 10 variables, 4 ont une moyenne significativement plus élevée chez les sujets du premier échantillon. S'il arrive que d'autres crânes viennent s'ajouter aux collections actuelles, à la suite d'autres trouvailles dans des musées, et que les tendances se maintiennent, d'autres différences pourraient être significatives.

Les effectifs des variables de la face, étant encore plus réduits, ne permettent pas un traitement statistique de ces données. Nous observons néanmoins que les dimensions externes du palais présentent certaines tendances. En effet, les gens de Dawson ont en moyenne un palais plus long, plus large, et relativement plus étroit. L'indice moyen de l'arcade alvéolaire supérieure est de 112, comparativement à 121 et 122 chez les gens de Westmount et de Mandeville respectivement. Ce fait ne serait vraisemblablement pas lié à un degré différent de prognathisme, puisque les moyennes de l'angle formé par le nasion, le prosthion et le basion sont toutes autour de 74°. Enfin, notons que les cavités orbitaires, déjà relativement larges sur

les individus de Mandeville et de Westmount, le sont encore plus sur ceux de Dawson.

Dans les comparaisons entre mandibules, les sujets qui attirent notre attention sont ceux de la Place Royale, dont les mesures de robustesse sont toutes plus élevées, en moyenne, que celles calculées aux autres sites. Elles sont présentées dans le tableau 2. On verra plus loin que ce fait est vraisemblablement en relation avec les observations sur la dentition. Pour l'épaisseur à la M_2g, la moyenne est significativement plus élevée dans l'échantillon de la Place Royale que celles des échantillons de Dawson et de Mandeville.

L'utilisation du test de la différence entre 2 variances, le test de F, pose les mêmes contraintes que celles du test de t.

La variabilité a été testée à 3 niveaux. Ont d'abord été comparés, les groupes mâles, ensuite les groupes complets, et finalement les mâles aux femelles d'un même échantillon.

De tous les tests sur l'égalité de 2 variances, un seul a révélé une différence significative entre 2 groupes mâles. C'est celui sur l'indice de hauteur-longueur des groupes de Mandeville et de Westmount. Le test ne peut être appliqué à la collection de Dawson, un seul indice ayant pu être calculé. D'autre part, ont été comparés les

TABLEAU 1

Données craniométriques (mâles)

	Mandeville		Dawson			Westmount	
	N	$\overline{X}$(mm)	N	$\overline{X}$(mm)		N	$\overline{X}$(mm)
longueur	3	185.0	4	194.5		4	183.3
largeur	3	139.3	4	147.3	*	4	140.8
larg. front. min.	3	94.3	6	97.0		4	94.3
corde Na Br	3	107.3	5	119.4	*	4	110.8
corde Br Ld	5	109.0	7	113.4		4	107.8
corde Ld Op	3	97.7	3	100.0		4	96.0
arc Na Br	3	117.0	5	132.4	*	4	123.5
arc Br Ld	5	120.4	7	126.0		4	118.3
arc Ld Op	3	117.0	3	122.3		4	116.0
arc Br Po	5	151.4	4	157.3		4	150.0
périm. horiz. max.	3	506.7	4	533.8	*	4	506.0
arc Po Po	5	306.8	5	315.6		4	303.5

*identifie une différence significative ($p \leqslant 0.05$)

TABLEAU 2

Mesures de robustesse de la mandibule (mâles et femelles)

	Mandeville			Place Royale			Dawson		Westmount	
	N	$\overline{X}$(mm)		N	$\overline{X}$(mm)		N	$\overline{X}$(mm)	N	$\overline{X}$(mm)
épais. à la M_2g	6	18.0	*	3	21.0	*	6	19.0	4	19.0
épais. à la symp.	5	16.4		3	17.0		7	16.4	4	16.3
haut. à la M_2g	2	24.0		3	30.3		2	25.5	3	27.3
haut. à la symp.	5	33.2		3	36.3		6	33.2	4	32.5

*identifie une différence significative ($p \leqslant 0.05$)

coefficients de variation des variables dont l'effectif mâle est au moins de 4 dans les échantillons de Dawson et de Westmount, sauf celles de la mandibule, dont l'effectif est de 3. Les mâles de Mandeville n'ont pas été retenus, les effectifs étant trop souvent inférieurs à 4. Des 15 variables ainsi sélectionnées, 11 ont un coefficient de variation plus élevé dans la collection de Dawson que dans la collection de Westmount, et dans 4 cas c'est le contraire (tableau 3).

Il semble donc que les mensurations tendent à être plus variables chez les mâles de Dawson, sauf celles de la mandibule, où cette tendance est, ou peu marquée, ou inverse.

La comparaison des groupes complets a donné des résultats semblables. Le test de F n'a porté que sur les échantillons de Mandeville et de Dawson, où le sex-ratio est sensiblement égal, et différent de celui de l'échantillon de Westmount. On observe alors que pour la largeur maximum et l'arc Br-Po, la variance est significativement plus grande parmi les sujets du site Dawson. Le calcul des coefficients de variation des variables dont l'effectif est au moins de 5 dans les 2 groupes, variables pour lesquelles les sex-ratios sont, sinon égaux, tout au moins très semblables, a donné les résultats présentés au tableau 4: 11 coefficients sont plus élevés au site Dawson, contre 3 au site de Mandeville. Si la variabilité intragroupe est surtout expliquée par le dimorphisme sexuel, alors ce dernier est plus important chez les gens de Dawson, sauf à nouveau à la mandibule.

La résorption alvéolaire a cependant pu fausser des mesures prises au niveau de la 2e molaire, mais certainement pas celles prises au niveau de la symphyse mandibulaire, où aucun cas de résorption n'a été remarqué. Il a d'autre part été vérifié que la présence de 1 ou 2 individus subadultes dans le calcul du coefficient de variation de certaines variables, ne suffit pas à expliquer les tendances observées, tant à la boîte crânienne qu'à la mandibule. Cette précision vaut aussi pour toutes les comparaisons jusqu'ici faites, bien que dans plusieurs cas elle ne s'applique pas

Pour savoir s'il y a des différences significatives entre les moyennes des mâles et des femelles d'un même groupe, le test de t a été appliqué à diverses variables des groupes de Mandeville et Dawson. Il arrive qu'il n'y a pas plus de différences significatives chez l'un que chez l'autre. Il semble donc que la variabilité intragroupe des variables métriques, plus grande dans l'échantillon de Dawson, soit due à

TABLEAU 3

Coefficients de variation (mâles)

	Dawson		Westmount	
	N	$\overline{X}$(mm)	N	$\overline{X}$(mm)
longueur	4	4.87	4	2.49
largeur	4	1.78	4	1.68
larg. front. min.	6	2.44	4	5.64
corde Na Br	5	2.18	4	2.79
corde Br Lb	7	6.49	4	3.96
arc Na Br	5	3.00	4	2.14
arc Br Ld	7	8.25	4	4.80
arc Br Po	4	5.90	4	2.83
périm. horiz. max.	4	3.15	4	1.46
arc Po Po	5	4.57	4	1.46
indice céphalique	4	5.97	4	3.94
indice fronto-pariétal	4	3.91	4	4.18
épais. à la M_2g	3	7.76	3	17.22
épais. à la symp.	3	6.93	3	6.25
haut. à la symp.	3	7.56	3	6.93

TABLEAU 4

Coefficients de variation (mâles et femelles)

	Mandeville		Dawson	
	N	V	N	V
longueur	5	4.31	8	6.24
largeur	6	2.48	* 8	6.75
larg. front. min.	5	2.74	9	6.34
corde Br Ld	8	6.05	12	7.23
corde Ld Op	5	1.98	5	4.84
arc Br Ld	8	6.45	12	8.72
arc Ld Op	5	5.41	5	7.26
arc Br Po	8	3.04	* 7	7.07
arc Po Po	8	4.05	8	6.23
indice céphalique	5	2.17	8	5.35
indice fronto-pariétal	5	2.76	7	6.06
épais. à la M_2g	6	9.94	6	6.65
épais. à la symp.	5	11.07	7	5.94
haut. à la symp.	5	10.08	6	9.23

* identifie une variance significativement plus grande dans la collection Dawson ($p \leq 0.05$)

une plus grande variabilité à l'intérieur de chaque sexe – tout au moins chez les mâles – plutôt qu'à un plus fort dimorphisme sexuel. La distribution bimodale d'une variable donnée présenterait un plus grand étalement pour la collection de Dawson que pour celle de Mandeville, sans qu'il y ait une plus grande différence entre les modes. Mais, pratiquement, on ne peut parler ici de distribution bimodale, vu les effectifs réduits.

Caractères discrets

Des quelques 20 caractères dont la fréquence a été relevée, environ la moitié permet à un groupe de se dégager des autres. Les fréquences de ces 9 caractères sont données dans le tableau 5. Ce sont les groupes de Mandeville ou de Westmount qui se détachent le plus souvent des autres, alors que celui de Dawson est intermédiaire, ou près de l'un des deux autres.

Les fréquences des caractères épigénétiques doivent toutefois être interprétées avec précaution, quand on songe à la subjectivité intervenant dans l'appréciation du degré d'expression de ces particularités. Il a en effet été démontré récemment que, dans une batterie d'observations répétées par le même observateur, certaines manquaient de fidélité au point où l'erreur intraobservateur pouvait fausser l'interprétation relative aux affinités biologiques (Molto, '79).

Caractères odontologiques

Tout comme pour les mesures de la mandibule, l'intérêt des observations sur la dentition est centré sur les habitants du site de la Place Royale. Les chiffres du tableau 6 montrent les faibles taux de caries et de dents tombées *ante mortem* à ce site. Il a d'autre part été établi par Clermont et Falardeau ('77), que les habitants

TABLEAU 5

Fréquences de quelques caractères discrets

	Mandeville		Dawson		Westmount	
	f	%	f	%	f	%
trous sus-orbit.	6/11	54	11/25	44	8/10	80
trous sus-orbit. doubles	0/11	0	4/23	17	6/10	60
carêne sagittale	5/8	62	3/18	16	1/5	20
aplatis. sus-lamb.	1/7	14	7/15	46	2/5	40
occipital bombé	4/8	50	11/11	100	3/5	60
déhiscence tymp.	4/15	26	1/17	6	0/10	0
arc mylohyoïdien	2/8	25	2/9	22	0/8	0
apoph. geni fortes	5/6	83	2/8	25	2/4	50
menton bilatéral	0/5	0	1/7	14	3/4	75

TABLEAU 6

Données odontologiques

	Mandeville		Place Royale		Dawson		Westmount	
	N	%	N	%	N	%	N	%
dents possibles	210	100	101	100	196	100	135	100
pertes *ante mortem*	33	16	2	2	49	25	12	9
pertes *post mortem*	28	13	33	33	45	23	98	73
dents en place	149	71	66	65	102	52	25	18
caries	24	16	6	8	19	17	4	16
incisives en pelle	18	72	3	75	10	48	–	–

des sites Mandeville et Dawson partageaient les mêmes attributs odontologiques. La découverte récente d'autres individus ne fait que confirmer ces observations antérieures, qui déjà faisaient croire que les Iroquoïens de la région de Montréal avaient un régime alimentaire plus dépendant des cultigènes que celui des Iroquoïens de la région de Québec, ces derniers ayant des modes de subsistance plus semblables à ceux des nomades (Clermont, '78). Rappelons que les documents ethnohistoriques et archéologiques abondent dans le même sens.

Les individus de Westmount se rangent plutôt du côté de ceux de Mandeville et Dawson, bien que le taux de chutes *ante mortem* soit intermédiaire entre celui de la Place Royale et celui des 2 autres groupes.

L'usure des dents est en général importante, et plus avancée sur les dents antérieures que sur les molaires, sauf à la Place Royale, où l'usure est plus uniforme. Cette usure différentielle est surtout marquée au site Mandeville, où les incisives sont parfois usées jusqu'au collet, alors que les sillons des molaires de mêmes individus sont toujours apparents (fig. 4).

Fig. 4 Site Mandeville. Une usure différentielle très marquée entre les I^1 et la C droite, et les molaires.

Une partie de cette usure différentielle serait due aux nombreuses pertes *ante mortem* de molaires. Ainsi, les dents antérieures auraient-elles davantage été utilisées, pendant que les quelques molaires toujours en place ne pouvaient plus s'user sur les molaires de l'arcade dentaire opposée affectée de pertes *ante mortem* (fig. 5a). Mais il est des cas où cette explication paraît insuffisante. Chez un individu du site Mandeville par exemple, l'usure est très avancée jusqu'à l'extrémité postérieure de la face occlusale des deuxièmes prémolaires, sans qu'il y ait de traces perceptibles d'usure à la face mésiale des premières molaires (fig. 5b). Une discontinuité de ce type peut difficilement être expliquée comme une conséquence exclusive de la mastication alimentaire.

CONCLUSION

Si préliminaire soit-elle, cette étude comparative de ces habitants de la vallée du St-Laurent permet néanmoins d'en dégager une nette hétérogénéité.

Les individus du site Dawson se distinguent des autres, non seulement par des boîtes crâniennes aux dimensions moyennes supérieures et à des formes qui leur sont propres, mais aussi par une plus grande variabilité à l'intérieur de chacune de ces catégories de caractères.

De plus, les gens de la Place Royale avaient à la fois l'appareil masticateur le plus robuste et la denture la plus saine. Ces deux faits sont vraisemblablement liés entre eux, ainsi qu'à un régime alimentaire plus semblable à celui des nomades que ne l'aurait été celui des habitants de la région de Montréal.

Malgré le faible effectif des échantillons, qui nous interdit toute généralité à l'échelle des populations, il est tout de même permis d'entrevoir certaines possibilités relatives à l'explication de l'hétérogénéité observée. Tout se passe comme si certaines populations d'Iroquoïens de la vallée du St-Laurent avaient entretenu avec les autres groupes de la vallée ou d'ailleurs, des réseaux de relations fort différents. L'homogénéité de l'échantillon de Mandeville fait penser à un groupe particulièrement endogame, alors qu'au site Dawson, il semble que tout se soit passé comme s'il y avait eu un important brassage de gènes, toujours à la condition qu'aucun étranger à la communauté locale se soit glissé dans

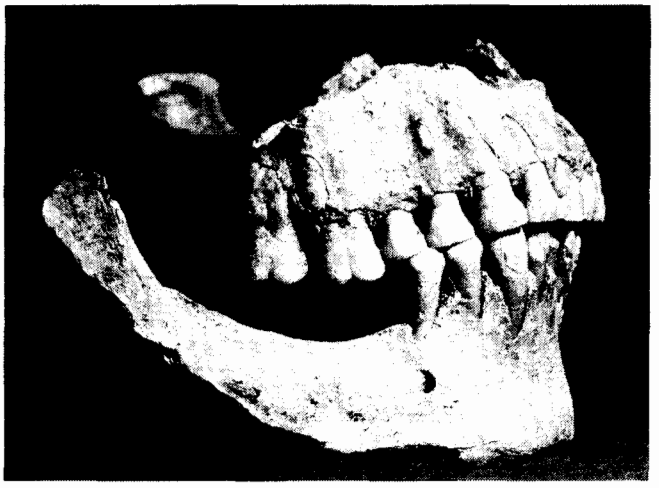


Fig. 5 Site Mandeville. A) La chute *ante mortem* de molaires inférieures a contribué à l'usure différentielle observée à l'arcade dentaire supérieure.

B) Un gros plan des faces occlusales de la P^2 d et de la M^1 d.

l'échantillon. D'autre part, la situation du site de la Place Royale, à l'extrême nord de l'Iroquoïsie, a pu engendrer une adaptation propre à un environnement au climat plus rigoureux, et peut-être moins permissif pour l'agriculture que la plaine de Montréal.

Il est de plus légitime d'envisager la possibilité que l'exploitation de ressources alimentaires distinctes, ou tout au moins dans des proportions différentes, ait engendré certaines différences entre les habitants des régions de Montréal et de Québec, non seulement dans les schèmes d'établissement, l'organisation sociale, la culture matérielle ou les phénotypes, mais aussi dans les échanges géniques. La pauvreté des documents ostéologiques de la Place Royale nous interdit d'être plus catégorique, mais les documents ethnohistoriques laissent entendre que les groupes de Stadaconé et d'Hochelaga étaient rivaux, et qu'ils entretenaient des relations différentes avec les groupes de l'intérieur.

L'important brassage de gènes qui paraît s'être passé dans la région de Montréal, pourrait s'expliquer par le fait que cette région aurait été plus propice à une assimilation culturelle et biologique de groupes plus ou moins distincts.

Le St-Laurent aurait donc pu favoriser la différentiation des groupes humains qui occupaient ses rives, et cela de deux façons. D'abord, son orientation, grossièrement selon un axe nord-sud, aurait favorisé une différentiation culturelle et phénotypique des groupes exploitant des environnements différents, ce qui est certainement moins le cas selon un axe est-ouest. Puis, cette différentiation initiale a pu donner lieu à une autre source de différentiation, à savoir l'établissement et le maintien, par les communautés des régions de Montréal et de Québec tout au moins, de relations avec des groupes humains différents. Cette dernière source de différentiation a pu se manifester notamment par le développement de patrimoines génétiques distincts, et aurait été d'autant plus importante que la région de Montréal était un carrefour.

Il est nécessaire d'observer d'autre restes humains pour donner du poids, s'il y a lieu, aux tendances relevées. D'autres recherches nous permettront peut-être de localiser le reste du matérial trouvé à Westmount, et aux sites Dawson et de la Place Royale. L'analyse des individus du site Roebuck, et de ceux des sites qui restent à découvrir, contribuera aussi à éprouver le modèle proposé, relatif aux relations qu'entretenaient les Iroquoïens de la vallée du St-Laurent, entre eux et avec d'autres groupes humains.

REMERCIEMENTS

La découverte d'autres crânes du site Dawson a été possible grâce aux démarches de M. Conrad Graham, du musée McCord, qui a de plus consenti à prêter les crânes de cette collection. Nous l'en remercions infiniment, de même que Mrs. Allison, du musée Redpath, qui a aussi

contribué à la découverte de quelques crânes. Nous remercions aussi le Dr. Jerome S. Cybulski, de Musée National de l'Homme, qui a bien voulu prêter les crânes de la collection de Westmount, et M. Laurent Girouard, qui a permis l'utilisation de données encore inédites sur les collections de Mandeville et de la Place Royale.

Robert Larocque
Norman Clermont

La présentation de la version initiale de ce texte, au 7e Congrès Annuel de l'ACAP, a valu à un des auteurs de la présente version, de partager le prix McKern-Oschinsky, attribué à l'étudiant dont la communication a été jugée la meilleure. Je tiens donc à remercier tous les membres de l'association qui, de près ou de loin, ont eu un rôle à jouer dans l'attribution de ce prix. Il est à souhaiter que l'attribution d'un tel prix, ainsi que l'invitation faite aux lauréats (-tes) de publier leur texte, deviennent une tradition de notre association, tant il est stimulant pour un étudiant de recevoir ces honneurs.

Robert Larocque

OUVRAGES CONSULTES

Anderson, J. E. 1972 Dawson site physical anthropology. In: Cartier's Hochelaga and the Dawson site, B. G. Trigger et J. F. Pendergast, éd. McGill-Queen's University Press, Montréal.

Clermont, N. 1978 Rapport sur les squelettes Sylvicoles de la Place Royale. Manuscrit.

——— 1979 Analyse des restes humains de Lanoraie. Manuscrit.

Clermont, N. et L. Falardeau 1977 L'analyse des sépultures du village iroquoïen de Mandeville (BiFg-1). Manuscrit.

Lighthall, W. D. 1898 A new Hochelagan burying ground. The Canadian Antiquarian and Numismatic J. 3e série, *1:*149-159.

——— 1899 Hochelagans and Mohawks: a link in Iroquois history. Mém. et comptes rendus de la Soc. Roy. du Canada, 2e série, vol. *5* sec. 2:199-211.

——— 1922 The Westmount stone-lined grave race. Mém. et comptes rendus de la Soc. Roy. du Canada, 3e série, vol. *16,* sec. 2:73-75.

——— 1924 Hochelaga and "The hill of Hochelaga". Mém. et comptes rendus de la Soc. Roy. du Canada, 3e série, vol. *18,* sec. 2:91-106.

Molto, J. E. 1979 The assessment and meaning of intraobserver error in population studies based on discontinuous cranial traits. *Am. J. Phys. Anthrop. 51:*333-344.

Trigger, B. G. et J. F. Pendergast 1972 Cartier's Hochelaga and the Dawson site. McGill-Queen's University Press, Montréal.

Possible Pre-Columbian Treponematosis on Santa Rosa Island, California

JEROME S. CYBULSKI
Archaeological Survey of Canada, National Museum of Man, National Museums of Canada, Ottawa, Ontario K1A 0M8

KEY WORDS Treponematosis • Cranial Syphilis • Radiocarbon Dates • California Prehistory

ABSTRACT Two crania from the Skull Gulch site on Santa Rosa Island, California, suggest treponematosis. The bone changes are described in view of recently proposed diagnostic criteria in dry bones. One cranium suggests vault lesions of the caries sicca sequence while the other mainly exhibits naso-palatine destruction. The site context suggests pre-European contact for both items. Pre-Columbian antiquity is strongly indicated for at least one skull on the basis of radiocarbon dates which, when corrected for fluctuations in atomospheric C-14, yield calendar dates of A.D. 1340 (error range from 1260 to 1390) and A.D. 1100 (error range from 1030 to 1190). The latter date is based on collagen from the right tibia believed associated with the skull.

RESUME Deux crânes provenant du gisement de Skull Gulch dans l'île de Santa Rosa en Californie semblent indiquer un cas de tréponématose. Il est possible de décrire l'altération osseuse à partir de critères diagnostiques récemment reconnus dans l'os sec. L'un des crânes suggère un cas de lésions de la voute affectant le séquence caries sicca alors que l'autre cas montre surtout une destruction naso-palatine. La contexte du gisement suggère un contact pré-Européen dans les deux cas. Les datations radiométriques suggèrent également un âge pre-colombien pour l'un des crânes; en effet, une date de 1340 avant J.C. (variant entre 1260 et 1390) et une date de 1100 avant J.C. (variant entre 1030 et 1190) on été obtenues en tenant compte des fluctuations de C-14 atmosphérique. La dernière date est basée sur le collagène du tibia droit que l'on croit être associé au crâne.

The question of pre-Columbian venereal syphilis in the New World has long been debated by many scholars largely on the basis of skeletal remains (cf. Williams, '32; Crosby, '69). It has been theorized, however, that venereal syphilis is but one of four syndromes in a common organismal disease, treponematosis, the others being pinta, yaws, and endemic (non-venereal) syphilis (or treponarid), and that environmental circumstances will dictate the form the disease takes (cf. Steinbock, '76, pp. 90-94). Moreover, the bone lesions that result from yaws and endemic syphilis are often difficult, if not impossible, to distinguish from those due to venereal syphilis. Hence, when referring to the bone lesions in archaeological materials, it is better to speak of treponematosis or treponemal infection than to assign a specific etiology.

Major problems in the debate have centered on the frequency of lesions in New World skeletal remains, correctness of diagnosis in putative specimens, and accuracy of dating. Stewart ('73) and, more recently, Hackett ('76) have suggested that a general survey of the New World material might resolve these problems.

Literature reviews of published specimens as well as proposed new material have been reported by Steinbock ('76) and El-Najjar ('79).

This report places on record two potentially pertinent additional specimens. Together, the two crania are not without problems in terms of certainty of diagnosis and temporal context. However, the lesions strongly suggest treponemal infection. Two different manifestations are present, the crania are from the same archaeological locality, and for at least one of the cases pre-Columbian antiquity is strongly indicated. This paper details the context of the items, the efforts made to establish their dating, and the lesions manifested.

MATERIAL AND CONTEXT

The two crania are in the collections of the Santa Barbara Museum of Natural History, catalogued NA-CA-131.2B-12-49 (formerly #4246) and NA-CA-131.2B-12-61 (formerly #4181). They were recovered early in the 1950's by Phil C. Orr, then curator of the museum, from the Skull Gulch site (SBMNH-131.2) located on the northwest coast of Santa Rosa Island in the Santa Barbara Channel. California. The site, intermittently excavated over a 14-year period (Orr, '68), consisted of a number of house-pits and three cemeteries designated A, B, and C. The skulls were recovered from two different parts of Cemetery B, designated eastern and western.

The eastern part of Cemetery B mainly consisted of individual interments, some disturbed, including 26 people. The western part was primarily "an unbelievable charnel of concentrated human bones" in which there was "70 skulls and hundreds of skeletal parts, jaws, and fragments of skulls." Ten skeletons were also present, "though most showed signs of having been disturbed, by a missing leg or arm." (Orr, '68, pp. 199-201).

According to field notes on file at the museum, NA-CA-131.2B-12-49 was given the field designation "Burial 50" while NA-CA-131.2B-12-61 was "Burial 11". The latter was a disturbed individual in the eastern part of the cemetery and the former was one of the 70 skulls in the western part. Their field positions are schematically illustrated in a burial map of Cemetery B in Orr's published report ('68, p. 198, fig. 64).

The crania were first brought to my attention in 1973 while I was teaching at the University of California. At the time, eight long bones, a sacrum, two innominate bones, and a mandible were boxed with the Burial 11 skull. Though some analysis was then undertaken, it was not until I was settled in a new position at the National Museum of Man in Ottawa that I was able to complete the study. In 1976 I requested that the materials be sent to Ottawa, and only the long bones and mandible were received with the skull. The remaining parts could not be found. Because the long bones had not originally been numbered, there is a measure of uncertainty regarding their field association with the skull. However, because of information in the field notes, similar preservation in substance and in staining, and commonness of sex identification, the long bones and skull are believed to be of the same person. The mandible articulates well with the skull and there is little question of its anatomical association. Both crania and the long bones were judged to be of adult females, the crania assessed at middle-age on the basis of the degree of suture closure. The long bones include the left humerus and radius, right and left ulnae, right femur and fibula, and right and left tibiae.

DATING

Overall, the Skull Gulch site appears to date from prior to European contact:

> Radiocarbon dates indicate the Skull Gulch site was inhabited from about 2000 BP to 400 BP. This latter date would indicate that the village may have been abandoned about the time of Cabrillo's visit to the Island in 1542 . . . , but if it was occupied later than that, no glass or metal found its way into the portions we have excavated (Orr, '68, p. 191).

Orr considered Cemetery B to be younger than Cemetery A, the latter yielding radiocarbon dates, based on shell, of 900 ± 100 C-14 years (UCLA-178) and 1820 ± 90 C-14 years (UCLA-135).[1] One radiocarbon date was ob-

[1] Walker ('78), in a dental study of materials from the site, incorrectly reported the dates as "1,050 ± 80 B.P. and 130 ± 90 B.P.". Both Orr ('68) and the UCLA Laboratory (Fergusson and Libby, '63, p. 4) list the dates as reported in the present study, although Orr gives an error term of ± 80 for the first date. Orr ('68) regarded the older date as the more accurate of the two.

tained from Cemetery B, specifically from black seeds of red maid (*Calandrinia ciliata*) which filled the "interstices" of the bones of Burial 13 in the eastern part. The date was 600 ± 70 C-14 years (UCLA-102) which when corrected for fluctuations in atmospheric C-14 yields a calendar date of A.D. 1340 with an error term from A.D. 1260 to A.D. 1390 (MASCA, see Ralph *et al.*, '74).

Burial 13 lay to the west of Burial 11. Orr's published description ('68, p. 200) and his field notes suggest that the seeds could have been deposited sometime after the interment of Burial 13, thereby making the time of death of that individual earlier. Although the single radiocarbon date might be sufficient ground to conclude pre-Columbian antiquity for the burials, it was deemed desirable to obtain a more direct date for Burial 11 and, not incidentally, a verification date for this portion of the cemetery. In 1977 I submitted the right tibia from the long bones believed associated with the NA-CA-131.2B-12-61 skull to the Saskatchewan Radiocarbon Laboratory. The date returned, based on collagen extraction, was 865 ± 65 C-14 years (S-1286, NMC-902) or, corrected, A.D. 1100 with an error term from A.D. 1030 to A.D. 1190 (MASCA).

Burial 50 may or may not be contemporaneous. Orr regarded the western part of Cemetery B to be younger than the eastern part. The mass of bones was said to lie "somewhat higher" than the latter, and their disposition suggested to Orr that the bones represented "reburials" in the manner found among late sites on the Santa Barbara coast. There is the possibility, however, that the bones could represent disturbance of earlier intact burials by later inhabitants of the site. This is suggested by the presence and condition of the ten skeletons, noted above, in the western part of the cemetery.

As no long bones were associated with the Burial 50 (NA-CA-131.2B-12-49) skull, a radiocarbon date was not attempted. Although a date might be obtained from the skull itself, I was reluctant to have it processed because of its potential comparative value for diagnosing the presence of pre-Columbian treponematosis in the New World. For this reason as well, the NA-CA-131.2B-12-61 skull was not directly dated. An attempt to date the mandible proved unsuccessful. The laboratory returned the jaw noting that it contained too much preservative (glue and plaster).

LESIONS

As stated in the introduction the two skulls are pathologically affected in different ways.

In NA-CA-131.2B-12-61 only the cranial vault is affected (fig. 1) including the frontal bone, parietals, and the occipital squama. The temporal bones, facial skeleton (including the mandible), and cranial base, all of which are intact, appear to be free of changes. A general area of involvement extends from the central part of the superior half of the frontal bone, through bregma, and through the medial halves of the parietal bones – the left more extensively than the right – almost to obelion. A small area of involvement is at left stephanion, and the area around right stephanion is more extensively involved. Most of the *planum occipitale* is involved, the lesions infringing upon but not extending below the nuchal ridge. There is a relatively small, near isolated lesion in the posterior half of the right parietal and a small isolated lesion in the left parietal posterior to the eminence.

The areas of involvement at the top of the vault, about right stephanion, and in the occipital show irregular knurled heaping of healed bone around foci of destruction. What has been described as the "stellate lesion characteristic of cranial syphilis" (Steinbock, '76, p. 129) is especially clear in the area of right stephanion.

"Caries sicca" has long been considered pathognomic of cranial syphilis (*cf.* Williams, '32). In an attempt to clarify problems in the identification of the lesion in dried bones, Hacket ('76) has recently proposed the "caries sicca sequence" as a *diagnostic criterion of syphilis* based on a study of 424 pathological crania in European medical museums. Of these, 281 were "labelled" syphilis (33 with authentic diagnoses), while the remainder were labelled with other diseases. Sound diagnostic criteria were additionally proposed for tuberculosis, leprosy, some neoplasms, Paget's Disease, trauma, and hyperostosis frontalis interna, all of which might be confused with syphilis (treponematosis) at some stage in their development.

Fig. 1 Top view of NA-CA-131.2B-12-61.

Fig. 2 Front view of NA-CA-131.2B-12-49.

The changes in NA-CA-131.2B-12-61 most closely fit Hackett's diagnostic criteria of syphilis. He illustrates several changes in the caries sicca sequence (see esp. p. 31, fig. B) which are represented in the skull: "focal superficial cavitation" and "circumvallate cavitation" at the top of the vault, and "circumvallate cavitation" and "radial scar" in the right stephanion area of involvement. Overall, the most extensive pathology is on the exterior surface of the cranium, as is expected in cranial syphilis. However, radiographs (now on file at the Santa Barbara museum) suggest thickening into the diploetic space and, as viewed through the foramen magnum, there is at least one focus of porosity on the inner surface at the top of the vault. These internal changes are also consistent with the diagnosis.

In NA-CA-131.2B-12-49 the pathology is mainly in the facial skeleton (fig. 2). There is irregular destruction of the hard palate, primarily through the midline and directed laterally; destruction of the alveolar bone between the first premolar sockets; destruction of the nasal borders of the maxillae with some infolding and healing; partial destruction and remaining malformation of the nasal bones with healing; destruction of internal parts of the nasal passage including the vomer and maxillary sinus walls. There is a small patch of porous osteitis on the right maxilla near the nasal aperture.

According to Hackett ('76, p. 65), naso-palatine destruction is a *diagnostic criterion of syphilis* "when extensive and healed". Specifically he refers to "an empty nasal cavity with smooth lateral walls presenting a smooth, 'bored out' tunnel-like passage-way" as characteristic of his specimens labelled syphilis (p. 63).

NA-CA-131.2B-12-49 does not exhibit this "advanced state" and its unhealed portions may give the impression of neoplasm (Hackett, '76, p. 65). However, the healing in the nasal area and infolding of the maxillary borders is more characteristic of what Hackett has described as syphilis. Further, there is a small area of healed bone change in the frontal to the left of midline that appears to include a depressed "radial scar" of the caries sicca sequence. On the basis of all evidence discussed by Hackett, it appears that the naso-palatine changes in the skull represent a less advanced state of "syphilis" than that deemed *diagnostic* of the disease.

DISCUSSION

None of the eight long bones believed associated with the NA-CA-131.2B-12-61 skull appear pathological, and x-rays show no clear internal abnormalities. Though treponematosis may affect most bones of the skeleton, confinement of lesions to the skull is not uncommon, particularly in known cases of venereal syphilis (Steinbock, '76, pp. 113-114, 127). Indeed, the lack of involvement in the long bones might, therefore, rule out yaws and endemic syphilis since the long bones are most often involved in these two syndromes. Further, the cranium is "rarely affected" in endemic syphilis while in yaws it is "infrequently involved" (Steinbock, '76, pp. 139, 143).

Applying the stringent criteria of Hackett ('76) to the present study, it does appear that both Santa Rosa Island crania exhibit treponemal infection. He emphasizes that the bone *lesions* of venereal syphilis, yaws, and endemic syphilis cannot at present be separated.

The overall context of the site suggests pre-European contact for both skulls, and pre-Columbian antiquity is strongly indicated for NA-CA-131.2B-12-61 on the basis of radiocarbon dates. The use of correction factors as applied here is now widely considered necessary to provide more accurate and consistent calendar information. The error terms for the dates further enhance the conclusion.

The Santa Rosa Island crania are not the first California specimens said to demonstrate possible pre-Columbian treponematosis. Roney ('66) has suggested "syphilis" to account for bone changes in nine individuals from a northern California coastal site dated to the 6th to 3rd centuries B.C. More recently, Brothwell and Burleigh ('75) reported "possible evidence of treponemal infection" in a Berkeley museum specimen which they radiocarbon dated at 857 ± 52 C-14 years with a corrected calendar date of A.D. 1105. Details concerning the specimen, including site of discovery, represented skeletal parts, and manifested lesions were not provided. Given these previous reports and, especially, the present data, a survey of existing California archaeological skeletal material as well as new excavations may well enhance our

knowledge of pre-Columbian treponematosis in the New World.

ACKNOWLEDGEMENTS

I thank Murchie Corcoran and Robin Krogfoss for their invaluable assistance with the field records of the Skull Gulch site excavations and Doctor D. Travis Hudson, Curator of Anthropology at the Santa Barbara Museum of Natural History, for entrusting me with the skeletal material and for his advice and encouragement during the analysis. Paul Heuston, with the Department of Anthropology at the University of California at Santa Barbara, took the photographs. Facilities and financial support were provided by the National Museum of Man, National Museums of Canada.

LITERATURE CITED

Brothwell, D., and R. Burleigh 1975 Radiocarbon dates and the history of treponematoses in man. J. Archaeol. Sci. *2:*393-396.

Crosby, A. W., Jr. 1969 The early history of syphilis: a reappraisal. Amer. Anthrop. *71:*218-227.

El-Najjar, M. Y. 1979 Human treponematosis and tuberculosis: evidence from the New World. Am. J. Phys. Anthrop. *51:*599-618.

Fergusson, G. J. and W. F. Libby 1963 UCLA radiocarbon dates II. Radiocarbon *5:*1-22.

Hackett, C. J. 1976 Diagnostic Criteria of Syphilis, Yaws and Treponarid (Treponematoses) and of Some Other Diseases in Dry Bones (for Use in Osteo-Archaeology). Springer-Verlag, Berlin-Heidleberg-New York.

Orr, P. C. 1968 Prehistory of Santa Rosa Island. Santa Barbara Museum of Natural History, Santa Barbara.

Ralph, E. K., H. N. Michael and M. C. Han 1974 Radiocarbon dates and reality. Archaeol. Eastern N. Amer., *2:*1-20. Reprinted from M.A.S.C.A. Newsletter, Vol. 9, No. 1, August, 1973.

Roney, J. G. Jr. 1966 Palaeoepidemiology: an example from California. In: Human Palaeopathology. S. Jarcho, ed. Yale University Press, New Haven and London, pp. 99-107.

Steinbock, R. T. 1976 Paleopathological Diagnosis and Interpretation. C. C. Thomas, Springfield.

Stewart, T. D. 1973 The People of America. Charles Scribner's Sons, New York.

Walker, P. L. 1978 A quantitative analysis of dental attrition rates in the Santa Barbara Channel area. Am. J. Phys. Anthrop. *48:*101-106.

Williams, H. U. 1932 The origin and antiquity of syphilis: the evidence from diseased bones. Arch. Pathol. *13:*779-814;931-983.

Sexually Dimorphic Variation in the Ossification of the Hand and Wrist in Japanese Children [1]

C. E. EYMAN
Department of Archaeology, University of Calgary, Calgary, Alberta T2N 1N4

KEY WORDS Ossification Center • Sexual Dimorphism • Growth • Japan

ABSTRACT Carpal and metacarpal ossification center maturity scores were recorded, and the skeletal/chronological age ratio as well as the ossification sequences were examined in a cross-sectional sample of 3,283 inbred and non-inbred ("control") Japanese children. All hand-wrist ossification centers were examined for the presence or absence of bony variations as well as for "missing" centers. Extensive statistical testing of the data indicated that sex was the only factor clearly associated with the variations, which occur in approximately half the sample. The higher frequencies of these variations among females, coupled with their faster maturation rates and smaller absolute skeletal sizes may reflect a hereditary sexual dimorphism, for which an explanation is suggested.

RESUME On a enregistré les décomptes des centres de maturité de l'ossification du carpe et du métacarpe et examiné le rapport squelette/âge chronologique dans un échantillonnage en section transversale de 3823 enfants japonnais innés ou non-innés ("de contrôle"). Tous les centres de l'ossification du poignet et de la main ont été examinés pour des centres "manquants". Une analyse statistique approfondie des données indique que le seul facteur clairement associé aux variations est sexuel; on le retrouve dans approximativement le moitié de l'échantillon. La plus grande fréquence de ces variations chez les femmes, associée à leur taux de maturation plus élevé et les dimensions absolues du squelettes plus réduites, semble refléter un dimorphisme sexuel héréditaire, pour lequel on suggérera une explication.

INTRODUCTION

In the 1950's, the Department of Human Genetics of the University of Michigan Medical School undertook an extensive study of children in Nagasaki and Hiroshima. Schull and Neel ('65) have presented the results of the overall study in a comprehensive monograph on some 7,700 children between the chronological ages of 5 and 11.5 years. The study was designed to assess the genetic effects of inbreeding on the biological and mental attributes of a large human sample.

About 60% of the children were the offspring of parents who had not been exposed to any atomic irradiation at all (Schull and Neel, '65, p. 5). Hiroshima and Nagasaki had been repopulated by Japanese immigrating from nearby rural areas. They are essentially aggregates of smaller villages, so they reflect much the same degree of consanguineous marriages as do the rural areas (Schull, '58).

There are numerous socioeconomic, religious, and familial-traditional patterns which reinforce the system of consanguinity even

[1] A version of this paper was presented at the 7th annual meeting of the Canadian Association for Physical Anthropology, Ste.-Adèle, Québec, 1979.

though the inbreeding patterns have largely broken down. The disruption and decrease in rural population densities accompanying the repopulation of Hiroshima and Nagasaki did not seriously affect the marriage and kinship patterns of inbreeding, nor did these changes create any non-random marital patterns in the three most common forms of consanguineous marriage. The frequencies of these mating categories were essentially the same for both cities. Approximately half the children, on the basis of marital records extending back for about 100 years, constitute a "control" sample of non-inbred children (or at least non-inbred beyond fourth cousins).

In the data collection, X-rays of left hands and wrists were taken. There were a number of purposes in assessing the hand-wrist X-rays. One was to attempt an assessment of the degree of skeletal maturation so that the two cities could be compared with each other and with populations outside Japan; another was to assess the possible effects of different degrees of inbreeding. Yet another was to compare the findings from the hand-wrist data with analyses of other areas of the body.

It soon became apparent during analysis of the X-ray films that many showed "anomalous" or "variant" centers. My interest in the frequencies and distributions of the variations increased as I continued the scoring and analysis of the films. Hence the focus of this paper is not on select areas of skeletal maturation in preadolescent children, that is, on human growth and development, nor with classifications of skeletal variations (gross skeletal pathology). Rather, it is an attempt to present the result of investigations of alternative interpretations of skeletal hand-wrist variations in preadolescent children within a particular gene pool.

The use of the term "variation" rather than "anomaly" stems from the fact that during the analysis it became apparent that these data included a comparatively high frequency of variations. The number of these variations was sufficiently large to justify abandoning the term "anomaly", especially since almost all the children in the sample were medically "normal". Some of the variations are identifiable as medically pathological "anomalies", yet there are twelve major variations that are relatively common and "normal" variations. A scrutiny of the standard comments about sexual dimorphisms in the adult human skeleton in the standard textbooks in physical anthropology indicated that there is relatively little attention paid to the meanings of these differences and to the reasons for their overlap between the sexes. While there is a wealth of data on skeletal maturation in male and female children, the meanings of the skeletal sexual dimorphism and the between-sex overlap with regard to the more rapid female maturation are still somewhat obscure. I thus began to question whether the patent sexual dimorphism in the overall human skeletal system partly follows from the sexual dimorphism in skeletal maturation rates among preadolescents. The females were observed to have higher frequencies of variations than did the males. Applying several Chi-square tests to the data indicated that the sex differences in these frequencies were significant beyond the .05 confidence limits only when between-sex associations were examined. There seems to be no general pattern for a significant association between the presence of one or more variations with chronological age, consanguinity status, or city.

These and other results suggest that the presence of a skeletal hand-wrist variation is associated with the sex of the child, but it does not suffice to relegate the presence or absence of a bony variation to simple sex influence alone. Similar data for some of the variations are known for other racial samples of both sexes, although the frequency of some of the observed variations may be higher among the Japanese than is the case for some other gene pools.

Whether suppression or inhibition in the mineralization of a particular cartilaginous area is temporary cannot be determined here. The literature favors the view that the child's nutrition, unless severely distrubed, does not seriously affect the growth pattern and Japanese data do not suggest that there were substantial nutritional differences (Schull and Neel, '65).

Thus, the basic question explored is the nature and distribution of skeletal hand-wrist variations, with a resulting hypothesis that such variations are associated with "short-cuts" which aid the female skeleton in development toward the size and shape necessary for puberty. Evidence from other areas of the

skeleton seems to support this hypothesis, in part, in that "anomalies," "variations," "discrete traits" of certain skeletal regions tend to show stronger female than male associations. Examples are, metopism (Woo, '49); metopism and occipital wormiana (Torgerson, '51a, b); shortened toe digits (Venning, '56b, '61b); "missing" toe phalanges (Garn, Rohmann, and Silverman, '65; Venning, '54, '56a); septal apertures of the olecranon fossa (Anderson, '62, '63); shortened fifth middle phalanx of the hand (Garn, Fels, and Israel, '67; Herzog, '67); and various cranial discrete traits (Ossenberg, '70; Corruccini, '74).

From the hand-wrist X-rays of 3,823 children (a 50% random sample), 112,867 centers were examined for variations and 57,345 maturity scores were recorded. There are 2,477 "variant" children in the total sample, and 6,230 "missing" centers.

X-ray films were read using the Greulich and Pyle ('59) atlas. Maturity scores were recorded only for the distal ulna and the distal radius, the carpals, and the metacarpals. However, the entire hand and wrist were assessed for the presence of variations and "missing" centers. The sample involved ranking according to city, the degree of inbreeding, age in months, skeletal age, sex and presence of a variation. Further details of the design including controls for observer bias are available in the original study (Eyman, '70).

Twelve major variations are described below. A thirteenth observation was made in connection with the presence of one or more variations. If an ossification center or epiphysis was "missing" it was not considered to represent a variation but was recorded only for statistical comparison with similar centers for those children who manifested no variations and were thus classed as "normal."

Variation 1: Presence of a single "growth scar" or "Harris's line" (Harris, '31). This is located at the distal end of the radius somewhere proximal to the diaphysis. One hundred sixty-three children show this.

Variation 2: The presence of multiple "growth scars" or "Harris's lines." This involves 101 children.

Variation 3: "Notches" or "pseudoepiphyses" noted for all metacarpals, and recorded for the second middle phalanx in two instances. The open end of the notch is almost always oriented towards the shaft ulnar surface. Several instances were seen of two metacarpal shafts being affected. This involves 251 children.

Variation 4: A "pseudofracture" distributed through all metacarpals, the fifth proximal phalanx, the second through the fifth middle phalanges and the first and fourth distal phalanges. Not noted in multiples for any given shaft but occasionally noted to occur simultaneously in two or more phalanges or metacarpals. Seventy-three children show this.

Variation 5: A shaft dysplasia, present in the metacarpals and middle and distal phalanges. Shaft dysplasia is most frequent in the middle phalanges, especially that of the fifth digit. Although by itself this category is not the most frequent kind of variation in the sample, it is a component of the most common kind of composite variation. Basically, this variation in combination with other kinds constitutes what has been described as "Geisha finger;" radial flexion of the fifth middle phalanx gives that digit the appearance of a radial deviation, a condition seen in some Japanese tapestries depicting Geishas (J. V. Neel and W. J. Schull, personal communication). This term seems even more apt in that variations involving radial flexion, especially of the fifth middle phalanx, are more frequent in females than in males. There are 166 children with this variation.

Variation 6: Essentially, this is a reciprocal shaping of the phalangeal epiphysis and the diaphysis so that the epiphysis takes on a rather characteristic "cone shape." This kind of variation is the most common one found in the overall Hiroshima-Nagasaki sample; by far the greatest number of occurrences are associated with the fifth middle phalanx, rather closely followed by the first distal phalanx. Cone-shaped epiphyses are much more common in the females than in the males, and are often associated with shaft dysplasia and other conditions; but like shaft dysplasia and other conditions the cone shaping can occur as a discrete variation. Also like shaft dysplasia, the cone shaping can occur in two or more digits simultaneously. When cone shaping was noted, it was easily recognizable in that the phalangeal proximal diaphyseal surface was indented in a vault-like appearance with the apex oriented towards

the distal end of the phalanx. Usually, but not always, this diaphyseal shape was accompanied by reciprocal shaping of the diaphyseal surface of the adjacent epiphysis. It was often apparent that the diaphyseal surface of the epiphysis had actually penetrated the diaphysis. Occasionally the apex of the cone was slightly to the radial side of the midline, less often it was slightly to the ulnar side. Six hundred forty-six children show this.

Variation 7: Almost totally restricted, "capitate indentation" or the "lateral intercarpal space" (O'Rahilly, '53a, p. 401; fig. 1, p. 403), found on the radial surface of the capitate in its middle or distal portion. In the two instances where the indentation occurred on the hamate ("medial intercarpal space," *ibid.* and p. 408) the location was approximately the same but on the radial surface of the hamate. The radial tubercle often appears immediately above the indentation, but sometimes below the indentation or is absent. When present, the indentation was marked and definite with a semilunar outline. This is seen in 415 children.

Variation 8: A "secondary" or "multiple" ossification center, usually in the carpus. The latitudinal nature of the study militates against determining whether the ossification center is a multiple one or a true accessory bone in most instances. Whether such secondary ossicles represent nucleation of the same cartilaginous precursor of a carpal bone or a metacarpal or phalangeal epiphysis in several areas, or whether some other situation obtains, cannot be answered since only one hand-wrist X-ray was obtained for each child. In those cases where the carpal ossicle did seem to represent a true accessory bone by reference to O'Rahilly ('53b, '57), it was so recorded. When present, the "secondary" or "multiple" centers appeared to be definitely separated from the remainder of the bone (or other ossicles of the immediate area). This condition was noted in 257 children.

Variation 9: A radiographically opaque nonlinear ovoid area quite separate from the radiographic appearance of a nutrient foramen in a phalangeal or metacarpal shaft, in that it appears as a very radiopaque area. Generally, it is associated with the short bones, but there are two instances of its presence in the carpus. When present in the metacarpals and phalanges, the entire epiphysis is usually affected and is markedly radiopaque. One or two children have small circular "stippled" (*cf.* Fairbank, '51) areas in the shaft diaphyseal region. Twenty-seven children manifest this variation.

Variation 10: Restricted to epiphyses and denoting "premature" fusion as defined by Greulich and Pyle's ('59) standards. It rarely occurred at the distal radial and ulnar epiphyses; it is most frequently associated with the fifth middle and the first distal phalanges. As previously mentioned premature fusion is associated with reciprocal or cone shaping of the epiphysis and quite often with the diaphysis; the overall impression is that the more pronounced the cone shaping, the more common the simultaneous occurrence of premature fusion. (Present in 26 children.)

Variation 11: Combines the presence of shaft dysplasia (Variation 5) and cone shaping (Variation 6) for the same short bone, appears much more frequently at the fifth middle phalanx than at any other. This variation exemplifies the "Geisha finger" even more than does Variation 5 alone, and is more frequent among females. When Variation 11 was perceived it was noted that both the radial shaft dysplasia and the reciprocal cone shaping were usually quite marked. This variation was noted for 233 children.

Variation 12: Another combination of other variations already discussed. It connotes the simultaneous presence of premature fusion (Variation 10), radial shaft dysplasia (Variation 5), and reciprocal cone shaping (Variation 6). The radiographic appearance of this condition is merely a combination of those given for the three component variations. (88 children.)

Other Combinations: Four other rather infrequent combinations of variations were noted. These conditions were generally difficult to assess from the radiographs and may very well represent deviations from the kinds of variations discussed above. All of these are confined to the metacarpals and phalanges except for one (Variation 7-8). Variation 5-10 (3 children) denotes radial shaft dysplasia and premature fusion, differing from Variations 11 and 12 in that no reciprocal cone shaping was noted. Variation 6-10 (24 children) is the most

frequent of this group of combinations: it connotes the simultaneous occurrence of reciprocal cone shaping with "premature" fusion, and differs from other combinations of variations in that there is no radial shaft dysplasia. Variation 3-4 (3 children) indicates the combination of a pseudoepiphysis and a pseudofracture. Variation 7-8 (one child) combines a radial capitate indentation ("lateral intercarpal space") with an accessory ossicle; whether this represents a true *os centrale* or not (*cf.* O'Rahilly, '53a; Virchow, '29) is unknown.

"Missing" Centers: A center was considered as "missing" when it could not be perceived on the hand-wrist X-ray, *not* merely when the maturity status of other centers indicated that it should be present according to the Greulich and Pyle ('59) standards. These were recorded for both "normal" and "variant" children and involve 6,230 centers. The overwhelming majority of "missing" centers are associated with the carpus; it is not surprising that the majority of "missing" centers are associated with the triquetral, due to its normal late appearance (Greulich and Pyle, '59; Johnston and Jahina, '65; Johnston, Whitehouse and Hertzog, '68). The possible association between "missing" centers and the occurrence of variations will be discussed later; for the present, suffice it to say that aside from the more standard comments upon "missing" centers, there is also a growing body of literature dealing with their significance.

The literature dealing with the possible etiologies and causes for all of these variations is voluminous, and a more detailed discussion of them can be found in Eyman ('70).

HYPOTHESIS

Following analysis of the frequencies of the variations previously described for the 3,823 Japanese children comprising this study, it is tentatively concluded that the higher frequency of these variations among the females reflects biochemical and derivative "shortcuts" which function to put the female skeleton as rapidly as possible into the basic size and shape necessary for childbearing – thus effectively lengthening the female reproductive span at the juvenile end, regardless of cultural practices militating against early maternity (Schull, Yanase and Nemoto, '62).

THE LITERATURE

In at least one area of the literature, the dual aspect of sex and maturation in children's skeletons has not been investigated.

Almost no attention has been paid to possible effects of sex and maturation upon the appearance of skeletal variations in the hand and wrist. Even those dealing with sex differences in the skeleton, primarily with hand and wrist variations, do not inquire into the problem of the meaning of skeletal variations with sex and skeletal maturation.

This paper therefore attempts to demonstrate that variations in the skeletal hand and wrist of some healthy Japanese children reflect the interaction of sex and skeletal maturation.

STATISTICAL ANALYSES

Statistical analyses included R-mode and Q-mode factor analyses, Chi-squares, and Pearsonian product-moment paired correlation coefficients. During the early stages of data reduction, six groups of "variant" children emerged. They were determined by relatively high frequencies of variations associated with certain ossification centers singly and secondarily in combination with others. Therefore, these anatomical regions are not mutually exclusive in that a "variant" group primarily defined by variations at center 3 (capitate) can and does include children who also manifest variations at centers 12 (MC2) through 29 (DP5). The center 3-29 "variant" group, however, would not include children with variations at the distal radial and/or ulnar epiphyseal centers (centers 1 and 2). So, each "variant" child was placed in only one "variant" group, with the placement determined by the order number of the "first" of the 29 centers manifesting a variation.

These "variant" groups are: children with variations at centers 1-29, primarily Variations 1 and 2 at center 1, the distal radius and its epiphysis; children with variations at centers 3-29, primarily Variation 7 at center 3, the capitate; children with variations at centers 12-29, primarily Variations 3 and 4 at center 12, the second metacarpal and its epiphysis; children with variations at centers 24-29, primarily Variations 5, 6, 11 and 12 at center 24, the fifth middle phalanx and its epiphysis; children

with variations at centers 25-29, again primarily Variations 5, 6, 11 and 12 at center 25, the first distal phalanx and its epiphysis; and children with variations at "other" centers but in no clear anatomical pattern or "field." These six groups and others were individually analyzed by most of the statistical applications employed.

Chi-Square Analyses

Analysis of the Chi-square matrix pertinent to females from first cousin matings indicates that there are more "variant" girls from Hiroshima than from Nagasaki. This may reflect a possible consanguinity or between-city effect, but there is little other evidence to bear out either of these conclusions. These overall findings suggest that the significant differences between pooled inbred girls and between girls of first cousin matings may well be "significant" results which occur by chance alone due to the number of Chi-square tests undertaken, enhanced by the sampling distribution of female children of first cousin inbred status.

As noted earlier, "missing" centers were not considered as variations *per se*. Twelve of the 89 Chi-square tests involved testing for the significance of association between "missing" centers in "normal" and "variant" children, and four of these indicated significance beyond the 2.5% confidence limit. There are higher frequencies of "missing" centers associated with boys than with girls in both the control and the inbred categories of the sample. This is in keeping with the differences in skeletal hand-wrist maturation rates between the sexes; since girls generally mature more rapidly than males, the boys generally exhibit more "missing" centers than do girls.

There is a significant association between sex and frequency of "missing" centers in those children with variations located at centers 24-29; analysis of the Chi-square matrix indicated that more Hiroshima girls had "missing" centers than did Nagasaki girls or the boys from both cities. Further analysis indicated a larger proportion of chronologically relatively young Hiroshima girls in this group; whether this is a sampling error or not is difficult to resolve, but no ancillary data are available to argue strongly against this concept.

Another significant association between sex and frequency of "missing" centers is found in those children with variations located at "other" centers, indicating that there are more "missing" centers among the boys than among the girls of both cities. Further analysis of this group indicated that there were more boys of relatively young chronological age than girls. The higher counts of "missing" centers for the boys compared with the girls is consistent with the generalized slower maturation rate of males. Sampling error becomes the more attractive explanation for the high frequency of "missing" centers among Hiroshima girls in the 24-29 "variant" group. Thus the Chi-square analyses reinforce the overall impression that the variations present in the sample reflect a sex influence rather than either a maturational one as such or a marked difference in consanguinity effects.

Certainly, the Chi-square tests do not indicate any consistent between- or within-sex consanguinity effect other than the ones mentioned here. It is possible however that the "control" children tend to obscure the inbred children with respect to the presence or absence of variations, and that the tests just discussed are significant for this reason rather than for spurious ones.

Ranked Maturity Scores

Garn, Rohmann and Blumenthal ("66, p. 113) have observed an ossification sequence polymorphism which basically refers to a rank-ordering of the ossification center maturation statuses in a given skeletal area, such as the hand or foot. Since they feel that this approach can be applied to latitudinal data, the sample was ranked according to the fifteen maturity scores available for each child. A listing was obtained of all children, arranged into the six "variant" groups described previously plus the "control" and the "inbred" groups. While the Q-mode and R-mode factor analyses and their derivative information did not indicate any effect of consanguinity status or presence or absence of variations upon the maturity scores individually and overall (as reflected in the skeletal age/chronological age ratios), rank-ordering the maturity scores might show different ossification sequence patterns between the sexes,

between "variant" and "normal" children, between control and inbred children, and/or between the six "variant" groups.

As Garn, Rohmann and Blumenthal ('66) have indicated, more indeterminate ossification sequences are expectable among children with rapid than with slow ossification rates; thus less variable ossification sequences are associated with girls much more frequently than with boys, since the former mature more rapidly skeletally than do the latter. The accuracy of this observation was apparent after the fifteen maturity scores had been ranked in terms of each other and the results examined. The girls in the sample manifested a more invariate ranking difference between one center and the next than the boys.

To determine if there was any definite pattern of ossification sequences after the fifteen maturity scores were ranked, the data were analysed again according to ossification sequences within each of the groups. Repeated scanning of the transformed data indicated that the groups could not be distinguished from each other on the basis of ossification pattern, sex, city, inbred or control status, or chronological and skeletal age. Thus, there appears to be no ossification sequence effect which can be linked with anatomic location of variations, kinds of variations, or with lack of variations.

Skeletal/Chronological Age Ratios

This consists of summing the fifteen maturity scores for each child (the "skeletal age") and then dividing this total by the child's chronological age in months. These ratios are admittedly crude since only about half of the total maturity indicators entered the computation, and these were the ossification centers which are considered by many workers to be the least reliable. However, the purpose of this ratio was merely to give a rough estimate of whether a child was a "fast" or a "slow" maturer as judged by these fifteen carpal and metacarpal ossification centers.

Inspection of the distribution of the skeletal/chronological age ratios indicated no marked effect upon the kind or distribution of any of the variations. The skeletal/chronological age ratio did seem to be associated with a "metacarpal – early appearing carpal" factor. Since none of the eight groups of children indicated that there is a preponderance of "fast" (index equal to or greater than 1.000) or "slow" (index less than 1.000) maturing children, I am satisfied that the maturation rate, as based upon the centers scored, is not associated with the presence or absence of variations by location or kind. There is no difference between "normal" and "variant" children in this light, and there seems to be no difference between controls and the various inbred groups. Finally, there seems to be no apparent relationship between the skeletal/chronological age ratio and the frequency of "missing" centers for either "normal" or "variant" children. This last set of inferences is in accord with the linear regression models for half the Hiroshima sample as discussed by Schull and Neel ('65).

Consanguinity Effects

Consanguinity status for the various groups of "normal" and "variant" children seem to have no clear or prominent influence upon the skeletal age or the presence or absence of variations. Again, the consanguinity effect upon hand-wrist skeletal maturation was not marked in the Hiroshima sample reported upon by Schull and Neel ('65), although an inbreeding effect may have been masked through assortative matings of control parents.

There seems to be no preponderance of "control" or of any category of inbred children within any of the six "variant" groups, so the consanguinity status of the child does not seem to be a factor here. Otherwise, it would have been expected not only in different frequencies of such categories within the "variant" groups, but also in the Q-mode and R-mode factor analysis distributions of all "normal" and all "variant" children. The numbers of control and inbred "normal" and "variant" children do not reflect any marked differences for these consanguinity categories, nor indicate marked consanguinity effects between kinds of variations.

The only consanguinity effects which seem apparent are associated with the Chi-square analyses. These puzzling but significant Chi-square associations were attributed to the possibility of sampling error within the distributions of the matrices, also suggesting that the significance of some of these tests might be purely chance.

The contingency coefficient C (Siegel, '56), as well as the coefficient of association phi (Spaulding, '60) were used to assess the strength of the distributions within the matrices for these five enigmatic and significant Chi-square tests. The contingency coefficients for tests indicated that the strengths of these Chi-square associations were quite low. Similarly, the phi values for these tests were quite low. In view of the results obtained from the contingency coefficients and the phi values, plus the overwhelming lack of consanguinity effects from other analyses of the data, it seems that there is no appreciable consanguinity factor operative upon the presence, absence, and/or distribution of the variations within the sample in spite of these five Chi-square tests.

City Effects

Any differences between Nagasaki and Hiroshima are slight and are not statistically significant. The only apparent city differences may be those indirectly indicated in certain of the Chi-square matrices, where the major difference is attributable to the number of "variant" and "normal" first cousin parentage girls in the two cities, specifically the number of "variant" first cousin parentage Hiroshima girls. This situation is best viewed as one of sampling error or of "chance" significance.

For "missing" centers, as already noted there were more young Hiroshima girls than boys and Nagasaki children. Hence this is attributed to sampling error also and it is concluded that no marked between-city effect probably exists. It is also worth noting that Schull and Neel ('65) could not demonstrate any meaningful differences between the two cities in terms of their inbreeding patterns, anthropometric analysis, or for the overall analysis.

Sex Effects

It thus appears that the only significant associations between the presence or absence of variations obtain for the sex of the child, with the few possible exceptions which have already been noted. Overall, females manifest the larger number of variations, and generally females are associated with the larger number of specific kinds of variations.

Numerous longitudinal studies of hand-wrist skeletal maturation have provided ample evidence that girls mature more rapidly during pre-adolescence than do boys. This observation is in keeping with the Hiroshima-Nagasaki sample, for when the skeletal/chronological age ratios are examined, by and large the girls are "faster" skeletal hand-wrist maturers than the boys although this is less clear in the distribution of children by sex in the Q-mode and R-mode factor analyses. Presumably this is a function of the expected more rapid growth rate of the bones involved in a "metacarpal – early appearing carpal" factor as I have interpreted it.

Normal and Variant Frequencies of "Missing" Centers

There are more "missing" centers among the "normal" than among the "variant" boys, the frequencies being approximately equal between the two cities. Since boys generally mature less rapidly than girls, not surprisingly there are higher frequencies of "missing" centers associated with boys than with girls. However, there are more "missing" centers among "variant" than among "normal" girls. The difference in frequencies of "missing" centers is relatively marked between the Hiroshima and Nagasaki girls, and it is the "variant" Hiroshima girls who have the highest frequencies of these centers for all girls.

The frequencies of "missing" centers are not very different between the "normal" and "variant" children who comprise the sample. There are 3,414 "missing" centers recorded for the Hiroshima sample and only 2,816 such centers for the Nagasaki sample. This primarily reflects the fact that there are slightly more younger children in the Hiroshima sample.

There are more "missing" centers associated with "normal" males and females of both cities than there are with "variant" children. There are also more "missing" capitates among "variant" children than among "normal" ones, primarily young males, perhaps due to the slower skeletal maturation of the hand and wrist exhibited by pre-adolescent boys. It is clear that "missing" centers in the sample are restricted to the distal ulnar epiphysis, the carpals, and the first metacarpal epiphysis.

From highest to lowest frequencies, the centers involved are: pisiform, distal ulnar epiphysis, scaphoid, trapezium, trapezoid, lunate, triquetral, capitate, first metacarpal epiphysis, hamate, and the fifth middle and first distal epiphyses. This ordering is almost identical for each "variant" group. This suggests that anatomical concentrations of "missing" centers are not influenced by the anatomical locations of variations, at least in any patent manner.

The frequencies of "missing" centers are essentially the same for "normal" Hiroshima and Nagasaki males and are not very different between "variant" boys from these cities, although in the former city the frequency is higher for "variants." The frequencies of "missing" centers among "normal" females are higher for Hiroshima than they are for Nagasaki; the "variant" girls indicate nearly twice as many "missing" centers for Hiroshima as there are for Nagasaki. The higher frequencies of these centers among the Hiroshima children seem to be due to the sample from this city containing more younger-aged children than does the Nagasaki sample.

It is interesting that there are more "missing" centers among the "normal" boys than among the "variant" ones, while there are more "missing" centers among the "variant" girls than there are for the "normal" girls. Since the boys' hand-wrist skeletons are known to mature less rapidly than the girls', one would expect more "missing" centers for boys than for girls; this is in fact true when "variant" and "normal" children are lumped and the two sexes are compared. But why should this same relationship not also obtain when the children are divided into "normal" and "variant" children within each sex? The skeletal age and hence the maturity scores do not seem to be affected by the presence or absence of variations; therefore, the frequencies of "missing" centers are not affected by the presence or absence of variations, which has been borne out by some of the Chi-square results.

Hence a sex effect seems operative in this case, at least for the "variant" females; and it seems that the higher frequencies of "missing" centers among "variant" as compared with "normal" girls is further evidence for economy of mineralization of bone in girls as a group when considered against boys as a group. Since there are more "variant" girls than there are "variant" boys, the higher frequencies of such "missing" centers in "variant" girls as opposed to "normal" girls may be a reflection of this. Nevertheless, it is difficult not to believe that the more numerous "missing" centers associated with "variant" girls is in fact indicative of the skeletal economy in mineralization associated with girls in general. Here, it should be remembered that the frequencies of "missing" *centers* indicate actual counts, *not* the number of affected children, since many children had instances of multiple "missing" centers. Due to the cross-sectional nature of the data it is impossible to say when these "missing" centers ossified, if in fact all of them did.

Frequencies of Variations Within Sexes

Males: Table 1 gives the percentage frequencies of these variations and their rank orders. It indicates that there are more "variant" Nagasaki males than "variant" Hiroshima males, although there are fewer "missing" centers in the Nagasaki sample than in the Hiroshima one. The probable explanation for the between-city difference with respect to "missing" center frequencies for "variants" has already been discussed. Pooling the males with respect to city, Table 1 also indicates that the frequencies of different kinds of variations ranked from highest to lowest are as follows: 6, cone shaped epiphysis; 7, lateral intercarpal space; 3, pseudoepiphysis; 8, "multiple" or "secondary" ossification centers; 5, radial shaft dysplasia; 11, radial shaft dysplasia and cone shaped epiphysis; 1, single Harris's line; 2, multiple Harris's line; 4, pseudofracture; 12, premature epiphyseal-diaphyseal fusion and radial shaft dysplasia with cone shaped epiphysis; 9, opaque area; 10, premature epiphyseal-diaphyseal fusion; 6-10, cone shaped epiphysis and premature epiphyseal-diaphyseal fusion; 3-4, pseudoepiphysis and pseudofracture, and 7-8, lateral intercarpal space and a "multiple" or "secondary" ossification center.

Table 1 also shows that the Nagasaki boys have higher frequencies of certain kinds of variations than the Hiroshima boys, while the reverse is true for certain other kinds of variations. Comparison between the Hiroshima and Nagasaki males of the frequencies of Variation 8, the "multiple" or "secondary" ossifica-

tion centers, is somewhat intriguing. The higher frequency obtains for Nagasaki, which is interesting in that there are more young Hiroshima males in the overall sample. If these "multiple" or "secondary" ossification centers were merely indicative of relatively late appearing centers beginning to ossify from several centers which would fuse together later, then it would be expected that more of them would be associated with the Hiroshima males, since more of them are younger. Arimoto (1952), Takahashi (1966), and Schull and Neel (1965) do not present data for prefecture differences between the boys to nutrition in terms of frequencies of "multiple" or "secondary" ossification centers. Therefore, this kind of variation cannot be attributed only to nutrition, illness, sex differences in hand-wrist skeletal maturation, or to skeletal age.

The Nagasaki and Hiroshima males are about equal in terms of the number of single variations and similar in consanguinity distributions for different kinds of variations. Somewhat more Nagasaki boys have two variations than Hiroshima boys. The boys from the two cities have about equal frequencies of the occurrence of three simultaneously occurring variations. The Hiroshima boys take the lead with regard to larger numbers of simultaneously occurring variations.

Females: Table 1 indicates that although there are a few more Hiroshima than Nagasaki girls, the overall frequencies are almost identical. When the girls are pooled by city, Table 1 shows that the frequencies of kinds of variations are as follows in order of decreasing frequency: 6, cone shaped epiphysis; 7, lateral intercarpal space; 11, radial shaft dysplasia and one cone shaped epiphysis; 8, "multiple" or "secondary" ossification centers; 1, single Harris's line; 3, pseudoepiphysis; 5, radial shaft dysplasia; 12, premature epiphyseal-diaphyseal fusion with radial shaft dysplasia and cone shaped epiphysis; 2, multiple Harris's lines; 4, pseudo-fracture; 6-10, cone shaped epiphysis and premature epiphyseal-diaphyseal fusion; 10, premature epiphyseal-diaphyseal fusion; 9, opaque area; 5-10, radial shaft dysplasia and premature epiphyseal-diaphyseal fusion; and 3-4, pseudoepiphysis and pseudofracture. There are no occurrences of Variation 7-8 within the female sample, the lateral intercarpal

TABLE 1

*Percentage frequencies of "variant" children by city, sex and kind of variation**

Variation	All ♂	Naga. ♂	Hiro. ♂	All ♀	Naga. ♀	Hiro. ♀	Pooled
1	6.63 (7)	1.84 (9)	11.55 (4)	6.53 (5)	2.78 (6)	10.26 (4)	6.58 (7)
2	4.59 (8)	6.38 (7)	2.76 (9)	3.61 (9)	4.78 (5)	2.45 (11)	4.08 (8)
3	14.80 (3)	14.76 (4)	14.83 (3)	5.92 (6)	8.02 (4)	3.83 (7)	10.13 (4)
4	4.00 (9)	2.52 (8)	5.52 (8)	2.00 (10)	0.62 (8)	3.37 (8)	2.95 (10)
5	7.91 (5)	10.07 (5)	5.69 (7)	5.61 (7)	8.02 (4)	3.22 (9)	6.70 (6)
6	19.90 (1)	17.78 (2)	22.07 (1)	31.67 (1)	33.18 (1)	30.17 (1)	26.08 (1)
7	16.50 (2)	16.11 (3)	16.90 (2)	16.99 (2)	14.66 (2)	19.30 (2)	16.75 (2)
8	13.86 (4)	18.62 (1)	8.96 (5)	7.22 (4)	10.34 (3)	4.13 (6)	10.38 (3)
9	1.11 (11)	1.51 (10)	0.69 (12)	1.08 (13)	0.62 (8)	1.53 (12)	1.09 (11)
10	0.76 (12)	0.50 (12)	1.03 (11)	1.31 (12)	1.70 (7)	0.92 (13)	1.05 (12)
11	7.57 (6)	8.56 (6)	6.55 (6)	11.07 (3)	10.34 (3)	11.79 (3)	9.41 (5)
12	1.70 (10)	1.17 (11)	2.24 (10)	5.23 (8)	4.78 (5)	5.67 (5)	3.55 (9)
5 - 10	–	–	–	0.23 (14)	–	0.46 (14)	0.12 (14)
6 - 10	0.51 (13)	–	1.03 (11)	1.38 (11)	0.15 (9)	2.60 (10)	0.97 (13)
3 - 4	0.08 (14)	–	0.17 (13)	0.15 (15)	–	0.31 (15)	0.12 (14)
7 - 8	0.08 (14)	0.17 (13)	–	–	–	–	0.04 (15)
Total	47.48	50.68	49.32	52.52	49.81	50.19	100.00

*Rank order position in brackets (1 = highest rank)

space and "multiple" or "secondary" ossification centers.

Most marked between city differences in frequencies occur for Variation 8, the "multiple" or "secondary" ossification centers; approximately three times as many Nagasaki girls show this condition as do Hiroshima girls. Recall that this was also true for the boys, but that the Hiroshima overall sample contains more young children than does the overall Nagasaki sample. Again this leads to the conclusion that these "multiple" or "secondary" ossification centers cannot be wholly attributed to the relatively young skeletal age of certain children manifesting incomplete mineralization of the cartilaginous precursor through multiple centers of ossification.

The Nagasaki and Hiroshima girls have about equal frequencies of single variations. This also applies to the frequencies of two simultaneous occurrences. More Hiroshima than Nagasaki girls show three simultaneous variations. These samples have almost equal frequencies of girls with four simultaneously occurring variations.

Frequencies of Variations Between Sexes

Of the sample of 3,823 children, 2,477 (64.79%) are "variant." It can be seen from Table 1 that there are more "variant" children by city and sex. The kinds of variations may be ranked in order of decreasing frequency: 6, cone shaped epiphysis; 7, lateral intercarpal space; 8, "multiple" or "secondary" ossification centers; 3, pseudoepiphysis; 11, radial shaft dysplasia and cone shaped epiphysis; 5, radial shaft dysplasia; 1, single Harris's line; 2, multiple Harris's line; 12, premature epiphyseal-diaphyseal fusion with radial shaft dysplasia and cone shaped epiphysis; 4, pseudofracture; 9, opaque area; 10, premature epiphyseal-diaphyseal fusion; 6-10, cone shaped epiphysis and premature epiphyseal-diaphyseal fusion; 5-10 and 3-4, radial shaft dysplasia with premature epiphyseal-diaphyseal fusion and pseudoepiphysis with pseudofracture; and 7-8, lateral intercarpal space and "multiple" or "secondary" ossification center.

To summarize the nature of the overall "variant" sample, Variations 6 (cone shaped epiphysis), 7 (lateral intercarpal space), and 8 ("multiple" or "secondary" ossification centers) account for 53.21% of the total kinds of variations. Wnen Variations 3 (pseudoepiphysis) and 11 (radial shaft dysplasia with cone shaped epiphysis) are included, these five kinds of variations account for 72.75% of the total variations. Thus cone shaped epiphyses are the primary kind of variation, intercarpal spaces secondary, "multiple" or "secondary" ossification centers third, and pseudoepiphyses are fourth. When combinations of variations are examined six groups are found to be involved. The most common are premature epiphyseal-diaphyseal fusion, radial shaft dysplasia, and cone shaped epiphyses alone and in combination with other variations (47.88%). Radial shaft dysplasia and cone shaped epiphyses alone and combined with other variations account for 42.19% of the variations. Cone shaped epiphyses and premature epiphyseal-diaphyseal fusions, alone and in combination with yet other variations, comprise 28.10% of the total variations. Pseudoepiphyses and pseudofractures comprise 13.20% of the total variations. Harris's lines are responsible for 10.66% of the total, while radial shaft dysplasias and premature epiphyseal-diaphyseal fusions constitute 7.87% of the total.

Table 1 also shows that males have higher frequencies than females for certain kinds of variations, and that the reverse is true for other kinds of variations. Variations 6, 7, and 8 (cone shaped epiphyses; lateral intercarpal space; "multiple" or "secondary" ossification centers) contribute more than 70% of the variation for both sexes. Variations 6 and 7 account for 36.40% of the male and 48.66% of the female variation. For both sexes, Variation 6 is the major kind of variation followed by Variation 7, while Variation 8 is the fourth major contributor. The third and fifth kinds of variations making up the remaining 30% are different between the sexes. Variation 3 or pseudoepiphysis is the third major kind of variation in males, but Variation 11, radial shaft dysplasia with cone shaped epiphysis, is third among females. Variation 5 or radial shaft dysplasia is the fifth major kind of variation in males; Variation 1, single Harris's line, is the fifth major kind of variation in girls. Females have almost twice as many cone shaped epiphyses as boys (Variation 6). The sexes have almost equal fre-

quencies of the lateral intercarpal space (Variation 7). Not unexpectedly, the boys have almost twice as many "multiple" or "secondary" ossification centers (Variation 8) as the girls. The within-sex differences have already been commented upon.

When different individual and combined variations of the same nature are compared between sexes, males have over twice as many involving pseudoepiphyses and pseudofractures as females (Variations 3, 4, and 3-4). Boys have a slightly higher frequency than girls of single and multiple occurrences of Harris's lines (Variations 1 and 2), and slightly more combinations of radial shaft dysplasia and premature epiphyseal-diaphyseal fusion (Variations 5, 10, and 5-10). Girls lead boys in the frequencies of all remaining combinations, sometimes approaching quantities which are twice as high. The combinations involving the same kinds of variations which are higher in girls are: radial shaft dysplasia and cone shaped epiphysis (Variations 5, 6 and 11); cone shaped epiphysis and premature epiphyseal-diaphyseal fusion (Variations 6, 10 and 6-10); and premature epiphyseal-diaphyseal fusion, radial shaft dysplasia and cone shaped epiphyses (Variations 5, 6, 10, 11, 12, 5-10 and 6-10). It seems obvious from this that while boys are more prone to pseudoepiphyses and pseudofractures as combinations than girls, for both the major kinds of variations involve shaft dysplasias, premature fusions, and cone shaped epiphyses. Thus these three factors are probably attributes of the Japanese gene pool, although more intensely associated with girls than with boys.

Slightly more girls than boys have single and double variations. Boys lead girls in the simultaneous occurrence of three variations, but these frequencies drop sharply from the single and double variation categories for both sexes (4.25% and 3.15%), where the frequencies for girls and boys were 51.78% and 51.04% and 17.29% and 16.07% for the single and double categories.

Frequencies of Affected Centers Within Sexes

Males: Table 2 gives the data as percentages nd by rank order. Ranked in descending order of "variant" center frequencies, the overall "variant" male sample is as follows: MP5; capitate; MC2; distal radius; DP1; lunate; MC5; distal ulna; trapezium; scaphoid; trapezoid; MC1; MC3 and MP2; triquetral, pisiform, and DP5; DP2; PP1; hamate, MC4, MP4, DP3 and DP4; PP2, PP3 and MP4. The sharp drop in percentages between the first distal phalangeal epiphysis and the lunate is to be noted. No male has variations at the fourth or fifth proximal phalanges.

The Nagasaki and Hiroshima male samples have certain different and identical positions for particular centers with reference to their percentage rank (Table 2). Both samples are identical in the rank positions for MP5, capitate, MC2, lunate, trapezoid, triquetral and MC4. They differ in that the rank order of DP1 and the distal radius are reversed; beyond this, the differences seem to follow no clear pattern in the rank order positions of the remaining centers.

As indicated earlier the "variant" children were sub-divided into six groups based upon anatomical regions of "variant" ossification centers. These regions are not mutually exclusive in that a group having variations at centers 1-29 (*i.e.*, encompassing all centers) can and does include children who also have variations at centers in another group (*e.g.*, center 1 and also centers 12-29). Nevertheless, each "variant" child was placed in only one of these six groups. The groups were established on the basis of those centers which seemed to be the primary sites for variations such as the fifth middle phalanx (center 24, hence group 24-29 with no variations patent for the first 23 centers).

Comparison of the Nagasaki and Hiroshima boys in terms of "variant" centers indicates that no city or inbreeding effects are apparent, but the primary sites for variations are the distal radius, the capitate, the second metacarpal, the fifth middle phalanx, and the first distal phalanx. The other affected centers reflect relatively small percentages of variations.

Females: Table 2 gives these data as percentages with rank order. Pooling the "variant" girls shows that almost half have variations at the fifth middle phalanx. The capitate is the next most frequently affected center. The remaining affected centers, ranked in decreasing percentage order, are as follows: DP1; distal radius;

MC2; lunate; distal ulna; MC5; MP2; MC1; trapezium; MC3; pisiform; PP5; MP4; scaphoid, PP2, DP2 and DP5; trapezoid and MC4; PP3, PP4, MP3 and DP3; and hamate, PP1 and DP4. There are no girls in the sample who have triquetral variations. There is a sharp drop in percentages of variations between the fifth middle phalanx, the capitate, the distal radius and the first distal phalanx, and the remaining centers.

When the Hiroshima and Nagasaki "variant" girls are compared according to decreasing frequencies of variations associated with specific centers, there are certain rank order similarities and differences. The fifth middle phalanx, capitate, and second metacarpal occupy the same rank positions in both samples. Like the boys, the rank order positions of the first distal phalanx and the distal radius are reversed between the two cities. The rank positions are different for the remaining centers. Unlike the "variant" males, the ordering of the "variant" girls is identical according to these six arbitrary groups except for the 1-29 and the "other" categories, which are reversed in position between the two female subgroups.

TABLE 2

*Percentage frequencies of "variant" children by city, sex and center**

Center	All ♂	Naga. ♂	Hiro. ♂	All ♀	Naga. ♀	Hiro. ♀	Pooled
D. Radius	11.42 (4)	8.61 (5)	14.28 (4)	10.20 (4)	7.53 (4)	12.86 (3)	10.78 (3)
D. Ulna	2.39 (8)	3.72 (7)	1.03 (10)	2.22 (7)	3.53 (6)	0.92 (10)	2.30 (7)
Capitate	16.54 (2)	16.38 (2)	16.70 (2)	17.25 (2)	14.90 (2)	19.60 (2)	16.92 (2)
Hamate	0.26 (17)	0.17 (16)	0.34 (14)	0.08 (19)	–	0.15 (14)	0.16 (22)
Triquetral	0.77 (14)	0.84 (12)	0.69 (12)	–	–	–	0.36 (17)
Pisiform	0.77 (14)	0.51 (14)	1.03 (10)	0.77 (13)	1.38 (10)	0.15 (14)	0.77 (14)
Lunate	3.92 (6)	4.73 (6)	3.10 (6)	2.38 (6)	2.76 (7)	1.99 (6)	3.11 (6)
Scaphoid	1.88 (10)	2.87 (8)	0.84 (11)	0.31 (16)	0.61 (12)	–	1.05 (11)
Trapezium	2.30 (9)	3.72 (7)	0.84 (11)	1.00 (11)	1.69 (9)	0.31 (13)	1.61 (9)
Trapezoid	1.53 (11)	2.03 (10)	1.03 (10)	0.23 (17)	–	0.46 (12)	0.85 (13)
MC 1	1.11 (12)	0.51 (14)	1.72 (8)	1.07 (10)	0.46 (13)	1.68 (7)	1.09 (10)
MC 2	14.41 (3)	14.36 (3)	14.46 (3)	5.14 (5)	6.61 (5)	3.68 (5)	9.53 (5)
MC 3	0.94 (13)	0.68 (13)	1.20 (9)	0.92 (12)	0.31 (14)	1.53 (8)	0.93 (12)
MC 4	0.26 (17)	0.34 (15)	0.17 (15)	0.23 (17)	0.15 (15)	0.31 (13)	0.24 (20)
MC 5	2.56 (7)	2.36 (9)	2.75 (7)	1.61 (8)	2.00 (8)	1.22 (9)	2.06 (8)
PP 1	0.60 (16)	0.51 (14)	0.69 (12)	0.08 (19)	–	0.15 (14)	0.32 (18)
PP 2	0.17 (18)	–	0.34 (14)	0.31 (16)	0.31 (14)	0.31 (13)	0.24 (20)
PP 3	0.17 (18)	0.17 (16)	0.17 (15)	0.15 (18)	0.15 (15)	0.15 (14)	0.16 (22)
PP 4	–	–	–	0.15 (18)	–	0.31 (13)	0.08 (23)
PP 5	–	–	–	0.54 (14)	0.31 (14)	0.76 (11)	0.28 (19)
MP 2	0.94 (13)	0.68 (13)	1.20 (9)	1.23 (9)	0.77 (11)	1.68 (7)	1.09 (10)
MP 3	0.17 (18)	–	0.34 (14)	0.15 (18)	0.15 (15)	0.15 (14)	0.16 (22)
MP 4	0.26 (17)	–	0.51 (13)	0.38 (15)	0.61 (12)	0.15 (14)	0.32 (18)
MP 5	24.04 (1)	23.99 (1)	24.20 (1)	42.02 (1)	43.01 (1)	41.04 (1)	33.51 (1)
DP 1	10.66 (5)	10.81 (4)	10.50 (5)	10.74 (3)	12.14 (3)	9.34 (4)	10.70 (4)
DP 2	0.68 (15)	0.51 (14)	0.84 (11)	0.31 (16)	0.15 (15)	0.46 (12)	0.48 (16)
DP 3	0.26 (17)	–	0.51 (13)	0.15 (18)	–	0.31 (13)	0.20 (21)
DP 4	0.26 (17)	0.17 (16)	0.34 (14)	0.08 (19)	0.15 (15)	–	0.16 (22)
DP 5	0.77 (14)	1.35 (11)	0.17 (15)	0.31 (16)	0.31 (14)	0.31 (13)	0.52 (15)

*Rank order position in brackets (1 = highest rank)

As with the boys, these comparisons of the girls do not indicate that any city or consanguinity effects are operative with regard to "variant" ossification centers. The girls are also like the boys in that these "variant" centers are essentially the same, except that the second metacarpal is included in the male category and the rank order sequence of the remaining four centers differs between the sexes. Thus the four primary "variant" centers for the girls are the fifth middle phalanx, the capitate, the first distal phalanx, and the distal radius.

Frequencies of Affected Centers Between Sexes

Since there seem to be no major city or consanguinity effects which influence the frequencies of "variant" centers, it is worthwhile to consider a between-sex comparison of the "variant" children. The percentages are presented in Table 2.

A total of 2,477 variations are present within the sample; 1,173 (47.36%) are associated with boys and 1,304 (52.64%) with girls. Combining "variant" boys and girls, it is clear that all centers have one or more variations. Ranking the overall "variant" centers by decreasing frequencies (Table 2), the following order results: MP5; capitate; distal radius; DP1; MC2; lunate; distal ulna; MC5; trapezium; MC1 and MP2; scaphoid; MC3; trapezoid; pisiform; DP5; DP2; triquetral; PP1 and MP4; PP5; MC4 and PP2; DP3; hamate, PP3, MP3 and DP4; PP4.

Certain "variant" centers have greater frequencies in boys than in girls; the reverse situation obtains for certain other centers. Table 2 shows that for both sexes, the fifth middle phalanx is the most frequently affected center. Then there is a sharp decrease in percentage frequency for both sexes, with the capitate being the second most frequently affected center. Here the similarity between the sexes ends; in decreasing order, males show the second metacarpal, the distal radius and the first distal phalangeal centers affected by variations on the order of 10% or more, while for females the first distal phalanx and the distal radius have frequencies of variations of 10% or more.

Comparison of the rank ordering between sexes again indicates certain similarities and dissimilarities. Both sexes have the same rank order positions for the fifth middle phalanx, the capitate, the distal radius, the lunate, the fourth metacarpal and the third proximal phalanx. The rank order positions are reversed between the sexes for the second metacarpal and the first distal phalanx (third in boys, fifth in girls for the second metacarpal; third in girls and fifth in boys for the first distal phalanx), and this is also the case for the fifth metacarpal (seventh in boys, eighth in girls) and the distal ulna (seventh in girls, eighth in boys). The ordered positions of the "variant" centers become more dissimilar between the sexes beyond these.

The 1,802 "variant" children represent almost half (47.14%) of the sample. For both sexes, the two "variant" groups with the highest frequencies are the 24-29 and 3-29 categories. The frequencies for the other groups do not follow the same rank order between the sexes.

The control and inbred boys in the "variant" group represent 45.61% and 54.39% of the total male "variant" sample. The control and inbred girls constitute 44.77% and 55.23% of the "variant" female sample.

For each of the six groups of "variant" centers within sexes and by consanguinity status, the majority of boys and girls constituting the 24-29 category are inbred. For the 25-29 and 1-29 groups, the control females and the inbred males constitute the majority. The 12-29 and "other" groups are similar in that the majority of children in them are control males and females. The 3-29 category is primarily composed of control males and inbred females.

In sum, it appears that neither city of residence nor consanguinity affect the distribution of variations within the hand and wrist to any notable degree. While some sex differences obviously obtain in frequencies of affected centers, it is nevertheless clear that there is no well-defined sex difference in *patterns* of centers affected by certain kinds of variations.

Skeletal/Chronological Age Ratios

The overall sample reveals no association between chronological age and the presence or absence of variations, nor is there any patent association between the skeletal/chronological age ratio and the presence or absence of varia-

tions relative to sex, city, or consanguinity. The sub-samples and the overall sample similarly indicate that no chronological age effect is significantly operative upon any of ten anthropometric measurements during Schull and Neel's (1965) analysis; but when they analyzed part of the Hiroshima hand-wrist maturity scores, they found a significant chronological age effect, which indicates that at least the children subjected to their statistical analysis mature similarly to other prepubescent children.

Variation 8, the "multiple" or "secondary" ossification center, is about twice as frequent in males as in females. Were this a function of a delayed male maturation (later mineralization of the cartilaginous model), then there should have been a between-sex difference in the skeletal/chronological age ratio since affected centers would receive "zero" maturity scores compared with unaffected centers. However, no sex differences were found for this variation and the skeletal/chronological age ratio. It became even more apparent in the within-sex comparisons that Variation 8 is not associated with maturation rate; its frequency was slightly higher in the Nagasaki males than in the Hiroshima boys, and about three times higher for the Nagasaki girls than the Hiroshima girls. Since more chronologically younger children of both sexes obtain for Hiroshima than for Nagasaki, neither chronological age nor consanguinity status appear to be causative factors. Furthermore, no between-city nutritional differences are apparent which might be invoked to explain these dissimilarities.

Therefore, differences in maturity scores or in overall maturation rates do not have prominent roles in the presence or absence of the different kinds of variations within or between sexes. Maturation rate, especially as associated with the child's sex, is *an* aspect to the meaning of variations; but it is not the only one.

DISCUSSION

There are seven deviations from the sequence of decreasing frequencies given in Table 1. All involve the Hiroshima children; the sequence is first cousins, controls, then first cousins once removed followed by second cousins or the reverse, and "other" inbreds. The kinds of variations involved with these sequences are Variation 6, "cone-shaped" epiphysis, for both males and females; Variation 12, premature epiphyseal-diaphyseal fusion with radial shaft dysplasia and "cone-shaped" epiphysis, for both boys and girls; and Variation 7, the lateral intercarpal space, for Hiroshima girls. The two remaining "deviant" sequences involve complexes of variations; the "shaft dysplasia – cone epiphysis" complex (Variations 5, 6, and 11) in Hiroshima boys, and the "shaft dysplasia – premature fusion – cone epiphysis" complex (Variations 5, 6, 10, 11, 12, 5-10, 6-10), also in Hiroshima boys.

The frequencies for all variations by sex and city indicate that about half the time those for second cousins are greater than those for first cousins once removed. If the alleles associated with these variations are associated with the X chromosome, then they are not primarily present in a homozygous state. If they were, one might expect the control category to have lower frequencies more often than the first cousin category at least, and this is not borne out by the evidence at hand. However, it should be recalled that the control children are the offspring of spouses who had no *known* genetic relatedness, and since Japan is an inbreeding isolate or has been until recently, the possibility must be taken into account that the frequency of homozygous alleles is actually higher than one might think.

Work has been done on gene involvement in sex differences as seen in skeletal hand-wrist maturation. If there are sex differences in those factors coordinating skeletal growth and maturation, then the greater female variability in maturation rate shifts and ossification timing may be associated with more female genotypes as represented by autosomal genes associated with the X chromosome. Whether the Y chromosome does tend to retard skeletal maturation is a moot question. If the kinds of variations discussed here are associated with maturation rates, it becomes difficult to understand why the variation frequencies should not differ more than they do between the sexes.

Another problem here is the inbreeding effect in the sample. Regardless of the autosomal genes associated with the X and Y chromosomes and those directly and indirectly in-

volved in producing the different variations, their frequencies might be higher in inbred than in less inbred gene pools when data are compared for variation frequencies.

If genes associated with the Y chromosome do tend to retard skeletal maturation while those associated with the X chromosome tend to produce "normal" or even "accelerated" maturation, one would expect the sex difference in maturation rates to be more marked than found for the Japanese sample. It is interesting to speculate whether the kinds of variations discussed herein do reflect a sex difference in hand-wrist maturation rates, albeit indirectly and clouded by inbreeding. Such a sex difference in maturation rates, as these are commonly thought of, is not indicated by the variations.

Except for the "complexes" of variations, most of the treatment of the kinds of variations has involved dealing with each variation as a discrete unit. However, it is quite possible that one or more of the alleles associated with the variations are pleiotropic and that many of the variations are expressions of incomplete dominance or incomplete recessiveness, or are maintained along with other characters having selective advantage.

This possibly was evaluated crudely by analyzing the percentage frequencies of each kind of variation between the sexes (Table 1). Those variations which had higher percentage frequencies in males than in females and the reverse were separated and then put together as "complexes." For males, one is the "pseudoepiphysis-pseudofracture complex" (Variations 3, 4, and 3-4); it has a frequency of 18.88% in boys and 8.07% in girls. Another is the "Harris's lines complex" (Variations 1 and 2), with a frequency of 11.22% in boys and 10.14% in girls. The "shaft dysplasia-premature fusion complex" (Variations 5, 10 and 5-10) has a frequency of 8.67% in boys and 7.15% in girls. The "shaft dysplasia – cone shaping complex" (Variations 5, 6 and 11) constitutes 48.35% of the girls' and 35.38% of the boys' variation. The "premature fusion – cone shaping complex" (Variations 6, 10 and 6-10) has a frequency of 34.36% in girls and 21.17% in boys. The "premature fusion – shaft dysplasia – cone shaping complex" (Variations 5, 6, 10, 11, 12, 5-10, and 6-10) has a frequency of 56.50% in girls and 38.35% in boys. These "complexes" indicate that while there is no definite sex-linkage, variations of similar nature do indicate some sex influence and/or association when grouped together.

In addition one final and crude estimate of some alternate interpretations of these "male complexes" and "female complexes" was attempted The overall "male complex" involves seven discrete kinds of variations and three "complexes." From the literature, single and multiple Harris's lines may or may not be associated with relatively slow skeletal maturation. Pseudoepiphyses, pseudofractures or notches, and "multiple" or "secondary" ossification centers would appear to be associated with the relatively slower skeletal maturation rate in males compared with females. Opaque areas and radial shaft dysplasia do not appear to be associated with growth. The "pseudoepiphysis-pseudofracture complex" and the "Harris's lines complex" seem to be associated with differential skeletal maturation rates between boys and girls; the "shaft dysplasia – premature fusion complex" does not. Hence, within the overall "male complex," five of the seven single kinds of variations and two of the three "complexes" seem to be associated with growth factors.

The overall "female complex" involves eight discrete kinds of variations and three "complexes." Premature fusions and pseudoepiphyses with pseudofractures are associated with growth fairly clearly; premature fusions and cone shaped epiphyses along with premature fusions and radial shaft dysplasias, less clearly. Radial shaft dysplasia and cone shaped epiphyses, radial shaft dysplasia with premature fusion and cone shaped epiphyses, cone shaped epiphyses, and the lateral intercarpal space are difficult to attribute to any appreciable skeletal hand-wrist maturation influence. The "premature fusion – cone shaping complex" would seem to be partly influenced by a skeletal maturation factor, but this is not as clear for the "shaft dysplasia – premature fusion – cone shaping complex" nor especially for the "shaft dysplasia – cone shaping complex." Thus within the overall "female complex," only two (and at the most, four) of the eight discrete kinds of variations may be attributed to skeletal maturation factors, while only one of the three "complexes" lends itself to that interpretation.

The kinds of variations and the "complexes" are by no means mutually exclusive between the sexes. However, it does seem apparent that most of the overall "male complex" is associated with sexual dimorphism in relation to hand-wrist skeletal maturation; the overall "female complex" cannot be similarly interpreted. The literature with regard to ossification sequence polymorphisms, sex ratios for various "anomalies," and the like, also fails to demonstrate that such skeletal hand-wrist variations are due to nutritional differences, maturation rates, or illness susceptibility between the sexes in any clear-cut fashion. Analysis of the Japanese data has indicated that maturation rates, inbreeding, or city of residence – along with nutritional differences between the gene pools and other data for the sample – can only be invoked with difficulty in interpreting the meaning of these variations. Insofar as the data and current research methods permit, the hypothesis of "shortcuts" associated with getting at least parts of the female skeleton into the basic sizes and shapes necessary for childbearing cannot be demolished easily. It now remains to investigate some possible mechanisms whereby these shortcuts might be effected, and why.

From the literature, it is apparent that some but not all bony conditions are plastic responses to biomechanical stresses. It is interesting to speculate as to how many bony "anomalies" are not necessarily biomechanical responses. Six come immediately to mind: deviations of the nasal suture to the left or to the right of the sagittal plane; pterion shape; metopic suture; "wormian" bones; septal apertures of the olecranon fossa; relative index finger length. The last four "anomalies" may be sex-influenced (*cf.* Woo, '49; Torgersen, '51a, b; Anderson, '63; Venning, '61b). It appears that certain bony joint surfaces shapes and synovial capsule tension are not necessarily biomechanical responses; hence the range of motion for certain joints.

Similarly, bone bipartitions and accessory or "multiple" bones and ossification centers do not appear to be influenced substantially by biomechanical factors. But what is their adaptive significance, if any? If pseudoepiphyses were due to mechnical stresses, one must again speculate as to the possible adaptive significance of pseudoepiphyses. Other investigators feel that pseudofractures and pseudoepiphyses are associated with ligamentous stress producing delayed or inhibited ossification in the latter condition. If these investigators are correct in their interpretation, then the ligaments and vascular supply to regions where pseudoepiphyses and notches appear would have to be positively charged in order to delay ossification and there would have to be an absence of ligamentous stress as well. This is the opposite of the truth and argues for bone mineral *deposition*, not its inhibition.

It is further possible that vasodilation (with an increase of negatively-charged ions, tending to increase ossification) is related to genetic differences between human gene pools. It is interesting to speculate whether the piezoelectric effect can be extended to differences between gene pools. Furthermore, the sequence of electrical events in bone building and bone destruction might be influenced by differences between different human gene pools in the anatomical orientation of ligaments and vascular systems.

If the shape of the bone is related to the distribution of its electrical charges, then does a round bone (*e.g.*, a carpal) have an electrical charge distribution different from a short bone (*e.g.*, a metacarpal or a phalanx)? If so, it is possible that variations such as cone shaped epiphyses and the lateral intercarpal space are influenced partly by the electrical charge distributions in the affected bones.

It is also tempting to speculate that radial flexion, especially of the fifth middle phalanx, is due to radial compressive and ulnar tensile stresses. In the X-rays showing this condition, fine dense lines of bone mineral occurred at the site of radial (concave) flexion and extended fanwise into the phalangeal shaft toward the ulnar (convex) surface. This is in keeping with Glucksmann's ('42) observations. The question immediately arises as to why the fifth middle and to a lesser extent the first distal phalanges should be subjected to flexions possibly associated with biomechanical stresses.

It is possible that when partly flexed, striking the respective ulnar and radial surfaces of the little finger and the thumb upon hard surfaces is partly responsible. When these two surfaces are so struck, they might undergo tension

stress and the opposite surfaces would undergo compressive stress. But such biomechanical stresses would not constantly obtain; even if they were responsible for the radial flexion of the fifth middle phalanx and the ulnar flexion of the first distal phalanx, there should be no appreciable frequency differences between gene pools for this kind of variation nor should the frequencies differ markedly between sexes.

It might be possible that there are gene pool differences with regard to the proximal joint surface shapes of one or both of these phalanges and that the presence or absence of cone shaped epiphyses is of importance also. The situation may be compounded by gene pool differences with regard to radial and ulnar synovial laxity at these two joints. Köhler ('68, p. 76) calls this "snapping finger" and noted that this condition is common in harp players, ball players, and in milkers of cows.

The capitate lateral intercarpal space observed in the sample is equally puzzling, if partly influenced by the bioelectric potential of bone. The anatomy of the capitate is such that it articulates with the scaphoid proximally and distally, and radially with the trapezoid by means of a smooth flat facet. The interosseous intercarpal ligament is situated between these two articular surfaces on the radial side, attaching the capitate to the trapezoid. The lateral intercarpal space, when present, is located in this region. If the interosseous intercarpal ligament were subjecting this region of the capitate to ligamentous stress, an accumulation of negatively-charged ions and a buildup of bone could be expected; however, the reverse is true, and so it does not seem that the lateral intercarpal space can be interpreted wholly as a plastic bone response to this ligament.

Considerable research has been done on the biomechanical nature of bone metabolism, modeling, growth, and crystal nucleation and inhibition. Baker and Angel ('65, pp. 105-106) have stated the problem:

> Between the level of whole bones and the basic biochemistry and microscopic structure there remains a gap . . . since we know very little about the pathological or age variations in structure and biochemistry between sections of the same bone.

The insights provided by biochemical investigations of bone are intriguing but they are also frustrating because of the extreme difficulty in devising *in vivo* studies to help explain certain phenomena on a macro-molecular level. There are methodological and procedural barriers associated with investigations of "how" and "why" phenomena such as wormian bones and hand-wrist variations are produced.

The literature clearly indicates that bone metabolism – whether it be concerned with remodeling, pathology, or growth – is under fairly direct genetic control through various bone cells, with this genetic control mediated directly or indirectly by the composition of collagen, ground substance, extracellular fluid, hormones, vascular supply, vitamins, and the like. This indicates that it is no longer sufficient to refer obliquely to the "genetics" of bone, and it also indicates that much future research directed towards understanding human skeletal variations, "anomalies" and pathologies must concentrate upon a more detailed understanding of the genetic-metabolic processess involved in their production.

Certainly some of the literature dealing with the biochemistry of pathologies and variations indicates that such studies are not impossible and that the classic phenomenological and morphological approaches to "explaining" them are no longer adequate. Nor is it sufficient any more even to discuss bone pathologies in the "standard" medical literature if such discussions and descriptions exclude what a certain pathology really means in terms of its production and subsequent changes.

Many non-serological, soft tissue phenotypic responses vary from one gene pool to another, and the genetic control seems to be clearly understood for many of them. If the epiphyseal vascular supply is involved with cone shaped phalangeal epiphyses, then by extrapolation what are we to infer about them when we know that there is gene pool variation in autosomal genetic control of the mammary venous plexus vascular pattern, the palmaris longus muscle, and the peroneous tertius muscle (this last having a statistically significant sex difference at least among the Ramah Navajo; Spuhler, '51)?

It is possible that human gene pools differ in terms of skeletal maturation and in steroid hormone production; it is also possible that male and female titration strengths of various growth and steroid hormones differ from one gene pool to another, while timing of onset, intensity, or duration need not be necessarily constant across gene pools. All of these factors should be assessed, especially for their possible roles in producing skeletal "economy" within and between gene pools.

It is possible that the rather high frequencies of some variations noted for the Japanese children represent phenotypic expressions of autosomal alleles in relatively high frequencies due to inbreeding. But why certain bones such as the captitate should be unossified in specific areas does not seem to be a question answerable on the strength of the data.

Some investigations have been carried out as to the possible effect of somatotype upon skeletal maturation, but little if any literature deals with the possible association between somatotype and minor skeletal variations of the kinds considered here. The literature shows an even greater dearth of investigation into the possible effects of skeletal maturation rates upon hereditary mortality and longevity. The literature is intriguing but difficult to interpret with respect to the possible effects of longevity and somatotype upon hand-wrist skeletal variations such as those discussed here. If there is a "skeleton-type" growth control mechanism and if different genotypes vary in response to common systemic agencies, these might also partly account for the different frequencies of hand-wrist skeletal variations between gene pools and sexes.

It is also possible that if the final adult male and female sizes and shapes reflect some genetic control associated with sexual dimorphism rather than with different maturation rates, while shape differences reflect sex differences in certain periods of maturation; there might be a sexual dimorphism factor operating upon hand-wrist variation frequencies and which is affected by within- and between-sex variability in specific maturation rates.

CONCLUSIONS

The R-mode factor analysis did not disclose any marked differences between the groups of "variant" children (six separated according to the ossification centers involved, plus all unrelated and all inbred children) with respect to the quarter-unit normalized standard deviation distributions. Thus the "factors" involved are not different with respect to centers affected by variations or maturation rates, since the "factors" are based upon the maturity scores. Within each group, the only clear distribution involves sex. From the R-mode factor analysis, the child's sex is the major factor in the distributions; the presence or absence of variations, consanguinity status, or city of residence do not markedly influence the maturity scores and the skeletal/chronological age ratios.

The Q-mode factor analyses of the eight groups agree with the R-mode factor analyses and again, sex has the most important effect upon the factor plane distributions and hence upon the maturity scores and maturation rate as assessed by the skeletal/chronological age ratios.

The Pearsonian product-moment correlation coefficients for the groups indicate that the skeletal/chronological age ratio has a low correlation with the fifteen centers assessed for maturity status; especially the distal radial and ulnar epiphyses, the triquetral, the pisiform, and to a lesser extent the capitate and hamate. This reflects the variability in carpal maturation, well documented in the literature. The trapezium, trapezoid and distal radial epiphysis have low correlations with the pisiform, consistent with its considerable ossification variability. Since these relationships are essentially the same for each of the eight groups, it is fairly clear that sex, consanguinity status, or the presence or absence of one or more variations do not affect the maturity score correlations; nor do they seem to affect the overall maturation rate as based upon the ossification centers. It is also clear the the carpals and essentially the metacarpals tend to mature as an anatomical "field."

The communality scores for the eight groups also indicate little between-group difference. For all groups, the communalities suggest the patent existence of the same two "factors." One involves the distal ulnar epiphysis, triquetral, lunate, scaphoid, trapezium and trapezoid. The other involves distal radial epiphysis, capitate, hamate, second through the

fifth metacarpal epiphyses, and skeletal/chronological age ratio. The pisiform and first metacarpal epiphysis are intermediate between these two factors. Thus regardless of the presence or absence of variations, sex, consanguinity status or city of residence, there appears to be a "carpal" factor and a "metacarpal – early appearing carpal" factor. The uniformity of the eight groups with respect to the components of these two factors indicates that maturation rates *per se* and consanguinity status do not affect the maturity scores of children who lack variations or who have them as specific centers.

Chi-square tests applied to the sample indicate that the few tests significant at or beyond the 5% confidence limit involved the sex of the child and the presence or absence of variations. The few exceptions to this involved city and consanguinity effects; but these results are probably "significant" ones which have occurred by chance alone, due to the number of Chi-square tests performed. This conclusion is reinforced by the absence of similar findings from other analyses of the data.

Other Chi-square tests indicate no significant association between frequencies of "missing" centers and variations, providing ancillary indications that maturation rate and probably ossification sequence are neither affected by nor associated with the presence or absence of variations. Those matrices involving "missing" centers indicate more for males than females, but this seems fairly in keeping with the overall slower male maturation rates compared with females. Other matrices involving frequencies of variations indicate that females have more variations than males, again suggesting a sex effect. Interpretation of the Chi-square results repetitiously leads one to conclude that the frequency of variations reflects a sex influence, but not a consanguinity effect and almost surely not a maturation effect.

Because approximately half the children in this sample reflect various degrees of inbreeding, it is possible that some consanguinity effect might be apparent in the ossification sequences and that these sequences also might be associated with the presence or absence or variations. These influences were assessed by ranking each of the eight groups according to the order of ossification. Analyses of these rankings suggested less variant female than male sequences, in keeping with others' observations attributing such lower female variability to their faster skeletal maturation rates.

Because the eight groups were subdivided by sex, consanguinity status, and (when present) anatomical location of variations, analysis of the ranked ossification sequences indicated something else as well. No clear sequences are apparent by sex, city, consanguinity status, presence or absence of variations, chronological age, or skeletal age. These findings also reinforce the conclusion that the presence, kind or anatomical locations of variations or their absence are not associated with maturation rates or with ossification sequences. If a consanguinity effect is present with respect to variations, it certainly is not apparent with respect to the ossification sequence.

Various investigators have found that the maturation rate seems to be associated with the presence or absence of certain variations discussed here; others have noted inbreeding effects upon anthropometrics. Maturation rates as indicated by the skeletal/chronological age ratios within each of the eight groups were examined. One cannot conclude that maturation rate is associated with the kind of anatomical location of variations or the lack thereof from this study. This analysis also indicated no clear difference between control and inbred children. There is no apparent association between maturation rate and "missing" centers for the "normal" and "variant" children. Because no group has a preponderance of "fast" or "slow' maturers based upon the skeletal/chronological age ratios and "missing" centers, I cannot establish either an inbreeding effect or a presence-or-absence of variations effect upon maturity rate. Stated somewhat differently, the maturation rate seems to have no effect upon the presence or absence of variations.

There are some possible consanguinity and city effects upon skeletal age, the kind and location of variations, and "missing" centers, apparent from a few Chi-square tests significant at or beyond the 5% confidence limit. I feel that these few significant effects are artifacts. If a consanguinity effect is operative, it is by no means clear from the data; the same applies more strongly to possible city effects. Should some such effects actually obtain, they should

be interpreted as probably reflecting small socioeconomic differences between cities and consanguinity groups; this is in keeping with Schull and Neel's ('65) conclusion for the overall study.

The outcomes of the various statistical procedures applied to the data indicate fairly clearly that there is some sex difference in the presence or absence of variations. Girls have greater absolute counts of variations and generally greater overall counts of specific kinds than boys. Perhaps this situation is associated with a more rapid female skeletal maturation rate, allied with "shortcuts" in the female skeleton oriented toward developing it into basic adult sizes and shapes.

"Missing" centers seem to militate against this conclusion at first glance. There are more "missing" centers for all boys than for all girls, to be expected with slower male maturation rates. But within-sex comparisons of "normal" and "variant" children present a somewhat confusing picture. More "missing" centers were found for "normal" than for "variant" boys, the reverse for "variant" and "normal" girls. If greater numbers of "missing" centers indicate a slow skeletal maturation rate, then "normal" males and "variant" females are slow maturers while "variant" males and "normal" females are fast maturers. This reversal in rates for "normal" and "variant" children between the sexes militates against a clear maturation rate influence upon the presence or absence of variations, at least in any clear way. However, the reverse situation between sexes for "normal" and "variant" children reinforces my conclusions: that among the females at least, "missing" centers are like the variations in reflecting a skeletal economy designed to orient skeletal development towards the basic adult hand-wrist size and shape, perhaps accompanying an earlier onset of reproductive maturity.

Percentages of variations between sexes showed that for both, cone shaped epiphyses (Variation 6) followed by the lateral intercarpal space (Variation 7) and then by "multiple" or "secondary" centers (Variation 8) were the most common. Males seem to be more prone to pseudo-epiphyses and pseudofractures than females, especially in combination. For both sexes, the kinds of variations seem to involve major groupings of radial shaft dysplasias, premature epiphyseal-diaphyseal fusions, and cone shaped epiphyses; these combinations seem to apply more to girls than to boys. The majority of centers associated with the majority of the kinds of variations are the same for both sexes; essentially fifth middle phalanx, capitate, and first distal phalanx. The sex differences in these percentages are not well defined according to the kind and location of the variations. Because city of residence and consanguinity status do not seem to affect the anatomical distribution of the variations, the major locations of the variations may reflect one attribute of the Japanese gene pool.

Not having been able to establish associations between chronological age and the skeletal/chronological age ratio with the presence or absence of variations; or between "missing" centers and maturation rate among "normal" and "variant" groups do not indicate any strong or clear effect upon the presence or absence of variations. Thus one cannot attribute variations to maturation rate differences either between or within the sexes, aside from noting that the overall maturation rates are generally faster for girls than for boys.

There seem to be some inbreeding effects upon specific congenital malformation frequencies in Japanese infants, as well as a slight retardation in hand-wrist maturation rates among part of the Hiroshima sample. Nevertheless, the data do not indicate that inbreeding affects maturation rate, frequencies of overall variations, or of particular kinds. Yet if the variations are associated with sex, inbreeding could increase the frequency of "variant" alleles which are presumably associated with the X chromosome. This might increase such allele frequencies among males, masking the sex differences somewhat. Here one must ask what the selective advantages of such variation-producing alleles might be within the Japanese gene pool, aside from sexual dimorphism. I have few if any indications of how to answer this.

One conclusion seems fairly clear with respect to the "meaning" of the different kinds of variations discussed here: nutritional deficiencies cannot be invoked among the children comprising the sample. Several recent studies have demonstrated that the Japanese nutritional status is quite high compared with other

Asian countries, and that Japan's post-war nutritional status has increased steadily. Since the great majority of the children were born after the end of World War II, it is difficult to conclude that nutritional deficiency is associated with the variation frequencies. There may be some nutritional differences between the cities and consanguinity classes, but they are not clearly apparent from the hand-wrist data.

The absence of a nutritional effect upon the frequency of variations also manifests itself in the comparative data for variations. The percentage of single and multiple Harris's lines is much lower among the Japanese sample than from some Caucasian samples; though the Japanese nutritionally lag behind U.S. Caucasian standards, clearly a nutritional effect does not obtain. The same is true for lower frequencies of notches or pseudofractures and for pseudoepiphyses in the Japanese sample compared with Caucasian samples. If these variations are associated with comparatively "slow" hand-wrist maturation, then the Japanese must mature more rapidly than U.S. Caucasians; and the difference in maturation rates could not be easily attributed to nutritional differences. Since the percentage of premature epiphyseal-diaphyseal fusion seems to be lowest among the Japanese data compared with other gene pools, there seem to be differences between different gene pools in maturation rates or maturation rate variability.

Furthermore, the percentage of the lateral intercarpal space is higher in the Japanese data than in Negro and Caucasian data, also true for the frequency of cone shaped epiphyses (with the addition of South American Indian data), but the Japanese between-sex ratios are much closer to equality than in the other samples. Percentages of radial shaft dysplasia, and specifically radial shaft dysplasia associated with cone shaped epiphyses likewise differ between gene pool samples; these are comparatively high in the Japanese sample, specifically the latter.

One explanation for these gene pool differences (aside from possible observer bias) is that there is an inbreeding effect reinforced by adaptive variation in environmental responses, since nutritional differences can be discounted as major factors affecting the variation frequencies and since the Japanese data show some between-sex differences in variation frequencies compared with other gene pool samples.

Thus, compared to other samples, the Japanese gene pool has higher allele frequencies responsible for the lateral intercarpal space, cone shaped epiphyses, radial shaft dysplasia, and radial shaft dysplasia combined with cone shaped epiphyses. It appears intermediate to other pools with respect to the allele frequencies responsible for radial shaft dysplasia with premature epiphyseal-diaphyseal fusion and cone shaped epiphyses. Comparatively, it has the lowest allele frequencies responsible for single and multiple Harris's lines, pseudoepiphyses, notches or pseudofractures, and radial shaft dysplasia with premature epiphyseal-diaphyseal fusion. The possible evolutionary significance of these differences is not clear to me.

Consider some possible effects of sex *per se* on the frequency and kinds of hand-wrist variations. That the male skeleton is more susceptible to growth *deterrents* than the female skeleton; this shows up in higher notch and pseudoepiphysis frequencies and in more "slow" than "fast" maturers for males than for females. The frequency of cone shaped epiphyses is generally higher in Japanese girls than in boys, especially for the fifth middle phalanx. It is also known that there are more "missing" phalangeal foot centers in girls than in boys.

Certain studies have shown that toe digit length is shorter among Japanese than among Caucasians, and that male index finger length is shorter than that of the female. It is also known that the length of the fifth middle hand phalanx is shorter in females than males, possibly indicating an adaptation to protein malnutrition through an absolute size reduction. It is thus possible that the between-sex differences in the frequencies of variations noted for this sample partly reflect smaller Japanese body builds as compared with other gene pools such as U.S. Caucasians; and that the variations are associated with some body size economy which may or may not be an adaptation to some environmental effect.

It is difficult not to conclude that these differences are somewhat associated with inbreeding. If the degree of inbreeding has been decreasing recently in some gene pools, then gene pool variations in inbreeding might in-

crease patent differences in skeletal variations. I feel that the sex differences in the frequencies of some variations noted for this sample are affected by inbreeding, and that some autosomal alleles associated with the X chromosome are responsible for these variations. If so, should the penetrance of the "variation" alleles be greater in a homozygous state (incomplete dominance or incomplete recessiveness), then a long-term inbreeding effect might tend to mask a sex difference.

This is partly borne out by the general lack of a sex difference in the frequency of variations for the unrelated and the various inbred groups. Because the frequency of specific variations is as often higher for second cousins than for first cousins once removed as not, I cannot conclude that the variation frequencies are dependent upon the frequency of homozygous alleles. Otherwise, the unrelated children should have the lowest variation frequencies, with these increasing according to the degree of inbreeding. This is not the case, but the generalized inbred character of the Japanese gene pool somewhat clouds this issue. Also, one must assume that one or more of the alleles producing the variations may be pleiotropic; thus some of the variations might be retained due to positive selection for other characters under the partial control of the same gene. Since I feel that there is this possibility, the argument for the association of variations with homozygous loci is threatened even more.

Even assuming that sexual dimorphism in these variations may be masked somewhat by inbreeding effects in the sample, one must conclude that such sex differences do exist. This is borne out by the "complexes' or variations for Japanese boys on the one hand and for Japanese girls on the other. Thus the "pseudoepiphysis-pseudofracture complex" is more frequent in boys than in girls. The "Harris's lines complex" has a slightly higher frequency in boys than in girls, as does the "shaft dysplasia – premature fusion complex." Conversely, the "shaft dysplasia – cone shaping complex," the "premature fusion – cone shaping complex," and the "premature fusion – shaft dysplasia – cone shaping complex," have higher frequencies among girls than among boys. Thus it is clear to me that these "complexes" are definitely sex associated.

More specifically, the overall "male complex" seems to involve single and combined variations which are associated with slower male than female maturation. Contrasted to this is the overall "female complex," which is poorly associated with clearly maturational factors. The few growth-associated factors in the overall "female complex" seem to be associated with rapid rather than with slow maturation, so that the "growth" effect is diminished even more. Therefore, I cannot conclude that maturation rates, inbreeding effects, nutrition, or between-city differences of whatever nature suffice to "explain" the variations I have discussed. While I acknowledge that inbreeding effects must be taken into account, I feel that the variations primarily reflect a sexual dimorphism. Even though some of the possible mechanisms behind this sex difference are based upon speculations from the literature, they may help to clarify the meaning of these variations.

If the kinds of variations discussed here in fact reflect a sexual dimorphism partly manifesting itself in "shortcuts" or "economies" which organize the female skeletal system into basic adult sizes and shapes, then what are some of the mechanisms which might be involved? Here one must turn to literature somewhat ancillary to physical anthropology.

I have speculated upon some biomechanical stresses which might produce the radial and ulnar flexions seen in the middle and distal phalanges and metacarpals of the first, second and fifth digital rays, and upon possible biomechanical forces which might inhibit mineralization of the radial surface of the capitate; but it should be apparent that in themselves, none of these forces is an adequate explanation for such variations. No evidence from the literature or from the sample indicates noteworthy differences in habitus patterns remotely sufficing to invoke such explanations for children from various human gene pools. However, with respect to biomechanical forces and the anatomical locations of these rays and their components, these forces probably influence the relatively high frequency of variations seen at these sites.

The question still remains as to genetic differences between human groups in terms of bioelectrical potentials in bone; especially as

these potentials affect the shapes of specific bones and bony regions and their remodeling cycles. The evidence for genetic differences in muscular and ligamentous orientation and that suggesting that some skeletal variations are associated with vascular supply would argue that human bone piezoelectric effects need not be constant from one human population to another.

Possibly there are human gene pool differences in the genetic control of bone tissue (not to mention the gene pool differences in skeletal "discrete traits"). Possibly many human skeletal tissue attributes reflect genetic differences, such as the variations discussed here. There are undoubtedly local differences in the rate of collagen synthesis even within a given skeletal system. Thus "pathological" bone collagen can differ from "normal" bone collagen in terms of "basic amino acid content," "local failures in mineral supply" can produce clinodactyly, and inherited conditions such as familial exostoses may possibly represent "delayed remodeling through a cartilage deficiency in inhibitor enzymes," to mention a few conditions discussed in the literature.

Grant that bone cell activities differ genetically between human populations, and recall that the structural genes within such cells are probably controlled by regulator genes responding to cellular microenvironments: then it is not unlikely that local bony regions and sites within individual bones may undergo selective inhibition and/or configurational changes which produce "variations." In this regard, the slower skeletal maturation of children with slight body builds compared with children having heavier body builds suggests genetic control of skeletal configurations, whatever the reasons might be. It is interesting to note that the literature indicates less ectomorphic (slight body build) than mesomorphic (heavier body build) variation in skeletal maturation rates – and that the hand-wrist ossification sequence variability is less in females than it is in males.

It has been suggested that genotypes may differ mainly in their tissue responses to essentially the same systemic control mechanisms; that bodily shape sex differences may be due to different growth rates for parts of the overall growth period, and that human sex differences in growth at about six years of age are due to different gene mechanisms. For the last, it has been suggested that sex differences in growth may be due more to size factors than to the earlier completion of female growth. It has also been noted that the number of toe phalanges, their lengths, and the presence of cone shaped epiphyses and "multiple" ossification centers are not associated with skeletal maturation rate, although metacarpal notches presumably are. These considerations suggest that if some hand-wrist variations do represent a sexual dimorphism (at least in Japanese children), then they are probably poorly associated with skeletal maturation rate; but that something such as a size factor is also involved.

I suggest that the smaller size of the female skeleton compared with that of the male reflects a skeletal "economy," at least partly associated with a shortcut to attain the minimum size necessary for the biomechanics of childbearing. Similarly, at least certain hand-wrist variations indicate to me that *shape* is primarily a function of size in this regard. Inhibiting or delaying mineralization of certain bony areas (*e.g.*, the capitate, "multiple" centers, epiphysis and diaphysis of the fifth middle phalanx) would be one way to attain minimum skeletal size, while "classic" or "normal"rugose shape (by male standards) would be developed later (or never).

If autosomal genes associated with the Y chromosome are partly responsible for male retardation in skeletal maturation compared with females, I do not feel that they are associated with the hand-wrist variations discussed here. Loosely classifying males as "mesomorphic" and females as "ectomorphic" in having medium and slight skeletal structures, females would mature more slowly than males (which they do not) but females would be less variable than males in skeletal maturation rates (which they are). Because the females lack a Y chromosome but have significantly higher frequencies of hand-wrist variations than males, it is difficult to invoke within- and between-sex differences in maturation rates or autosomal genes associated with the Y chromosome to interpret the variations.

It seems increasingly clear that autosomal genes associated with the X chromosome influence skeletal hand-wrist ossification timings

and patterns. Because females have less variability than males in this sense and also have more variations (at least of certain kinds), then the autosomal genes influencing these variations are probably associated with the X chromosome. Females have a wider range of genotypes than males with respect to the X chromosome; therefore, females might differ more widely from each other than males in their skeletal tissue responses to generalized systemic control mechanisms. Thus a wider phenotype range might be expected to obtain for females than would be seen for males with respect to hand-wrist variations. Repeatedly, for this sample and perhaps for other inbred gene pools, the sex difference in hand-wrist variations could be obscured somewhat if the alleles responsible for them had some selective advantage elsewhere in the body.

From all of this, then, one interpretation of hand-wrist variations (and perhaps others as well, such as the frequency of metopism) is that they represent a sexual dimorphism expressed by autosomal alleles associated with the X chromosome and which is allied with the general earlier arrival of girls at puberty than boys. The significance of many of these variations would be the approximate reduction of bony shape to a functional minimum so as to attain approximately minimum absolute size at, or before, puberty, so that the onset of puberty would not need to be delayed by the skeletal system. The accuracy of this conclusion can only be tested by a longitudinal study of variations and maturation rates in the skeletal systems of both sexes, with a comparison of ages at which each sex attains puberty.

SUMMARY

The frequency of certain hand-wrist skeletal variations noted in a sample of Japanese children indicates higher frequencies for girls than for boys. These variations do not seem to be associated with ossification patterns, city of residence, or nutrition. There is a tendency for the frequency of the variations to be associated with maturation rates (*e.g.*, more "missing" centers in boys than in girls, presumably indicative of slower maturation in the former) and with consanguinity status. The autosomal "variation" alleles are probably associated with the X chromosome and a true sexual dimorphism exists in the form of these variations, although the sex differences are somewhat obscured by the fact that much of Japan essentially represents an inbred human population. The adaptive significance of these variations remains unknown; but there must be more positive selection for them because almost half of the children in the sample have one or more "variation," and approximately half of the children in the sample are known to be inbred.

Because the capitate, hamate and distal radial epiphysis are the earliest appearing and perhaps are the most "stable" of the carpal bones in that they are almost always present when variations appear elsewhere in the hand and wrist, there might be some justification for assuming that some widespread disturbance of cartilage model mineralization would be partly necessary to inhibit the nucleation sites of these three centers. Conversely, the most variable carpal bones in terms of their absence when one or more variations are present elsewhere are the pisiform, the distal ulnar epiphysis and the scaphoid. This suggests that possibly any minor disturbance suffices, or tends, to block their mineralization. Centers tending to appear late in skeletal hand-wrist maturation tend to have fewer variations associated with them, but this is not always the case; hence time of appearance of centers does not strongly modify the previous statement.

The frequencies of variations by center suggest that the fourth digital ray is the most stable, followed by the third; the second, first and fifth digital rays are much more unstable. The frequencies of variations also indicate that the triquetral and the hamate are the least affected bones of the carpus. Because this sample is latitudinal rather than longitudinal, there is no way to determine how realistic these impressions are. Also, since only the left hand is represented, there is no way to determine whether these conditions are symmetrical or not.

When age group, sex, and consanguinity are taken into account the regularity of the observations provides some measure of confidence. The most "variant" centers are the fifth middle phalanx, capitate, distal radial epiphysis, first distal phalanx and second metacarpal respectively, exclusive of "missing" centers. The loca-

tion of these centers relative to the remainder of the hand and wrist provides a clue as to the relative stability of certain centers and the comparative instability of others. This becomes more clear when one recalls that the carpus is the region where "missing" centers are almost exclusively found, and that the highest frequencies of "missing" centers (excluding the pisiform) are associated with the radial side of the hand.

Perhaps it is partly due to the dynamics of the relatively wide range of motion in the thumb that the radial group of carpals is absent so frequently. We may be observing a "sacrifice" of those centers less functionally necessary to the dynamics of hand-wrist movement than others, in order to gain more rapid skeletal maturation of the hand and wrist (especially in females). This may be reinforced by the almost total restriction of "multiple" or "secondary" ossification centers to the carpus. This argues that other nucleation areas are present in addition to the "normal" or "major" nucleation sites in the carpal cartilage models. The data suggest that a "multiple" or "secondary" ossification center may indicate some inhibition in the ossification of parts of these cartilage models. It is as if one or more areas of the cartilaginous mold were either inhibited or totally blocked from calcification, with the unblocked portions continuing their roles as nucleation sites.

This interpretation seems to be much more in keeping with what is known of the various nucleating mechanisms in bone tissue. It also provides a possible explanation for the indentation on the radial surface of the capitate. It is suggested that within the cartilaginous model of the capitate, a certain nucleation site or local area is consistently blocked and does not ossify. If the emphasis is upon developing a mature bone which approaches the "ideal" shape generally rather than *exactly*, it is possible that an indentation on the capitate radial surface can meet the functional requirements of interosseous ligaments as easily as a tubercle, thus saving a certain amount of bone mineral for use elsewhere or later.

As for the first and second distal and the fifth middle phalanges, their prominent susceptibility to variations and the predominant kind of variation (cone shaped epiphysis with reciprocal conical crater shaping of the diaphysis) suggest something else. Since the study is latitudinal, there is a fair possibility that this "reciprocal shaping" is actually part of a continuing process in which the reciprocal shaping indicates a trend toward premature fusion of the epiphysis with the diaphysis. The conical crater indentation on the fifth middle and the first and second distal phalangeal diaphyses might be other examples of nucleation inhibition designed to economize upon the amount of bone mineral necessary for the approximately minimal functional shape. Since these three centers are in exposed positions relative to the biomechanics and kinetics of the hand, premature fusion could serve to strengthen them.

The stability of the hamate, triquetral, pisiform, and the fourth digital ray in terms of absence of variations can also be explained by this reasoning. These three carpals are more intimately associated with the fourth (and fifth) digital rays than are the others; the hamate, triquetral, pisiform and the fourth digital ray thus seem to be relatively unaffected by tangential biomechanical forces. Furthermore, the fourth digital ray is somewhat protected by the adjacent third and fifth digital rays while the triquetral, pisiform and hamate are somewhat removed from the rotatory and kinetic effects of the first digital ray.

If the pressure for earlier skeletal maturation in at least the female hand can be satisfied without a given ossification center exactly replicating its adult configurations, it is possible that those functionally least important areas of a given center may be at least temporarily sacrificed to reduce the time required for mineralization of the adult bone cartilaginous blueprint. It would thus appear that the higher frequencies of hand-wrist variations, along with relatively faster maturation rates and smaller absolute size in females compared with males, reflect a sex effect where the more rapid female maturation is partly manifested skeletally by "sacrificing" overall mineralization (smaller sizes) in rather specific localities of certain bones (shape variations). That there may be some selective advantage to the autosomal alleles responsible for these variations seems apparent in that they are also present in males, and in that approximately half of the sample children manifest such variations and half are

the results of consanguineous matings. This, and other, questions can only be resolved through future research.

LITERATURE CITED

Anderson, J.E. 1962 The Human Skeleton: A Manual for Archaeologists. National Museum of Canada, Ottawa.

——— 1963 The People of Fairty. National Museum of Canada, Bulletin No. 193.

Arimoto, K. 1952 Nutrition in Japan. Nutrition Reviews *10:*321-323.

Baker, P. T. and J. L. Angel 1965 Old age changes in bone density: sex and race factors in the United States. Hum. Biol. *37:*104-121.

Corruccini, R. S. 1974 An examination of the meaning of cranial discrete traits for human skeletal biological studies. Am. J. Phys. Anthrop. *40:*425-445.

Eyman, C. E. 1970 Hand-Wrist Variability in Japanese Children. Ph.D. Dissertation, University of Calgary.

Fairbank, T. 1951 An Atlas of General Affections of the Skeleton. Williams and Wilkins, Baltimore.

Garn, S. M., S. L. Fels and H. Israel 1967 Brachymesophalangia of digit five in ten populations. Am. J. Phys. Anthrop. *27:*205-209.

Garn, S. M., C. G. Rohmann and T. Blumenthal 1966 Ossification sequence polymorphism and sexual dimorphism in skeletal development. Am. J. Phys. Anthrop. *25:*147-151.

Garn, S. M., C. G. Rohmann and F. N. Silverman 1965 Missing secondary ossification center of the foot: inheritance and developmental meaning. Annales de Radiologie *8:*629-644.

Glucksmann, A. 1942 The role of mechanical stresses in bone formation in vitro. J. Anat. *76:*231-239.

Greulich, W. W. and S. I. Pyle 1959 Radiographic Atlas of Skeletal Development of the Hand and Wrist, 2nd. ed. Stanford University Press.

Harris, H. A. 1931 Lines of arrested growth in long bones in childhood: correlation of histological and radiographic appearances in clinical and experimental conditions. Br. J. Radiol. *4:*561-588.

Hertzog, K. P. 1967 Shortened fifth middle phalanges. Am. J. Phys. Anthrop. *27:*113-117.

Johnston, F. E. and S. B. Jahina 1965 The contribution of the carpal bones to the assessment of skeletal age. Am. J. Phys. Anthrop. *23:*349-354.

Johnston, F. E., R. H. Whitehouse and K. P. Hertzog 1968 Normal variability in the age and first onset of ossification of the triquetral. Am. J. Phys. Anthrop. *28:*97-99.

Köhler, A. 1968 Borderlands of the Normal and Early Pathologic in Skeletal Roentgenology, 3rd. American ed. Grune and Stratton, New York.

O'Rahilly, R. 1953a Epitriquetrum, hypotriquetrum, and lunatotriquetrum. Acta Radiologica *39:*401-411.

——— 1953b A survey of carpal and tarsal anomalies. J. Bone and Joint Surg. *35A:*626-642.

——— 1957 Developmental deviations in the carpus and the tarsus. Clin. Orthopaedics *10:*9-18.

Ossenberg, N. S. 1970 The influence of artificial cranial deformation on discontinuous morphological traits. Am. J. Phys. Anthrop. *33:*357-371.

Schull, W. J. 1958 Empirical risks in consanguineous marriages: sex ratio, malformation, and viability. Am. J. Hum. Gen. *10:*294-343.

Schull, W. J., T. Yanase and H. Nemoto 1962 Kuroshima: the impact of religion on an island's genetic heritage. Hum. Biol. *34:*271-298.

Siegel, S. 1956 Nonparametric Statistics for the Behavioral Sciences. McGraw-Hill, New York.

Spaulding, A. C. 1960 Statistical description and comparison of artifact assemblages. In: The Application of Quantitative Methods in Archaeology. R. F. Heizer and S. F. Cook (eds.). Viking Fund Publications in Anthropology, No. 28.

Spuhler, J. N. 1951 Some genetic variations in American Indians. In: The Physical Anthropology of the American Indian. W. S. Laughlin (ed.). Fourth Viking Fund Summer Seminar in Physical Anthropology, New York.

Takahashi, E. 1966 Growth and environmental factors in Japan. Hum. Biol. *38:*112-130.

Torgersen, J. 1951a Hereditary factors in the sutural pattern of the skull. Acta Radiologica *36:*374-382.

——— 1951b The developmental genetics and evolutionary meaning of the metopic suture. Am. J. Phys. Anthrop. *9:*193-210.

Venning, P. 1954 Sib correlations with respect to the number of phalanges on the fifth toe. Annals of Eugenics *18:*232-254.

——— 1956a Radiological studies of variations in the segmentation and ossification of the digits of the human foot. I. Variation in the number of phalanges and centers of ossification of the toes. Am. J. Phys. Anthrop. *14:*1-34.

——— 1956b Radiological studies of variation in the segmentation and ossification of the digits of the human foot. II. Variation in length of the digit segments correlated with differences of segmentation and ossification of the toes. Am. J. Phys. Anthrop. *14:*129-151.

——— 1961 Radiological studies of variation in ossification of the foot. IV. The length and growth of bones of the foot in relation to morphology. Am. J. Phys. Anthrop. *19:*137-145.

Virchow, H. 1929 Das os centrale carpi des menschen. Morphol. Jahrbuch, vol. *63*, part 2, pp. 480-530.

Woo, J. K. 1949 Racial and sexual differences in the frontal curvature and its relation to metopism. Am. J. Phys. Anthrop. *7:*215-227.

The Estimation of Maximum Crown Dimensions in Human Permanent Teeth with Severe Attrition

M. McKEOWN[1] and K. ISOTUPA[2]
[1]*Department of Oral Biology, University of Saskatchewan, Saskatoon, Saskatchewan S7N 0W0, and* [2]*52, Lemminkaisenkatu 2, Turku, Finland*

KEY WORDS Human Tooth Wear • Quantitative Variation • Prediction

ABSTRACT A study of 589 unworn human permanent teeth shows that strong statistical correlations are present between linear measurements of maximum crown dimensions and similar measurements in the cervical region in human teeth. These relationships provide a basis for estimation of previously present crown dimensions in teeth severely worn by attrition. Correlation values for different teeth suggest that some teeth are more morphologically stable than others.

RESUME L'étude de 589 dents humaines permanentes, et sans usure, a démontré la forte corrélation statistique qui existe entre les mensurations linéaires des dimensions maximum de la couronne et les mensurations semblables de la région cervicale de la dent humaine. Ces rapports offrent la base de l'estimé des dimensions originales de la couronne dans le cas de dents extrèmement usées par attrition. La valeur des corrélations obtenues pour des dents différentes suggère que certaines dents sont morphologiquement plus stables que d'autres.

INTRODUCTION

The presence of severe attrition, by which the major portion of the crown is removed, is a substantial handicap in studies that seek to examine the size of the unworn tooth in skeletal material. An investigation was carried out to establish the mathematical relationship between certain root and crown measurements in unworn human teeth, in the hope that valuable relationships could be established that would permit an accurate estimate of the previously present crown dimensions to be made from the remaining tooth substance.

MATERIAL AND METHODS

A collection of unworn human permanent teeth from the cities of Winnipeg and Saskatoon, Canada, was examined. The material was primarily of white Caucasian origin, although the presence of some North American Indian material could not be excluded. A total of 589 teeth were examined and there were between 45 and 50 teeth in each tooth group. The material was classified into tooth types individually by each author. Teeth of dubious classification were excluded. No distinction was made between left and right sides, nor was the sex of the material known. The 1st and 2nd molars in both upper and lower jaws were grouped together, as positive identification was not possible.

Measurements were made of maximum mesio-distal and bucco-lingual crown dimensions and mesio-distal and bucco-lingual cervical root dimensions on the root surface. In addition, the root length was measured along the buccal root face in all teeth except the molars (Fig. 1). Measurements were made using a vernier caliper calibrated to 1/20 mm. Each measurement was carried out by one observer on three separate occasions. The mean values were calculated and used in the study. The

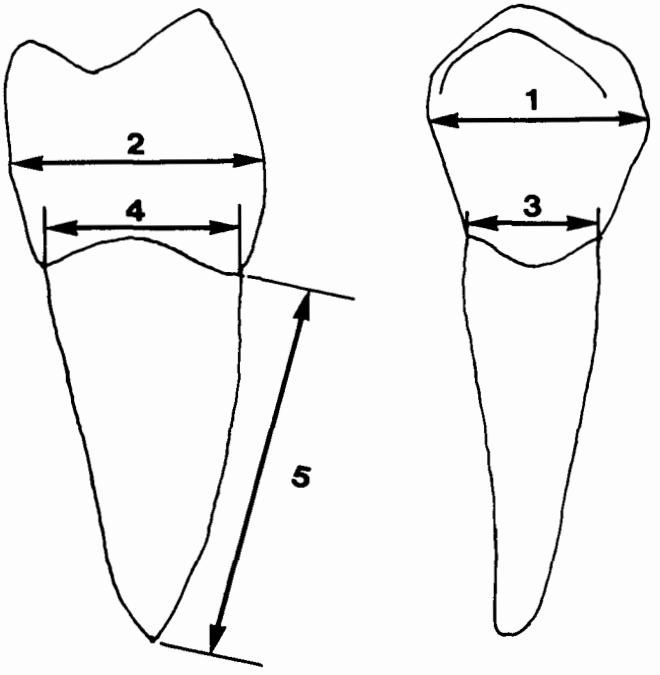


Fig. 1 Linear measurements as taken on an upper second premolar tooth (see Table 2). Two-rooted first premolars were also measured on their buccal root.

group mean values and standard deviations were calculated and a correlation matrix obtained with the use of a computer program. The mathematical significance of the correlations was then calculated. The primary purpose of the correlations was to identify associations best suited for establishing a prediction technique. The accuracy of prediction of a crown measurement from a root measurement was calculated for two of the best correlations obtained, using a curve fitting procedure. The correlations chosen were those between the mesio-distal crown measurements and mesio-distal cervical measurements of the upper canines and molars. (see Table 2). A series of curve fits was carried out by computer in which a least squares curve fit of the linear transformations was carried out. Using the index of determination a best curve was chosen for the data. Table 3 shows the curves chosen for upper molars and upper canines.

RESULTS

The means and standard deviations for each parameter of each tooth was calculated. Table 1 shows the values for the mesio-distal crown diameter of each group. Table 2 shows the linear correlation matrix for the four and five variables in each tooth group.

The relationship between two of the best correlations in the study was then examined. A test of the ability to estimate an unknown dimension, e.g., mesio-distal crown diameter from a known value such as mesio-distal cervical diameter, was then carried out. The actual values of each measurement for all the teeth were set out accompanied by the value predicted by the equation for the unknown crown dimension. The actual and predicted values were then compared and the percentage by which the predicted measure deviated from the actual one recorded for each set of measurements (each tooth). The range of variation of these percentage differences together with the mean value on both positive and negative sides of the actual values is shown in Table 3. If we consider the upper molars, we can say with certainty that the actual value of any prediction within the range of the teeth studied lies between −8.2% and +9.1% of the predicted value. One can of course substantially reduce that range by accepting an element of chance in the prediction. A range of variation of approximately 8.5% for a value of 10 mm is ±0.85 mm. This is a moderately large range of variation. The distribution of the data, however, showed that 60% of the material lay inside the mean limits of −2.41 and +2.87%. Thus, if one is willing to accept this level of probability, the range of variation is substantially smaller.

DISCUSSION

The highly significant correlations seen between many parameters in the tooth groups suggests a cohesive structural variation pattern in overall form. It is apparent (Table 2) that root length has the poorest relationship with any of the other measurements, in all the teeth. It is also apparent that within each tooth group, the level of correlation varies considerably, being highest in the canines and lowest in the second premolars. It appears that some teeth are more consistent in form than others and may prove more valuable for measurement studies related to variability. It is also interesting to observe that the correlations for the crown dimensions of upper and lower teeth in the

TABLE 1

Mesio-distal crown diameter (mm)

Upper	S.D.	0.62	0.52	0.52	0.45	0.47	0.78
	Mean	8.70	6.58	7.62	6.83	6.74	9.88
		1	2	3	4	5	6 & 7
Lower	Mean	5.61	6.09	6.87	6.99	7.06	11.31
	S.D.	0.33	0.39	0.39	0.34	0.43	0.67

TABLE 2

Correlation coefficients

Variables	Centrals	Laterals	Canines	1st Premolar	2nd Premolar	Molars	
MDCR/BLCR	0.69*	0.69*	0.86*	0.80*	0.79*	0.71*	Upper
	0.66	0.54*	0.76*	0.75*	0.80*	0.75*	Lower
MDCE/MDCR	0.65*	0.82*	0.87*	0.67*	0.34	0.90*	Upper
	0.68*	0.45*	0.81*	0.76*	0.33	0.71*	Lower
MDCE/BLCR	0.59*	0.59*	0.87*	0.77*	0.49	0.61*	Upper
	0.69*	0.43	0.86*	0.68	0.35	0.69*	Lower
BLCE/MDCR	0.60*	0.62*	0.75*	0.76*	0.47*	0.72*	Upper
	0.66*	0.39	0.77*	0.52*	0.50*	0.58	Lower
BLCE/BLCR	0.86*	0.86*	0.88*	0.84*	0.59*	0.61*	Upper
	0.92*	0.79*	0.98*	0.58*	0.63*	0.80*	Lower
BLCE/MDCE	0.59*	0.59*	0.82*	0.73*	0.35	0.65*	Upper
	0.75*	0.40	0.84*	0.36	0.31	0.79*	Lower
RL/MDCR	−0.03	0.11	0.59*	0.32	0.25	–	Upper
	0.61*	0.31	0.44	0.09	0.12	–	Lower
RL/BLCR	0.07	0.19	0.55*	0.43	0.28	–	Upper
	0.44	0.42	0.45	0.17	0.22	–	Lower
RL/MDCE	−0.02	0.11	0.59*	0.38	0.27	–	Upper
	0.33	0.22	0.52*	−0.01	−0.16	–	Lower
RL/BLCE	0.21	0.31	0.52*	0.47*	0.08	–	Upper
	0.45	0.41	0.48*	0.33	0.12	–	Lower

*$P < 0.001$; MDCR = mesio-distal crown diameter; BLCR = bucco-lingual crown diameter; MDCE = mesio-distal cervical diameter; BLCE = bucco-lingual cervical diameter; RL = root length (buccal face).

TABLE 3

The curves used and the relationship between predicted and actual data

Teeth	Correlation	Best Curve Type	Mean difference between calculated and actual values (%)		Range of Percentage Difference
			Negative Values	Positive Values	
Upper canines	0.87	$Y = A + B \log X$ ($A = -6.37$, $B = 5.85$)	−2.49	+2.38	−10.5 to +7.7
Upper first and second molars	0.90	$Y = \frac{1}{A + BX}$ ($A = 0.17$, $B = -0.01$)	−2.41	+2.87	− 8.2 to +9.1

same groups are surprisingly similar, with the exception of upper and lower lateral incisors. This may be a reflection of phylogenetic origins.

The fitting of curves to the data is, of course, a mathematical exercise designed for practical purposes and of limited biological significance. It does show, however, that it is possible to predict crown dimensions from cervical root measurements with some degree of accuracy. It is not, however, claimed that the mathematical expressions used here are necessarily the best or only method of estimation, nor should the data presented here be extrapolated beyond their mathematical limits. The results should, of course, be applied with caution to other material. It does seem, however, that further investigations, using more diverse large samples, would be worthwhile. Studies using multiple associations derived from measures on 'unrelated' teeth are probably of limited value. It may be more advantageous to examine complete dentitions as opposed to individual unrelated teeth. Interrelationships using multiple linear regression procedures could be established which would enhance estimative capability.

An accurate estimation technique would be valuable in anthropological studies seeking to examine crown size, in cases where attrition has removed the major part of the crown. This study suggests that such a technique can be developed.

ACKNOWLEDGEMENTS

The authors would like to thank Dr. F. Chebib and his staff, Biostatistics, College of Dentistry, University of Manitoba and Mr. Dennis Duncan of the College of Dentistry, University of Saskatchewan for their assistance with statistics.

L'Utilisation de l'Analyse de Variance Multiple en Anthropologie de la Santé [1]

F. FOREST et D. BERTHELETTE
Département d'Anthropologie, Université de Montreal, Montréal, P.Q. H3C 3J7

MOTS CLES Anthropologie Médicale • Ethno-psychiatrie • Niveau de Santé • Environnement Industrialisé

RESUME L'anthropologie médicale est un domaine qui tend de plus en plus à se développer. Des anthropologues se sont déjà penchés sur les problèmes relatifs à l'ethno-psychiatrie et à la morbidité comparée de différentes populations. Il semble cependant que les recherches anthropologiques considérant l'impact de l'environnement socio-culturel sur les maladies physiques et psychiques soient limitées en nombre. Ce fait est d'autant plus frappant en ce qui concerne l'étude des sociétés industrialisées. Nous nous proposons donc, dans cet article, de présenter une méthode statistique permettant d'analyser l'influence de plusieurs facteurs environnementaux sur la variation des niveaux de santé d'une population de travailleurs.

ABSTRACT Medical anthropology is emerging as a major subfield within the discipline of anthropology. Already important contributions have been made in ethno-psychiatry and the comparative study of morbidity in various populations. Nonetheless, there is a derth of studies dealing with how specific sociocultural environmental factors influence physical and mental disease patterns-especially in modern industrialised societies. In order to promote and facilitate research activities in this area, we present a statistical method capable of analysing the influence of an array of environmental variables on health standards in an industrialised setting.

INTRODUCTION

La variabilité humaine demeure l'intérêt fondamental de l'anthropologue physique. Ce phénomène soulève des questions primordiales quant à l'effet des conditions environnementales sur la variation phénotypique. De plus en plus de chercheurs concernés par cette problématique, désirent s'impliquer dans leur milieu en identifiant les causes de variation, afin d'améliorer la qualité de vie.

La santé est certes le lieu privilégié des intéractions entre la biologie et le milieu. L'identification des facteurs de risque, dans une population, peut nous permettre de les diminuer. L'environnement est toutefois constitué d'un ensemble de variables matérielles, psychologiques et culturelles qui interagissent selon des modèles complexes. Le chercheur doit donc se doter d'un minimum d'outils statistiques afin de faciliter ses recherches et d'engager le dialogue avec d'autres disciplines.

Le but de cet article est de présenter un modèle statistique utilisé afin d'analyser la variation d'indices morphologiques et physiopathologiques en fonction de nombreuses sources de variations environnementales différentes.

[1] La méthode statistique dècrite dans cet article a été adaptée et opérationnalisée pour des fins de recherches en anthropologie, par M. F. Forest. Le présent texte, rédigé par Mme. D. Berthelette, fait suite à une communication qu'elle a présentée à l'occasion du septième congrès de l'Association pour l'Anthropologie Physique au Canada, Ste.-Adèle, Québec, 1979.

Cette étude s'inscrit à l'intérieur d'un projet de recherches portant sur la variation des niveaux de santé d'une population de 3000 travailleurs québécois. Le lecteur pourra se référer à des articles déjà parus (Bastarache et al., '78; Auger et al., '79), afin de prendre note des méthodes relatives au recueil des données et à la mise au point des indices morphologiques et physio-pathologiques.

METHODE

Notre modèle comporte 39 critères de classification subdivisés en 12 groupes (tableau 1). Ces variables ont été considérées simultanément dans une analyse de variance multiple basée sur la régression multiple (Overall et Klett, '72). Cette méthode statistique possède l'avantage d'être plus fidèle à la réalité qui veut qu'une cause n'agisse pratiquement jamais seule. Il est en effet important de tenir compte des corrélations existant entre les critères, afin de ne pas mésestimer leurs effets.

Ceci peut être assuré par le calcul de résultats ajustés représentant l'effect réel d'un critère, comme s'il n'était aucunement corrélé aux autres critères présents dans le modèle. Ces résultats sont d'autant plus représentatifs de la réalité, que le nombre total de critères significatifs est élevé.

La première étape de cette méthode consiste à construire une matrice de prédicats contenant l'information relative à la dispersion des sujets à l'intérieur des différents niveaux des critères. Chacun des critères y est représenté par une quantité de pseudo-variables égale à la somme du nombre de ses niveaux, moins un. Ainsi, la profession possède cinq catégories et les quatre premières servent de pseudo-variables.

Dans la matrice, la valeur +1, assignée à une pseudo-variable d'un vecteur, signifie que le sujet considéré appartient à cette catégorie; la valeur zéro est alors donnée aux autres prédicats. On attribue la valeur -1 à toutes les pseudo-variables d'un vecteur, lorsque le sujet considéré se situe dans le dernier niveau du critère, absent de la matrice.

Il est possible d'inclure les effets d'intéraction dans le modèle. Nous préférons cependant les délaisser au profit d'autres effets principaux, l'espace en mémoire centrale étant limité.

Les pseudo-variables x, au nombre de p, font par la suite l'objet du calcul de leur matrice de corrélation et de l'inverse de celle-ci (R^{-1}). On établit enfin les corrélations entre la variable dépendante y, et chacune des pseudo-variables x, pour obtenir un vecteur ν.

A partir de ces deux renseignements, R^{-1} et ν, nous procédons au calcul du vecteur des coefficients β, de même qu'à celui du coefficient de régression multiple R^2_T.

$$\beta = R^{-1}\,\nu$$
$$R^2_T = \nu'\,\beta$$

Le R^2_T représente la proportion de la variabilité totale de la variable dépendante y, qui est expliquée par sa régression sur les pseudo-variables représentant l'ensemble des critères de classification et leurs niveaux. On peut vérifier

TABLEAU 1

Critères de classification

Groupes et Critères	Niveau 1	Niveau 2	Niveau 3	Niveau 4	Niveau 5
A–Stratification socio-professionelle					
1– Profession	manuel non spécialisé	manuel spécialisé	contremaître	employé de bureau	cadres
2– Scolarité (cours)	primaire	secondaire	technique	collégial	universitaire
3– Employés à charge	aucun	manuels	de bureau		
B–Socio-démographie					
1– Age	20-29	30-39	40-49	50-59	60 et plus
2– Etat civil	célibataire	marié	séparé	veuf	
3– Nombre d'enfants	aucun	1 à 3	4 à 6	7 et plus	

C– Famille d'origine				
1– Taille de la fratrie	nulle	1 à 3	4 à 6	7 et plus
2– Rang de naissance	premier	2e à 4e	5e à 7e	8e et plus
D–Habitation				
1– Propriétaire	oui	non		
2– Nombre de pièces	3 ou moins	4 à 5	6 et plus	
3– Autres personnes vivant à la maison	aucune	parents	amis	chambreurs
E– Travail				
1– Même travail depuis	moins d'un an	1 à 10 ans	plus de 10	
2– Nombre d'emplois	plus d'un	un seul		
3– Degré d'activité au travail	nul	modéré	important	
F– Facteurs psychologiques liés au travail				
1– Absence d'intérêt au travail	nullement	légèrement	modérément	pleinement
2– Sous-utilisation des capacités	nullement	légèrement	modérément	pleinement
3– Travail trop dur physiquement	nullement	légèrement	modérément	pleinement
4– Manque d'autonomie	nullement	légèrement	modérément	pleinement
G–Facteurs psychologiques extrinsèques				
1– Tension développée au travail	nulle	légère	modérée	importante
2– Mauvais climat de travail	nullement	légèrement	modérément	pleinement
3– Absence de possibilités de promotion	nullement	légèrement	modérément	pleinement
4– Trop de pressions au travail	nullement	légèrement	modérément	pleinement
5– Absence de reconnaissance	nullement	légèrement	modérément	pleinement
6– Difficultés avec les supérieurs	nulles	modérées	importantes	
H–Fateurs psychologiques extrinsèques liés a l'aspect rémunération				
1– Salaire insuffisant	nullement	légèrement	modérément	pleinement
2– Manque de sécurité d'emploi	nullement	légèrement	modérément	pleinement
I– Anomie				
1– Anomie 1	nulle	modérée	importante	
2– Anomie 2	nulle	modérée	importante	
J– Antécédents héréditaires				
1– Cancer	présence	absence		
2– Maladies cardio-vasculaires	présence	absence		
3– Maladies du système nerveux	présence	absence		
4– Obésité	présence	absence		
K–Habitudes de vie				
1– Degré d'activité physique hors travail	nul	modéré	important	
2– Utilisation de médicaments	nulle	modérée	importante	
3– Nombre de cigarettes par jour	aucunes	1 à 15	16 à 25	25 et plus
4– Quantité d'onces d'alcool par mois	moins de 3	4 à 15	16 et plus	
L– Diète				
1– Quantité de lipides	faible	moyenne	forte	
2– Quantité de glucides	faible	moyenne	forte	
3– Quantité de fruits et légumes	faible	moyenne	forte	

la non équivalence à zéro de la valeur R^2_T par le test de signification de régression suivant, n étant le nombre total de sujets:

$$F = \frac{R^2_T\,(n\text{-}p\text{-}1)}{(1\text{-}R^2_T)\,p} < F\,(1\text{-}\alpha\,;p;n\text{-}p\text{-}1)$$

Les coefficients β_i au nombre de p, doivent par la suite être transformés en valeurs b_i, afin de permettre le calcul des moyennes ajustées de nos critères. L'équation suivante doit être utilisée:

$$b_i = \beta_i\, Sy/Sx_i$$

i, variant de 1 à p, Sy représentant l'écart-type de la variable dépendante y et Sx_i, l'écart-type du prédicat x_i.

Les coefficients b_i sont d'abord utilisés pour calculer le moyenne générale ajustée, qui correspond à la valeur K dans l'équation de régression multiple et qui sera la référence à partir de laquelle toutes les déviations seront évaluées:

$$K = \overline{Y} - (b_1\overline{X}_1 + b_2\overline{X}_2 + \ldots\ldots\ldots b_p\overline{X}_p)$$

Dans cette expression, $\overline{Y}$ est la moyenne empirique de la variable dépendante et les différentes moyennes $\overline{X}_i$, sont les moyennes des pseudo-variables.

Le calcul des diverses moyennes ajustées des niveaux des critères se fait en utilisant les coefficients de régressions multiples b_i:

$$\overline{Y}_i = K + b_i$$

Cependant, à cause de l'abandon, dans la matrice des pseudo-variables, d'un niveau par critère, il y aura au moins autant de coefficients b_i qui manqueront, qu'il y a de critères. Pour chacun de ces derniers, la déviation b_i manquante, peut être calculée en sachant que la somme des déviations ajustées b_i de tous les niveaux d'un critère est égale à zéro:

$$\text{Pour tout critère: } \Sigma\, b_i = 0$$

Dès lors, pour le critère "A", par exemple, qui comporterait 5 niveaux différents, le vecteur *b* comporterait les b_i correspondant aux déviations des quatre premiers de ces niveaux. Le dernier, absent du vecteur *b*, peut être calculé en sachant que la somme de ces cinq déviations est égale à zéro.

Dans un deuxième temps, nous devons procéder au calcul d'un R^2 brut et ajusté pour chacun des critères. Ceci nous permet de partitionner la somme des carrés d'écarts inter-groupe en ses componsantes d'effets principaux et d'effets d'intéraction. Nous identifions ainsi les impacts respectifs de chacun des critères sur la variabilité de la variable dépendante.

Le coefficient de régression du critère "A", par exemple, est calculé à partir d'un modèle qui ne contient pas les pseudo-variables de ce critère "A". On obtient donc un nouveau R^2 total excluant le critère "A" dont nous désirons connaître l'effet, et qui sera noté R^2_{-A}. La méthode de partition de la somme des carrés d'écarts inter-groupe que nous utilisons, ajuste chaque effet principal aux autres effets principaux du modèle.

Le R^2 correspondant à l'effet ajusté du critère "A", noté R^2_A, sera calculé de la façon suivante:

$$R^2_A = R^2_T - R^2_{-A}$$

et cet effet ajusté du critère "A" pourra être éprouvé selon la procédure habituelle:

$$F = \frac{R^2_A\,(n\text{-}p\text{-}1)}{(1\text{-}R^2_T)\,(a\text{-}1)} < F\,(1\text{-}\alpha\,;a\text{-}1\,;n\text{-}p\text{-}1)$$

dans laquelle a correspond au nombre de niveaux du critère "A".

Toutefois, lorsque plusieurs critères de classification sont très fortement corrélés entre eux, une telle procédure peut correspondre à une sous-évaluation certaine de l'effet de chacun d'eux. Le regroupement de ces critères et le calcul de coefficients de régression ajustés, pour chacun des groupes peut remédier à ce problème. Lorsque des critères fortement corrélés, ont approximativement le même effet sur la variable dépendante, dans le même sens et avec la même amplitude, la probabilité ajustée de chacun d'eux est généralement assez faible, alors que leur probabilité de groupe, ajustée à tous les autres critères, est beaucoup plus importante. Ainsi, au niveau de l'interprétation des résultats nous pouvons supposer que la variable dépendante puisse être liée à des phénomènes dont les critères du groupe sont les reflets, bien qu'ils n'aient pas d'effet ajusté significatif lorsqu'ils sont considérés isolément, à cause de la présence des autres critères du même groupe. Le R^2 d'un groupe est calculè de la façon suivante:

$$R^2_G = R^2_T - R^2_{-G}$$

Il s'agit dans un premier temps, de calculer un R^2 ne contenant aucune des pseudo-variables des critères du groupe (R^2_{-G}) et de soustraire ce R^2_{-G} du R^2_T. La contribution d'un groupe à la régression sur la variable dépendante est ensuite éprouvée par les test de F suivant:

$$F = \frac{R^2_G\,(n\text{-}p\text{-}1)}{(1\text{-}R^2_T)\,g} < F\,(1\text{-}\alpha;G;n\text{-}p\text{-}1)$$

la lettre g représentant la somme du nombre de pseudo-variables des critères faisant partie du groupe.

Afin de faciliter l'interprétation des résultats découlant de ces diverses opérations mathématiques, nous utilisons des procédés graphiques que nous nous devons d'expliquer quelque peu. Les résultats qui sont présentés à titre d'exemples dans cet article, concernent les trois variables suivantes: pourcentage de tissus adipeux, tension diastolique, symptômes neurologiques.

Chaque diagramme peut être interprété comme suit: sur l'échelle de droite sont notées les valeurs centrales de 15 classes de résultats de la variable dépendante, en unités normalisées ($\overline{Y} = 100$, $Sy = 20$). La classe "114" contient aussi toutes les valeurs qui lui sont supérieures et la classe "86", toutes les valeurs inférieures. Ces classes ont une étendue de 0.1 écart-type. L'échelle de gauche rapporte les mêmes valeurs centrales de classes, mais dans les unités originales de la variable dépendante. L'avant-dernière ligne du bas indique les différents niveaux du critère, alors que la dernière ligne identifie le critère, donne le rang d'importance obtenu par sa probabilité ajustée et rapporte les probabilités brutes et ajustées ($P(1-\alpha)$).

Les lettres apparaissant dans le tableau ainsi délimité, indiquent les valeurs des moyennes brutes (B) et des moyennes ajustées (A) de chacun des niveaux du critère. La présence d'un C signifie que la moyenne brute de ce niveau est dans la même classe que sa moyenne ajustée. Les différentes moyennes ajustées sont reliées par un trait continu et représentent l'effet ajusté du critère aux autres critères présents dans le modèle. Les moyennes brutes jointes par des traits en pointillés, ne représentent que l'effet apparent du critère.

Les variables dépendantes que nous avons analysées sont de trois types. Dans un premier temps, nous avons étudié la variation de variables anthropométriques. Il est en effet important de préciser la morphologie des individus qui composent notre population, car cet aspect est fortement lié à plusieurs tests physiologiques. Ainsi, le pourcentage de tissus adipeux, indice d'obésité, a des effets sur la morbidité de plusieurs pathologies et notamment sur les maladies cardio-vasculaires.

RESULTATS

La moyenne générale de pourcentage de tissus adipeux est de 18.34%, dans notre population, l'écart-type est de 6.50%. L'ensemble de nos critères de classification réussit à expliquer 15.91% de la variation totale de cette variable.

La stratification socio-professionnelle explique 0.54% de la variation, mais de façon non significative, la probabilité étant égale à 0.871. La profession, premier critère de ce groupe, possède un R^2 brut de 0.42% et les différences apparentes entre les moyennes de ses cinq niveaux sont significatives. On note cependant que les écarts entre les moyennes brutes disparaissent lorsque les calculs sont faits de façon ajustée, le R^2 étant alors égal à 0.12%, avec une probabilité de 0.483. Ceci nous indique donc que le critère serait fortement corrélé à un autre critère ayant un impact sur la variation du pourcentage de tissus adipeux.

La scolarité demeure le seul critère de ce groupe qui présente des différences significatives entre les moyennes ajustées ($P = .950$). L'âge (fig. 1) est le critère dont la probabilité ajustée est la plus élevée. On peut toutefois remarquer que les moyennes brutes dont le R^2 est égal à 9.13%, ont tendance à surestimer l'importance de l'effet du critère sur la variation de notre variable dépendante. De façon ajustée, l'âge explique 2.55% de sa variation.

On observe des différences significatives entre les moyennes des niveaux du critère concernant la présence (niveau 1) et l'absence (niveau 2) de personnes souffrant ou ayant souffert d'obésité dans la famille du sujet. Les résultats bruts possèdent un R^2 de 1.45% alors que les résultats ajustés expliquent 2.18% de la variation. On note une tendance selon laquelle le pourcentage de tissus adipeux serait plus élevé chez les individus du premier groupe.

La consommation de cigarettes est responsable de 1.65% de la variation de notre variable dépendante, et ce de façon significative, en ce

qui a trait aux résultats ajustés. La relation entre les niveaux du critère et la variable dépendante semble être curviligne. On peut observer de ce fait, que les non-fumeurs et les fumeurs de plus de 25 cigarettes par jour semblent avoir des résultats plus élevés que les fumeurs de 1 à 15 et de 16 à 25 cigarettes par jour.

Enfin, le degré d'activité physique, dont le R^2 ajusté est de 0.24%, serait en relation inverse avec le pourcentage de tissus adipeux. On observe en effet (fig. 1), une diminution des résultats liée à l'augmentation du degré d'activité physique et ce de façon significative.

La deuxième série de variables dépendantes qui a été analysée, porte sur les résultats relatifs aux divers tests physiologiques. Ceux-ci sont des indicateurs importants quant à l'état de santé de notre population.

L'une de ces variables, la tension diastolique, obtient une moyenne générale de 81.44 mm.Hg. et un écart-type de 12.08. Notre modèle parvient à expliquer 18.76% de sa variation. La stratification socio-professionnelle possède un R^2 de 0.95% et les différences observées sont significatives, $P(1-\alpha)$ atteignant le seuil de 0.999. On observe des différences significatives entre les professions, ce critère expliquant, de façon ajustée, 0.36% de la variation. D'après le graphique, les manuels spécialisés de notre population possèdent les résultats les plus élevés, alors que les contremaîtres se situent dans la classe de résultats la plus faible. Les trois autres catégories professionnelles ont des résultats comparables.

Le degré de responsabilité au travail, explique 0.27% de la variation et on observe des différences significatives entre les moyennes ($P > 0.999\ldots$); ce même critère présente des différences significatives tant au niveau des moyennes brutes qu'ajustées. On note cependant que les résultats bruts ($R^2 = 11.69\%$) ont tendance à surévaluer l'importance de l'effet de ce critère par rapport aux résultats ajustés qui n'expliquent plus que 3.51% de la variation. Les deux courbes (fig. 2) nous indiquent que la tension diastolique tend à augmenter de 20 à 59 ans, pour ensuite diminuer légèrement chez les individus plus âgés.

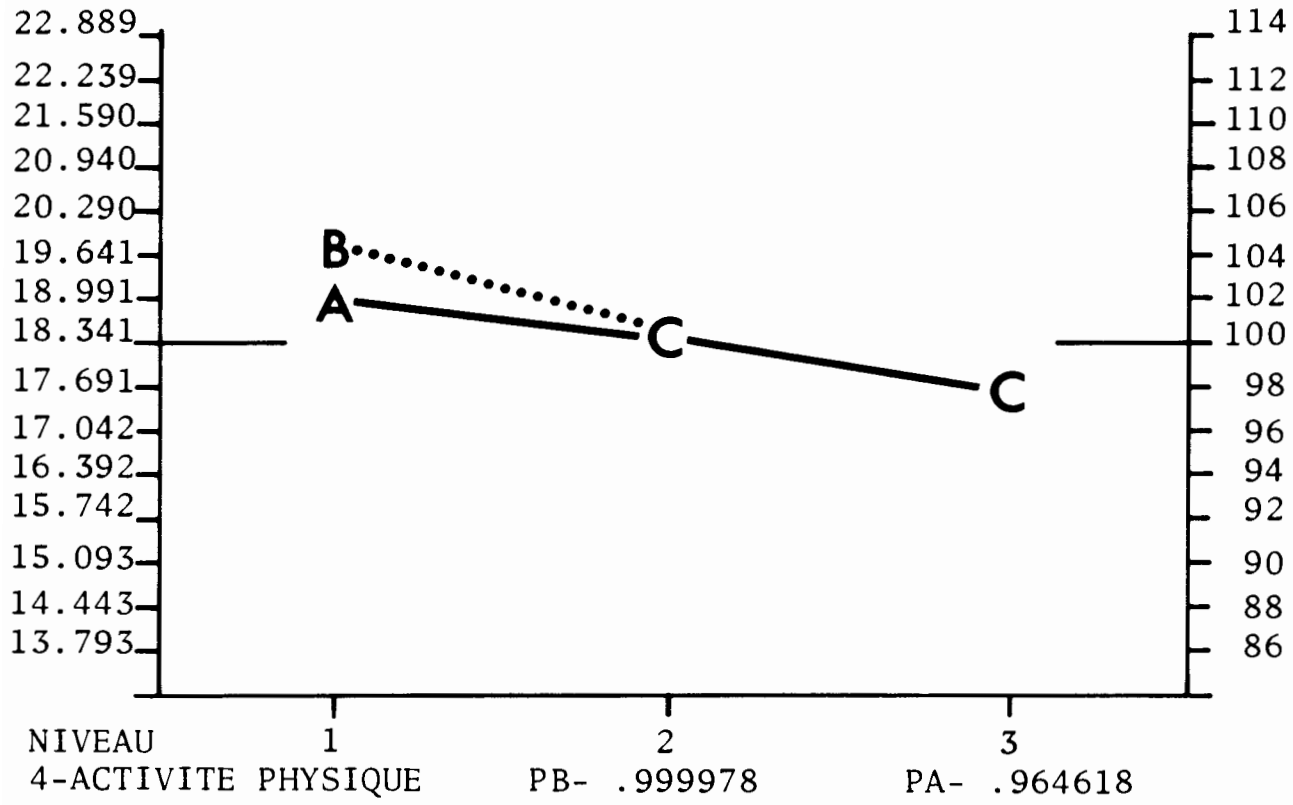


Fig. 1 Variation du pourcentage de tissus adipeux en fonction du degré d'activité physique.

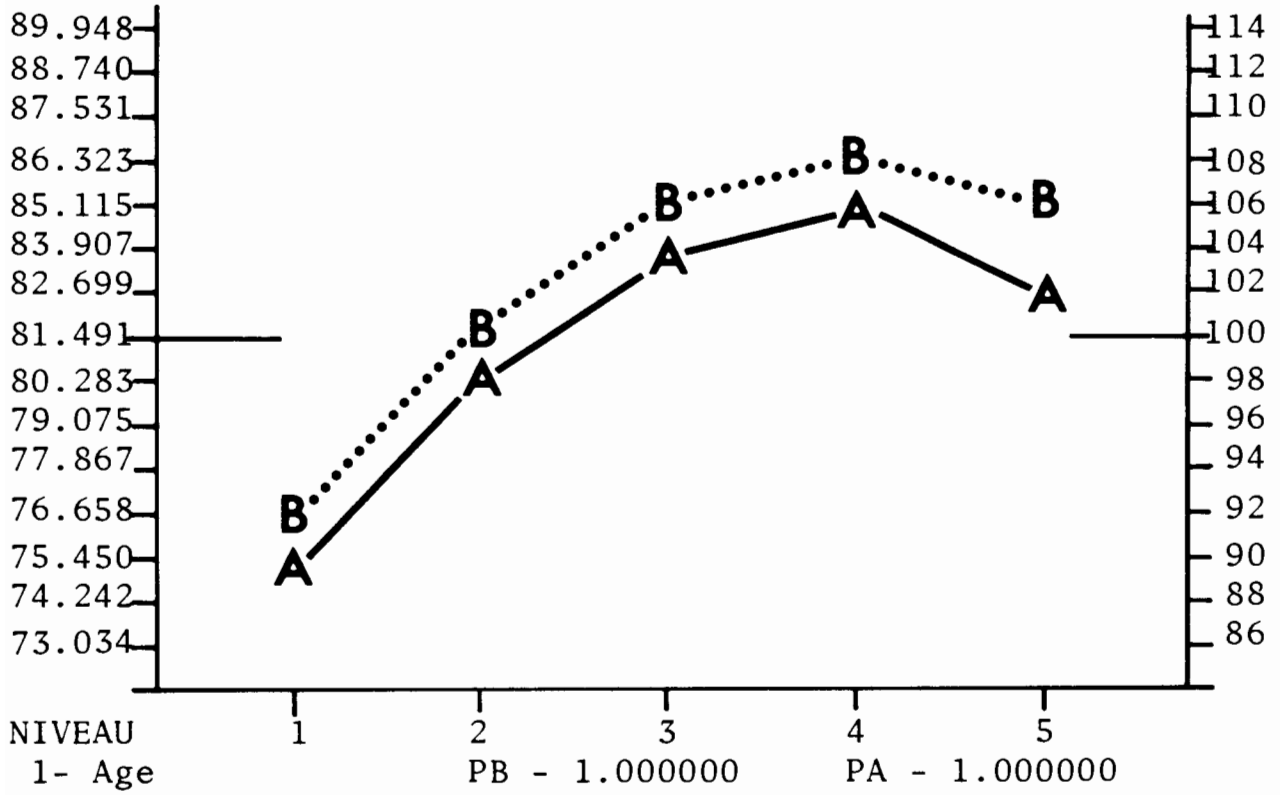


Fig. 2 Variation de la tension diastoloque en fonction de l'âge.

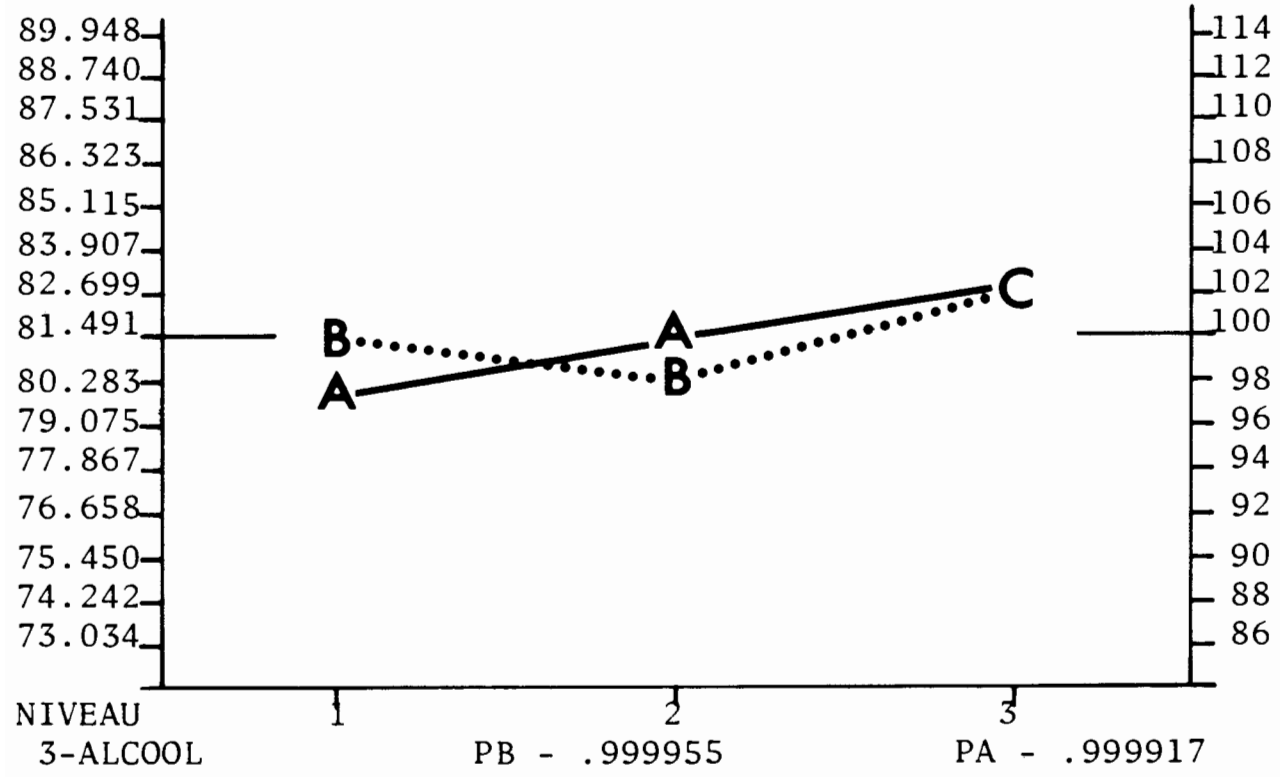


Fig. 3 Variation de la tension diastoloque en fonction de la consommation d'alcool.

Le nombre de cigarettes fumées par jour est un critère possédant des R^2 brut et ajusté de 1.19%. On observe des différences significatives entre les moyennes des quatre niveaux.

La quantité d'alcool consommé par mois, possèderait un effet posifit sur l'augmentation de la tension diastolique. Ce critère est responsable de 0.63% de la variation de la variable dépendante (fig. 3). On note enfin, une tension diastolique possédant une tendance à augmenter chez les individus ayant des antécédents héréditaires en ce qui a trait à l'obésité. Ce dernier critère parvient à expliquer, de façon ajustée, 0.31% de la variation.

La dernière catégorie de variables dépendantes analysées concerne des symptômes rattachés à des systèmes particuliers. Les symptômes du système neurologique par exemple, ont été calculés à partir de nombreuses réponses aux questions obtenues dans un questionnaire pré-examen médical. C'est en fonction de la relation entre chacun de ces symptômes et de la cote d'appréciation attribuée par un médecin à l'ensemble du système, que chaque symptôme a pu être pondéré. L'indicateur global du système neurologique représente le cumul de ces diverses pondérations. La moyenne des résultats obtenus dans notre population est de 11.54 et l'ecart-type, de 1.63.

La stratification socio-professionnelle explique de façon significative ($P > 0.999\ldots$) 0.94% de la variation de la variable concernant les symptômes neurologiques. La scolarité et le degré de responsabilité au travail, ont respectivement, des R^2 ajustés de 0.52% et de 0.15%. Les différences entre les moyennes sont significatives. Il n'en est pas de même pour la profession.

L'utilisation de médicaments détient la probabilité ajustée la plus élevée ($P > 0.999\ldots$) et explique 2.29% de la variation (fig. 4). On peut observer qu'une tendance à l'augmentation des symptômes neurologiques serait liée à l'accroissement de l'utilisation de médicaments.

De même, les individus tendus au travail présentent des résultats plutôt défavorables en ce qui a trait aux symptômes considérés ici. Ce deuxième critère nous permet d'expliquer 0.90% de la variation et ce, de façon significative (fig. 5). Les antécédents héréditaires relatifs au système nerveux sont responsables de 0.58% de la variation. On note également une tendance à l'augmentation des symptômes neurologiques chez les individus dont les parents souffrent ou ont souffert de ces symptômes.

Enfin, un indice d'anomie explique 0.62% de la variation. Les différences entre les moyennes sont significatives et on observe une prépondérance des symptômes neurologiques chez les sujets dont l'anomie est importante.

CONCLUSION

Les résultats qui ont été présentés à titre d'exemple, démontrent bien l'importance de l'impact des facteurs environnementaux sur la variation des niveaux de santé. Une cinquantaine d'autres variables physiologiques ont été analysées selon le technique préconisée ici et feront l'objet de publications dans un futur rapproché.

Cette methode tire son importance du fait qu'elle nous permette de différencier les effets bruts ou apparents d'un critère, de ses effets réels ou ajustés. Ces derniers, étant plus représentatifs des relations existant entre l'environnement et l'incidence des maladies, pourront par la suite être la source de campagnes d'intervention dans le milieu et favoriser ainsi l'amélioration de la qualité de vie de notre population.

OUVRAGES CONSULTES

Auger, F., F. Forest and E. Bastarache 1979 An anthropological project on French Canadian workers: a progress report. Can. Rev. Phys. Anthrop. *1*:5-9.

Bastarache, E., F. Auger, F. Forest et R. Bastarache 1978 Utilisation d'un questionnaire pré-examen médical auprès d'une population de travailleurs québécois. L'Union Médicale du Canada *107*:1-12.

Overall, J. E. and J. C. Klett (eds.) 1972 Applied Multivariate Analyses. McGraw-Hill, New York.

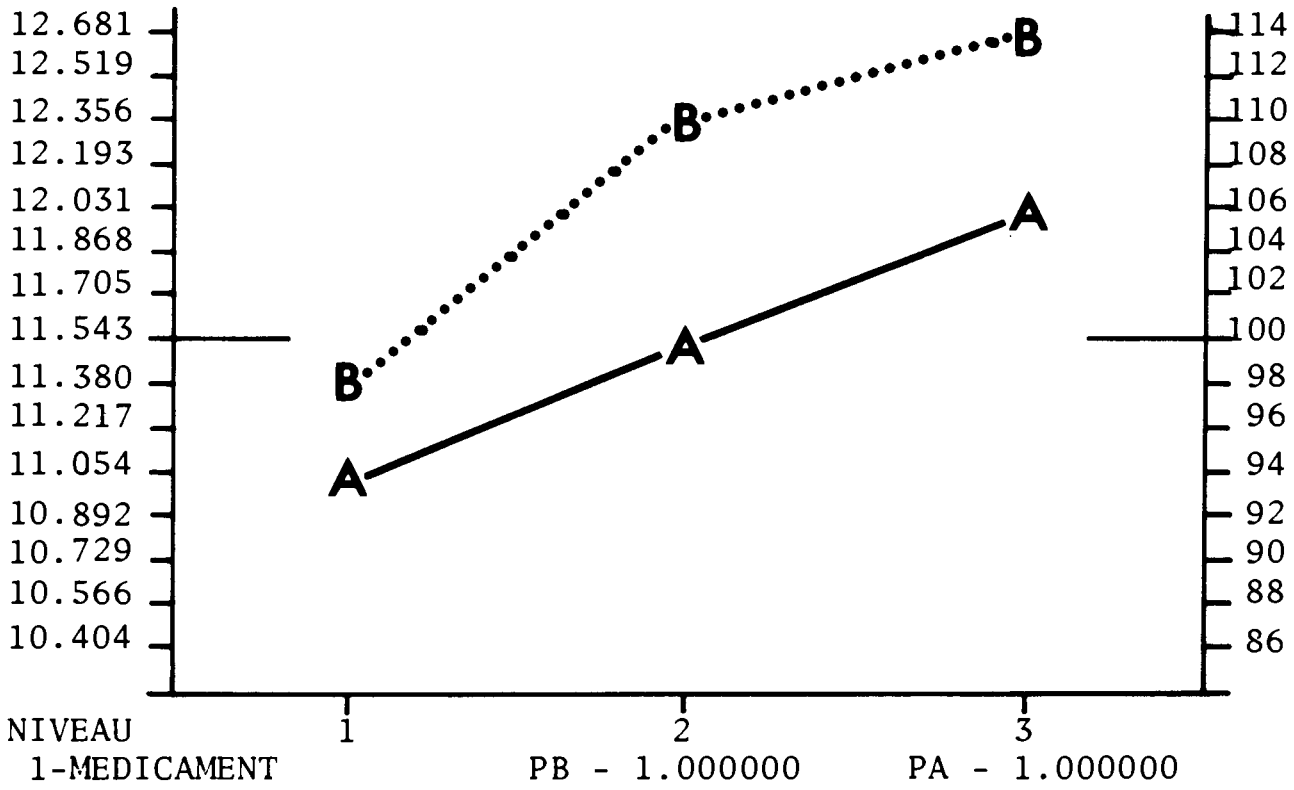


Fig. 4 Variation des symptômes neurologiques en fonction de l'utilisation de médicaments.

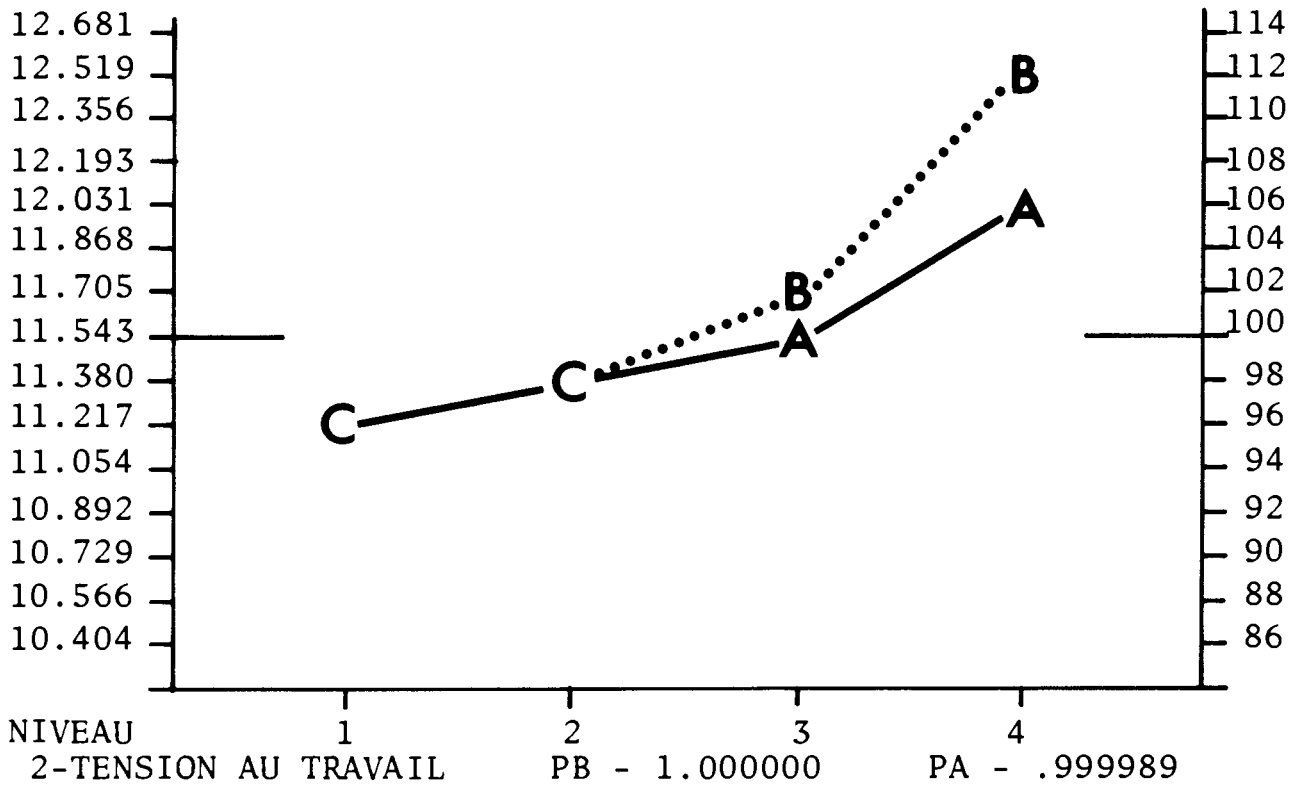


Fig. 5 Variation des symptômes neurologiques en fonction de la tension au travail.

Différences entre les Sexes et Latéralisation au Niveau de Performances Manuelles [1]

YVON DESJARDINS
Département d'Anthropologie, Université de Montréal, Montréal, P.Q. H3C 3J7

MOTS CLES Différences Sexuelles • Latéralité
Tests Moteurs • Performance Manuelle

RESUME Les différences entre sexes et la latéralisation ne sont pas des questions nouvelles, si l'on tient compte des idéologies qui entourent ces questions. Nous avons cherché dans un petit échantillion d'étudiants sous-gradués si nous pouvions répondre à ces questions. Nous avons trouvé qu'effectivement il y avait des différences entre les sexes au niveau de trois tests manuels et que l'hypothèse de latéralité ne s'applique qu'à l'un d'entre eux. Nous suggérons en fonction de nos résultats qu'il existe des différences entre les sexes au niveau des performances manuelles de certains tests moteurs. Ces différences ne seraient que partiellement dues à des facteurs morphologiques. Pour un de nos tests, le test de l'alphabet écrit, les sujets féminins de notre échantillon sont plus latéralisés que les sujets masculins.

ABSTRACT Sex differences and laterality are not new questions, inasmuch as the research upon these questions are fulfilling new designs. We have surveyed a small sample of undergraduate students to see if we could answer them. We have found that there are sex differences in three manual tests and that the laterality hypothesis applied only to one of them, the written alphabet. We suggest, in view of our results, that there is a sex difference in terms of manual performance on certain motor tasks due in part to morphological factors and that, for one of the tests, the females in our sample are more lateralized than the males.

INTRODUCTION

L'hypothèse de latéralité de même que celle de différence entre les sexes ne sont pas nouvelles (Garai et Scheinfeld, '68). Depuis longtemps, les chercheurs se sont penchés sur ces questions. La latéralisation peut être définie comme une asymétrie fonctionnelle que l'on retrouve dans les segments corporels de manière prévalente, sans pour autant exclure le rôle complémentaire des segments contra-latéraux (Azémar, '75). Cette asymétrie bilatérale couvre l'ensemble du corps humain (Levy et Levy, '78). Nous nous sommes cependant limité à une région du corps: les mains. C'est dans cette optique que nous avons organisé une recherche ayant pour but l'étude des différences entre les sexes en terme de performances manuelles.

Il va de soi que l'étude de ces performances serait incomplète si on se limitait à la seule main prédominante, puisque l'hypothèse de latéralité implique un rapport différentiel entre les deux mains. L'analyse portera sur les performances tant de la main droite que de la main gauche ainsi que sur leurs différences. Nous sommes en présence, effectivement, de deux questions dans cette recherche. Premièrement, existe-t-il des différences entre les sexes au niveau des performances manuelles?, ce qui est

[1] Le présent texte fait suite à une version présentée au septième congrès de l'Association pour l'Anthropologie Physique au Canada, Ste.-Adèle, Québec, 1979.

notre première question. La deuxième s'énonce en deux volets. Existe-t-il une latéralisation effective chez les individus, c'est-à-dire une différence systématique entre le coté gauche et le coté droit de leur corps? Si oui, pouvons-nous dire que cette différence est dissemblable chez les deux sexes?

L'argument de départ de notre étude, pour les deux questions en cause, est qu'il n'existe pas de différence entre les sexes. Ce choix comme point de départ n'en est pas un de facilité, mais plutôt d'ouverture d'esprit et d'objectivité (Maccoby et Jacklin, '74).

METHODE

L'échantillon de 122 sujets sur lequel porte notre étude est constitué en très grande majorité d'étudiants sous-gradués du département d'Anthropologie de l'Université de Montréal. L'âge moyen des sujets, tant féminins que mansulines, est de 23 ans. Mentionnons que l'échantillon est particulièrement homogène, tant par la provenance des individus que par leur situation présente. Les sujets ont subi trois épreuves: le test de frappe, le test de l'alphabet écrit et la dynamométrie. Les deux premiers tests mesurent grosso-modo la motricité et l'habileté manuelle. Bien que le test de l'alphabet écrit soit plus élaboré que le test de frappe, il fait aussi appel à la rapidité du mouvement des mains. Le dernier test, la dynamométrie, mesure la force musculaire.

Le choix de ces tests est tout désigné par notre problématique. Nous recherchions – en tout premier lieu – les différences au niveau des performances manuelles et, en second lieu, nous cherchions une différence, un biais systématique entre la main droite et la main gauche, ce qui est en fait une des définitions de la latéralité. Ce n'est peut-être pas le meilleur indicateur de latéralité (Colbourn, '78); mais notre indicateur, c'est-à-dire les performances de la main droite "moins" les performances de la main gauche, nous offre la possibilité d'apprécier à un degré réel la latéralité dite fonctionnelle.

Nous avons deux types de variables opératoires: les performances de la main gauche et puis celles de la main droite pour lesquelles nous tenterons de voir s'il y a des différences entre les sexes, et les différences de performances entre celles-ci afin de tester l'hypothèse de latéralité différentielles entre les sexes. Ajoutons toutefois que, pour la latéralisation, chacune des épreuves n'aura pas la même signification ni le même mécanisme de base (Maccoby et Jacklin, '74; Fairweather et Hutt, '72; Buffery et Gray, '72).

Description des épreuves

Le test de frappe est simple (Provins et Cunliffe, '72). Il s'agit pour le sujet de frapper sur une clé le plus grand nombre de coups possible pour une période totale de 30 secondes, alternativement de la main droite et de la main gauche; ces coups sont enregistrés sur un compteur par période de 10 secondes. Une pratique est allouée aux sujets. Il est peu probable que les sujets aient eu la possibilité de pratiquer souvent ce type d'activité (Provins et Cunliffe, '72). Le test de l'alphabet écrit consiste, pour le sujet, à écrire l'alphabet en lettres détachées le plus rapidement possible. L'épreuve est répétée quatre fois, d'une main et de l'autre alternativement. Les temps d'exécution sont pris à l'aide d'un chronomètre, à la fin de chaque alphabet complété; un temps d'arrêt suit. Aucune pratique n'est allouée pour cette épreuve, l'écriture étant une activité qui sûrement est celle la plus pratiquée par le main prédominante (Provins et Cunliffe, '72). Pour la dynamométrie, il est demandé au sujet d'appliquer la plus grande traction possible avec sa main sur l'appareil de mesure (Preston hand-dynamometer). Le meilleur de deux essais de la main droite et de la main gauche sont retenus pour l'analyse.

Méthodes statistiques

Pour d'analyse de données recueillies, nous avons utilisé trois méthodes statistiques: l'analyse de variance simple, l'analyse de covariance simple (Snedecor et Cochran, 1967) et l'analyse de variance par régression multiple ou l'analyse de variance multiple (Overall et Klett, 1973).

RESULTATS

La majorité des individus sont droitiers et ce, dans une proportion de 85%. Le reste de l'échantillon se partage entre gauchers et ambidextres, respectivement 8% et 7% de l'échantillon total.

On retrouve dans notre échantillon une distribution de préférence manuelle (le fait de se servir le plus souvent de la main droite ou encore de la main gauche, ou encore également des deux mains) semblable à celle que l'on retrouve dans les autres populations humaines (Annett, 1972).

Test de frappe

Les performances des sujets, pour le test de frappe, ont été standardisées en nombre de frappe par seconde. L'analyse de covariance (fig. 1 et 2) nous montre des moyennes très différentes en fonction du sexe. Les sujets masculins frappent en moyenne 6,1 coups par seconde de la main gauche et 6,8 de la droite, tandis que les sujets féminins frappent moins de coups par seconde: 5,7 coups de la main gauche et 6,3 de la droite. Ces résultats représentent les moyennes des trois périodes prises ensemble et non séparément. Les moyennes de la différence entre la main droite et la main gauche, indicateur de latéralité, diffèrent peu; 0,61 coups de différence pour les sujets féminins et 0,70 pour les sujets masculins (fig. 3). Il peut donc exister une différence appréciable entre les mains chez les deux groupes, si l'on tient compte de l'ordre de grandeur de la variable en cause.

L'estimation par la période de temps, c'est-à-dire la régression en fonction des durées moyennes, est significative tant pour la main gauche que pour la main droite. Nous trouvons cependant pour la différence droite-gauche une estimation non-significative. La régression dans ce cas n'est pas de bon aloi et la relation entre l'indicateur de latéralité et la durée n'est pas significative. Bien que la régression de la main gauche et de la main droite le test de frappe soit significative, il n'y a pas de différence de pente en fonction du sexe.

A l'analyse de variance multiple, nous avons constitué un modèle (variables de contrôle ou indépendantes) à partir d'une banque d'informations contenant des renseignements multiples sur les individus que nous avons examinés. Ces renseignements comprennent des données socio-démographiques, d'habitudes corporelles et alimentaires, d'image de soi (personnalité et perception de soi), morphologiques et un relevé de la main le plus utilisée selon plusieurs activités, ce qui nous donne une indication de la préférence manuelle ou main préférentielle. Nous avons retenu parmi ces informations 35 critères tels le sexe, la fratrie, l'âge, des indicateurs morphologiques, la préférence manuelle, etc.

L'analyse de variance multiple confirme en partie les résultats mentionnés ci-dessus, une différence en fonction du sexe tant pour la main gauche que pour la main droite (tableau 1). Les moyennes présentées à l'analyse de variance multiple peuvent différer légèrement de celles qui sont obtenus à l'analyse de covariance en raison du processus d'ajustement de chaque critère à tous les autres du modèle. Notre modèle explique de 50 à 60% de la variation de ces deux performances alors que le critère sexe n'explique que 1,50% de la variation de la main gauche et que 2,09% de celle de la main droite. Notre indicateur de latéralité n'est plus sensible au critère sexe. Il semble vraisemblable que le sexe lui-même, si on le considère à âge, à morphologie et à d'autres conditions équivalentes, ne soit pas la source la plus importante de variation des trois variables opératoires du test de frappe. Les facteurs morphologiques semblent les plus importants dans notre modèle. Mentionnons aussi un autre critère qui pourrait expliquer, beaucoup plus que le sexe, la variation considérée: la préférence manuelle ou main préférentielle (dextralité, ambidextralité et sinistralité).

Test de l'alphabet écrit

Les résultats du test de l'alphabet écrit sont inversés au niveau des performances des deux groupes, relativement au test de frappe (fig. 4 et 5). Les sujets féminins ont des temps d'exécution meilleurs, tant de la main gauche que de la main droite, comparativement aux sujets masculins.

Les temps moyens pour compléter l'alphabet par les sujets féminins sont respectivement 22,11 secondes pour la main gauche et 13,32 secondes pour la main droite. Les sujets masculins sont plus lents: 25,88 secondes pour la main gauche et 14,38 pour la droite. La différence entre les deux mains, la main droite "moins" la main gauche, serait plus grande chez les sujets masculins que chez les sujets féminins, respectivement −11,50 secondes et −8,79 secondes (fig. 6). Il semble que la plus grande différence qui existe entre les sexes soit au niveau de la main droite. La relation simple

Source Var.	Rap. F	DL1,2	P (1-α)
Régression	47.91	1,349	0.999999
Df Pente	0.00	1,347	0.030355
Df Position	19.89	1,348	0.999923

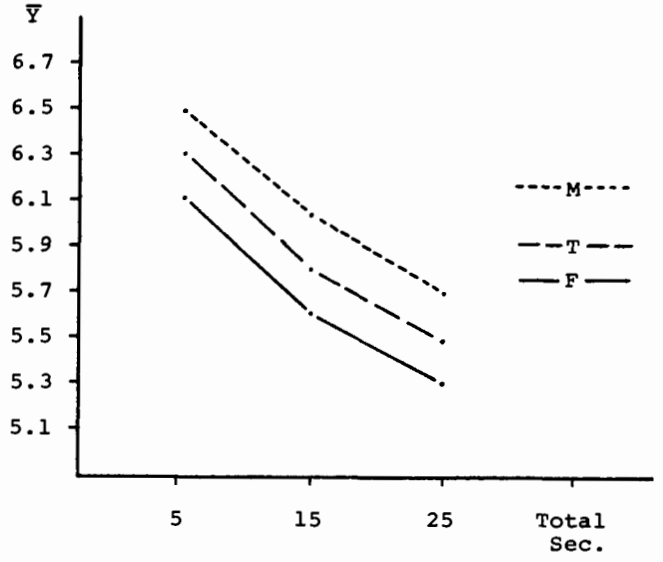


Fig. 1 Test de frappe main gauche; $\bar{Y}$: nombre de coups à la seconde; sexe : F – sujet féminin, M – sujet masculin, T – sujet féminin et masculin.

Source Var.	Rap. F	DL1,2	P (1-α)
Régression	27.87	1,349	0.999988
Df Pente	0.59	1,347	0.447453
Df Position	48.82	1,348	0.999999

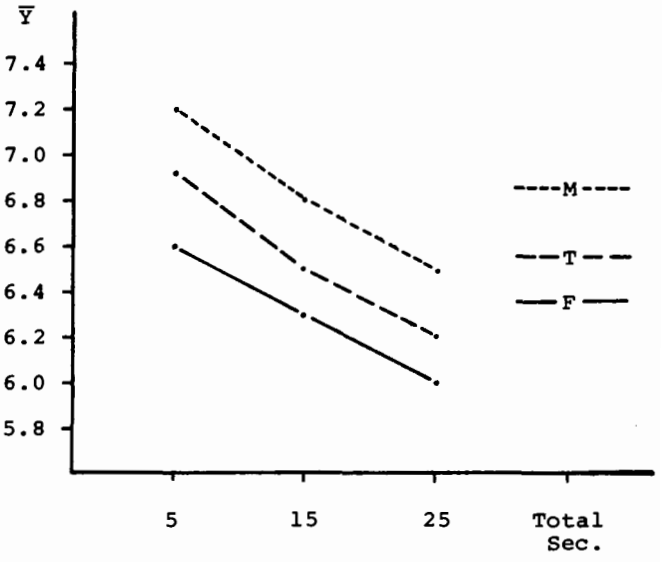


Fig. 2 Test de frappe main droite; $\bar{Y}$: nombre de coups à la seconde; sexe : F – sujet féminin, M – sujet masculin, T – sujet féminin et masculin.

Source Var.	Rap. F	DL1,2	P (1-α)
Régression	1.82	1,349	0.825592
Df Pente	0.50	1,347	0.488070
Df Position	46.52	1,348	0.999999

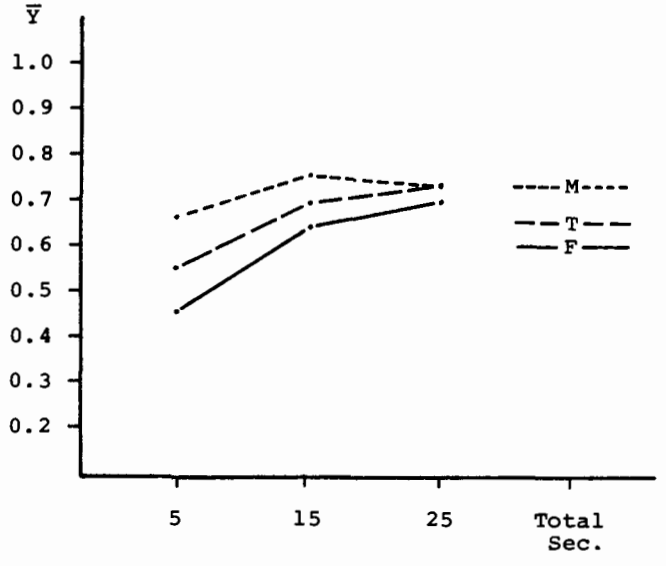


Fig. 3 Test de frappe différence entre main droite et main gauche; $\bar{Y}$: nombre de coups de différence; sexe : F – sujet féminin, M – sujet masculin, T – sujet féminin et masculin.

Source Var.	Rap. F	DL1,2	P (1-α)
Régression	15.69	1,258	0.999730
Df Pente	0.18	1,256	0.324423
Df Position	26.39	1,257	0.999982

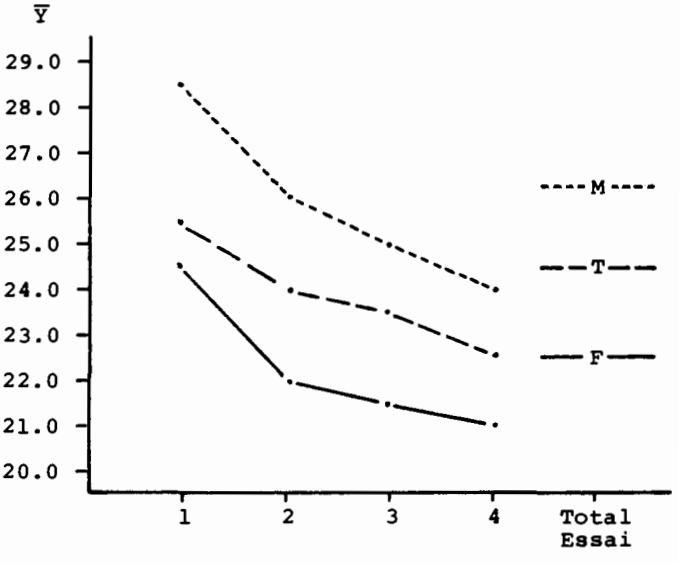


Fig. 4 Test de l'alphabet écrit main gauche; $\bar{Y}$: secondes d'exécution; sexe : F – sujet féminin, M – sujet masculin, T – sujet féminin et masculin.

Source Var.	Rap. F	DL1,2	P (1-α)
Régression	17.65	1,258	0.999851
Df Pente	0.08	1,256	0.223541
Df Position	186.82	1,257	1.000000

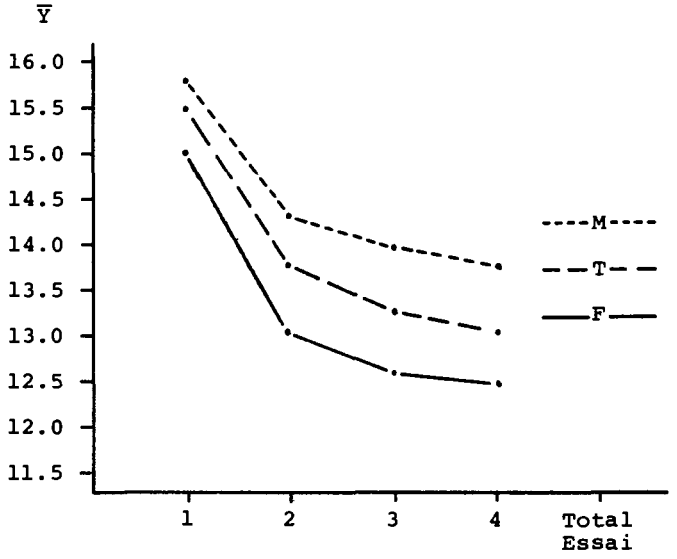


Fig. 5 Test de l'alphabet écrit main droite; Y : secondes d'exécution; sexe : F – sujet féminin, M – sujet masculin, T – sujet féminin et masculin.

Source Var.	Rap. F	DL1,2	P (1-α)
Régression	2.73	1,258	0.904422
Df Pente	0.48	1,256	0.496001
Df Position	69.98	1,257	1.000000

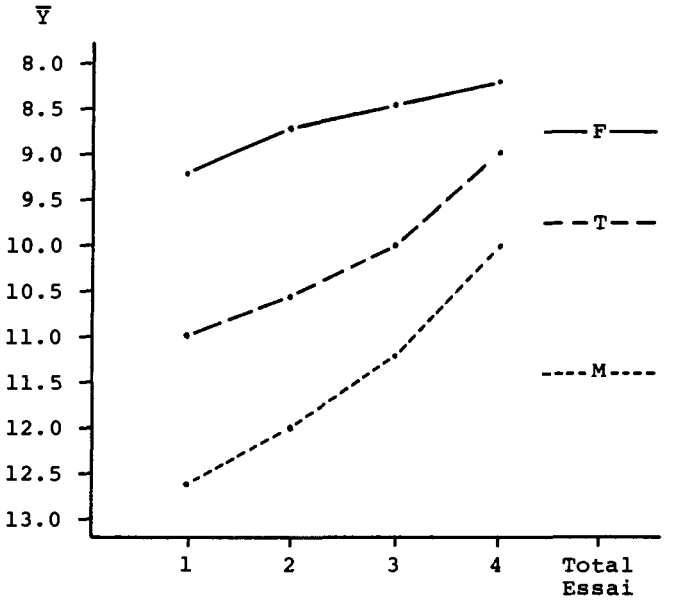


Fig. 6 Test de l'alphabet écrit différence droite-gauche; Y : secondes; sexe : F – sujet féminin, M – sujet masculin, T – sujet féminin et masculin.

entre le temps d'exécution et le nombre d'essais est statistiquement significative pour la main gauche et pour la main droite, mais non pour la différence entre les deux. De plus, pour les trois variables, il n'y a pas de différence de pente en fonction du sexe. Cette absence de différence de pente chez les deux groupes indiquerait un même mode de fonctionnement chez les deux sexes.

L'analyse de variance multiple ne nous donne pas les mêmes indications que l'analyse de covariance (tableau 2). Il n'y aurait pas de différence entre les deux sexes en ce qui concerne la main gauche. Bien que notre modèle de critères tende à expliquer, pour notre échantillon, plus de 90% de la variation de ces trois indicateurs, il semble que le sexe des sujets n'en soit responsable que pour un très petite part. Les performances de la main droite montrent, après ajustement, un écart encore plus prononcé en faveur des sujets féminins, et ce de façon significative. L'écart que l'on observe entre les deux groupes, pour la main droite, a été augmenté à la suite de l'ajustement aux autres critères. Lors de cet ajustement, on observe une baisse de temps chez les sujets féminins tandis qu'il y a une augmentation de temps chez les sujets masculins, respectivement 13,1 secondes à 7,6 secondes et de 14,4 secondes à 20,2 secondes (tableau 2). L'importance du critère sexe semble quand même toute relative, puisque le R2 est inférieur à 1 %.

La différence entre les deux mains est aussi significative en fonction du sexe. Le pourcentage de variation lié au critère sexe demeure cependant très faible. Les résultats les plus étonnants que l'on observe avec l'analyse de variance multiple sont ceux de la différence droite-gauche après ajustement. Nous avions avant l'ajustement une différence de −8,79 secondes pour les sujets féminins et de −11,50 pour les sujets masculins; après ajustement, on obtient −16,6 chez les femmes et −3,7 chez les hommes, indiquant un plus grand écart entre les

TABLEAU 1

Liste des variables opératoires du test de frappe en fonction du sexe d'un échantillon d'étudiants x (n=117) (résultats ajustés)

Var. oper.	Féminin (65)	Masculin (53)	R 2(%)	P(1- α)	R 2Total (%)
Main gauche (coups/sec)	5.67	6.16	1.50	0.9982	59.3242
Main droite (coups/sec)	6.26	6.87	2.09	0.9992	52.0847
Droite-gauche	0.59	0.71	0.09	0.4958	44.2150

TABLEAU 2

Liste des variables opératoires du test de l'alphabet écrit en fonction du sexe d'un échantillon d'étudiants x (n=65) (résultats ajustés)

Var. oper.	Féminin (34)	Masculin (31)	R 2(%)	P(1-α)	R 2Total (%)
Main gauche (sec/es)	24.2	23.9	0.00	0.0489	93.2623
Main droite (sec/es)	7.6	20.2	0.78	0.9999	92.3571
Droite-gauche (sec)	−16.6	−3.7	0.19	0.9753	92.8646

TABLEAU 3

Liste des variables opératoires de la dynamométrie en fonction du sexe d'un échantillon d'étudiants x (n=120) (résultats ajustés)

Var. oper.	Féminin (63)	Masculin (57)	R 2(%)	P(1- α)	R 2Total (%)
Main gauche (kg)	26.0	48.5	14.62	0.9999	91.2489
Main droite (kg)	28.3	53.2	16.67	0.9999	92.7590
Droite-gauche	2.26	4.62	1.44	0.8643	64.6966

deux mains chez les sujets féminins que masculins.

Dynamométrie

Pour la dynamometrie, nous trouvons par l'analyse de variance simple des différences significatives entre les sexes. Tant pour la main gauche que pour la main droite, les sujets masculins sont physiquement plus forts que les sujets féminins. Les performances moyennes des sujets masculins sont, pour la main droite et la main gauche respectivement, de 53,3 kg et 49 1 kg, et pour les sujets féminins, de 29,3 kg et 26,6 kg. Pour la différence entre les deux mains, nous ne trouvons pas de différence significative entre les sexes. Ces différences sont de l'ordre de 2,71 kg pour les sujets féminins et de 4,25 kg pour les sujets masculins.

Nous avons obtenu de même, par l'analyse de variance multiple (tableau 3) des différences significative entre les sexes en ce qui concerne la main gauche et la main droite. Le critère sexe explique en très grande partie la variation des scores de la main gauche, le R2 ajusté étant de 14,62%, ce qui est très élevé. Il en est de même pour la main droite pour laquelle le R2 ajusté lié au sexe est 16,67%. Nous voyons au tableau 3 que l'ensemble de notre modèle explique plus de 90% de la variation des performances des mains droite et gauche. La différence droite-gauche par contre, n'est pas statistiquement lié au sexe. Il semble que le critère sexe ne soit pas prépondérant dans l'explication de la variation de la différence droite-gauche. Les facteurs morphologiques semblent beaucoup plus liés à la variation de cet indicateur, leur R2 groupe étant supérieur à 11%.

DISCUSSION

Test de frappe

L'absence d'une différence de pente nous suggère, pour les variables du test de frappe, que la décroissance de la performance serait équivalente chez les deux sexes pour cette tranche d'âge (Garai et Scheinfeld, '68; Fairweather et Hutt '72). Comme nous l'avons mentionné, il semble qu'on ne peut trouver de différence en terme de latéralité pour cette fonction motrice. Ceci étant dit, on observe tout de même une différence de performances des mains gauche et droite entre les sexes. Sans doute, le critère sexe est-il lui-même lié à un ensemble de caractéristiques qui expliquerait cette différence entre les sexes. On ne peut, par conséquent, attribuer à une latéralisation différentielle les performances respectives des deux groupes dans le cas du test de frappe, c'est-à-dire une fonction motrice assez grossière (Garai et Scheinfeld, '68).

L'analyse de variance multiple confirme les résultats obtenus par l'analyse de covariance, mais elle nous renseigne sur l'importance des facteurs responsables de la variation de nos variables opératoires. Comme nous l'avons fait remarquer, l'importance du critère sexe, même si significative est assez réduite. Les facteurs qui semblent les plus importants sont les indicateurs morphologiques et la main préférentielle. Ces tendances semblent confirmer l'explication la plus souvent invoquée par les auteurs, qui veut que les meilleures performances des sujets masculins seraient partiellement le fait d'une masse masculaire plus importante chez l'homme que chez la femme. Un autre facteur, antérieur au précédant, serait un taux maturationel plus lent chez les sujets masculins (Garai et Scheinfeld, '68). Ce taux plus lent permettrait aux individus de sexe masculin de développer, pour ce genre d'activité, des voies neurales plus efficaces, c'est-à-dire une meilleure ou plus grande myélination des neurones (Connolly, '70; Buffery et Gray, '72). De plus, il détermine en partie une masse masculaire et osseuse plus importante. Suite à ces constatations, on ne peut véritablement parler dans le cas du test de frappe d'une latéralisation différentielle en fonction des sexes.

Test de l'alphabet écrit

La tendance qui se dégage des résultats obtenus pour le test de l'alphabet écrit représente l'inverse de ce qui a été observé pour le test de frappe. Nous ne trouvons aucune différence de pente, ce qui suggère fortement un rappel de l'alphabet semblable chez les deux sexes. Au niveau de la main gauche, nous observons des performances semblables chez les deux sexes, tandis que pour la main droite les sujets féminins ont des performances plus rapides que celles des sujets masculins, et ce à âge et à morphologie équivalents. On retrouve au niveau de l'indicateur de latéralité une plus

grande différence chez les sujets féminins que chez les sujets masculins, ce qui semble suggérer une plus grande latéralisation chez les femmes.

Toutefois, selon nous, le test de l'alphabet comporte trois composante: la mémoire de l'alphabet, l'alphabet en tant que structure verbale, et la dextérité manuelle. Il a été montré par de nombreux auteurs (Garai et Scheinfeld, '68; Maccoby et Jacklin, '74) que les femmes obtiennent de meilleurs résultats au niveau de la mémoire (en terme de rappel), et de la dextérité manuelle. Dans ces deux types d'activités, il ne semble pas que l'hypothèse de latéralité puisse s'appliquer. Si l'on reconnait que l'alphabet constitue une structure verbale, l'hypothèse de latéralité différentielle pourrait s'appliquer. Il semble que le sexe féminin ait de meilleures performances en ce qui concerne la verbalisation, c'est-à-dire une certaine facilité verbale (Maccoby et Jacklin, '74; Garai et Scheinfeld, '68). La verbalisation serait fortement latéralisée. Le siège de la parole ou de l'élocution de la parole se situe dans l'hémisphère cérébral gauche (Oppenheimer, '77). Ces dernières années une hypothèse a été mise de l'avant concernant la latéralisation chez les sexes. Il est dit que les femmes présenteraient une latéralisation moindre, voire une bilatéralisation hémisphérique des fonctions linguistiques, alors que les hommes montreraient une latéralisation plus nette de ces mêmes fonctions (De Agostini, '79). Cette hypothèse est en contradiction avec nos résultats, qui semblent indiquer que les sujets de sexe féminin seraient plus latéralisés que les sujets de sexe masculin. Nos résultats, cependant, sont obtenus par la technique de variance multiple, qui "ajuste" l'effet principal du critère sexe à l'ensemble des effets principaux des autres critères du modèle (âge, morphologie, socio-démographie, etc). Sans cet ajustement, tel que par exemple obtenu par le technique plus conventionnelle de l'analyse de covariance et tel qu'illustré dans nos propres résultats utilisant cette dernière, ce sont les hommes qui "paraissent" manifester une latéralisation plus prononçée. Ce revirement complet de la situation suite à la technique plus sophistiqué de l'analyse de variance multiple, en plus de jeter un éclairage nouveau sur le problème de la latéralisation entre les sexes, nous invite à une plus grande prudence lors de l'interprétation de méthodes univariées et bivariées.

Dynamométrie

Nous trouvons, à la dynamométrie, des différences entre les sexes tant pour la main droite que pour la main gauche. Le sexe des sujets semble un facteur important dans la variation des performances. Toutefois, d'autres facteurs tels la morphologie, habitudes corporelles, etc, manifestent aussi leur influence. Il semble que la différence droite-gauche, soit sensiblement la même chez les deux sexes.

Les meilleures performances des sujets masculins pour la dynamométrie semblent être une question partiellement morphologique. Le fait d'appliquer une meilleure pression est fonction de l'ossature et de la musculature. L'effet de maturation différentielle des sexes peut en être une des causes principales, ce qui implique que les sujets masculins ont plus de chances d'un plus fort développement osseux et musculaire que les sujets féminins (Garai et Scheinfeld, '68). Pour la dynamométrie, il n'est pas possible, selon nos résultats, de parler de latéralisation différentielle.

CONCLUSION

Il a été montré que les sujets de sexe masculin, au seul niveau de la vitesse montrice, ont des performances plus rapides que les sujets féminins. Toute épreuve de rapidité neuro-motrice, d'une activité peu spécialisée, favorise les hommes de l'adolescence à la sénescence. L'exemple le plus adéquat de ce type d'activité est le test de frappe. Le test de l'alphabet écrit est un test plus complexe. Il fait appel à plusieurs fonctions, entre autre la plus importante selon nous, le langage écrit. Plusieurs études ont montré que les sujets féminins étaient favorisés au niveau de langage (Maccoby et Jacklin, '74). Le lien entre le contrôle de la main droite et les fonctions linguistiques a aussi été mis en évidence (Annett, '77). Il n'est donc pas étonnant d'avoir trouvé de meilleures performances chez les femmes dans notre échantillon. Les masses musculaire et osseuse plus importantes chez l'homme expliquerait en grande partie les meilleures performances de ces derniers à la dynamométrie (Garai et Scheinfeld, '68).

Dans l'étude des performances manuelles, il y a deux notions qui découlent de la latéralisation: la latéralisation fonctionnelle, c'est-à-dire

l'organisation spécifique au niveau des hémisphères cérébraux et la latéralisation usuelle, c'est-à-dire la main préférentielle sur laquelle nous n'avons pas axé notre étude. Nos résultats peuvent nous aider à préciser notre principale question: la latéralisation fonctionnelle des sexes. Le test de l'alphabet écrit tend à montrer une plus grande latéralisation chez les femmes et une certaine bilatéralisation chez les hommes. Cette plus grande latéralisation à l'hémisphère gauche, tient au test lui-même mettant en évidence le lien entre le contrôle de la main droite et le langage écrit. Les autres tests ne montrent pas cette tendance.

Les études sur les différences entre les sexes deviennent de plus en plus fréquentes. Les réticences d'un coté comme de l'autre sont grandes. Afin de minimiser les inégalités entre les sexes, il faut connaître l'étendue et les limites des capacités de chacun des sexes pour en apprécier à leur juste valeur ce qui est commun. Les sexes différent, effectivement, mais n'en manifestent pas moins une communalité de capacité.

REMERCIEMENTS

Nous tenons à remercier le Dr. Francis Forest de ses conseils et de ses critiques gentiment apportés à l'élaboration de cet article.

OUVRAGES CONSULTES

Annette, M. 1972 The distribution of manual asymmetry. Br. J. Psych. *63:* 343-358.

1977 Handedness and the cerebral representation of speech. In: Physiological Variation and its Genetic Basis. J. S. Weiner (ed.). Halsted Press, New York.

Azémar, G. 1975 Latéralité et différenciation qualitative des conduites motrices. Revue de Neuropsychiatrie Infantile *23:* 13-21.

Buffery, W. H. and J. A. Gray 1972 Sex differences in the development of spatial and linguistic skills. In: Gender Differences: Their Ontogeny and Significance. C. Ounsted and D. C. Taylor (eds.). Churchill, London.

Colbourn, C. J. 1978 Can laterality be measured? Neuropsychologia *16:* 283-289.

Connolly, K. (ed.) 1970 Mechanisms of Motor Skill Development. Academic Press, New York.

De Agostini, M. 1979 Hommes et femmes ont-ils la même organisation cérébrale? La Recherche *10:* 77-79.

Fairweather, H. and S. J. Hutt 1972 Sex differences in perceptual-motor skill in children. In: Gender Differences: Their Ontogeny and Significance. C. Ounsted and D. C. Taylor (eds.). Churchill, London.

Garai, J. E. and A. Scheinfeld 1968 Sex differences in mental and behavioral traits. Genetical Psychology Monographs *77:* 169-299.

Levy, J. and J. M. Levy 1978 Human lateralization from head to foot: sex related factors. Science *200:* 1291-1292.

Maccoby, E. E. and C. N. Jacklin 1974 The Psychology of Sex Differences. Stanford University Press.

Oppenheimer, J. M. 1977 Studies of brain asymmetry: historical perspective. Ann. N.Y. Acad. Sci. *299:* 4-17.

Overall, J. E. and C. J. Klett 1972 Applied Multivariate Analysis. McGraw-Hill, New York.

Provins, K. A. and P. Cunliffe 1972 The reliability of some motor performance tests of handedness. Neuropsychologia *10:* 199-206.

Snedecor, G. W. and W. G. Cochran 1967 Statistical Methods. Iowa State University Press, Ames.

Book Review

AN EARLIER POPULATION OF HESQUIAT HARBOUR, BRITISH COLUMBIA. By Jerome S. Cybulski. Cultural Recovery Paper No. 1; Physical Anthropology Contribution No. 1, Hesquiat Cultural Committee; British Columbia Provincial Museum, Victoria. 1978. 80 pp., 12 figures, tables, references, appendices. $2.00 (paper).

This work represents the first in a series of volumes which are intended to be summaries of a scientific investigation known as the Hesquiat Project. Hesquiat Harbour, located on the southwest coast of Vancouver Island, is the traditional territory of the Hesquiat peoples, a localized group of the Nootka ethnolinguistic division of the Northwest Coast culture area. Because of increasing vandalism of historic burial sites the Hesquiat Band formed a Cultural Committee in 1970 to prevent the complete destruction of the burials and to attempt to reconstruct and preserve as much of their heritage as possible. This physical anthropological study represents Dr. Cybulski's attempt to reconstruct information from the skeletal material by recovery (begun in 1971) and *on-site* data analysis before reburial in a crypt at the village of Hesquiat. Consequently, the work represents one of a present few in an increasing number of future reports where skeletal material is expected to be completely analysed *on-site* before reburial.

Having gone through the same experience with a skeletal sample which could not be removed to a professional lab for analysis, I sympathize and congratulate Dr. Cybulski on his efforts at the skeletal reconstruction, and herein lies the publication's strong point. It is an admirable model for what physical anthropologists can accomplish while working under the enforced restrictions set by native peoples regarding ancestral burials. Any conscientious investigator would recognize the "after the fact" regrets one has in thinking about what information might have been missed and what one could have done, but didn't, while in the field. Therefore, I cannot criticize the author for errors of omission, such as neglecting to take portable x-ray equipment or other technical apparatus into the field in 1971, particularly when the skeletal material itself was scattered and in poor condition. In fact, the author has done an efficient job of wringing as much information (and speculation) as possible from what might appear to be a rather "miserable" collection of bones which, even 20 years ago, would have been virtually ignored by a field investigator to the exclusion of skulls only. Nevertheless, a report of this type is notably lacking in one area that would be expected for bones we will never see again, and that is photography. Although the included drawings by Brian D. Seymour are of excellent quality, I would have liked to see more photos of the general Hesquiat area, the burial sites, and specific bones.

General organization of the report is logical and concise. In chapter I the site and sample are introduced and the aims of the analysis set out. Chapter II, basically an apologia, discusses the problems the investigator had to deal with because of the condition of the skeletal remains and the additional disturbing influence of the practice of cranial deformation. Chapter III includes the description of individual burials by site, a necessary exercise, it seems, in all site reports that makes for tedious reading and which I for one have often wished to be relegated to an appendix. Chapters IV to XI present the results of analyses of age and sex estimations, further details about cranial deformation, cranial morphology, dental morphology, non-metric postcranial morphology, stature, and dental and skeletal pathology. Chapter XII attempts interpretive analyses reconstructing demography, making physical comparisons with other groups, and assessing health status.

My criticisms of various details in Chapters I to XI are few but bear some mention. Some of the aging and sexing methods seem a bit outmoded. The Schour and Massler dental eruption aging chart could have been updated but, of course, was still in wide use in 1971. No mention is made of the Phenice method of sexing hip bones which was published in 1968. Reliance was said to have been placed on the form of the sciatic notch, a feature known to be quite variable in terms of sex determination. The problems associated with aging females from pubic bones are not discussed.

In the section on non-metric post-cranial morphology, the trait descriptions for the atlas vertebra are somewhat confusing between the text and Table 9. In addition, the author continues to follow the tradition set by other physical anthropologists in simply mentioning certain traits and their frequencies (e.g., Fossa of Allen) without considering some of the difficulties in subjective assessments of trait presence. One should note, though, that Cybulski at least considers how available sex, side, and age differences might be affecting the presence of some traits.

More details and traits might have been examined for dental morphology, and this is one area where future field investigators would due well to consider taking dental cast impressions in the field. The statement that osteoarthritis is by far the most common of pathological manifestations in prehistoric skeletal material is self-evident and expected but it would have been interesting to see a comparison of the degree and distribution of degenerative joint disease in this sample compared to other populations such as Jurmain (1977) has done.

Of far more interest than these small points are the author's summary statements about this skeletal sample in Chapter XII, the Interpretive Analyses. However, in all sections of this chapter it is apparent that the basic problem in making general interpretations is the incompleteness of the sample. Nevertheless, Cybulski presents some cogent arguments, backed by ethnohistoric references to say that the skeletal remains represent members of the prehistoric local lineage group, the ma'apiath. He then reconstructs population size from what was known of the size of the ma'apiath to calculate a mortality profile. The profile for Hesquiat Harbour compares well with published mortality profiles of other prehistoric groups and the author concludes that the burials represent individuals who were living under relatively favorable conditions just prior to the decimating influences of white contact. Cybulski also presents a number of arguable but feasible interpretations for an apparent lower mortality rate for Hesquiat females.

The attempt to assess the biological features of the Hesquiat sample compared to other Nootkan groups using cranial non-metric traits is interesting but seems to me, fruitless. Cybulski's statement that the MD^2 distance statistic is sophisticated and sensitive rather than robust has been contested elsewhere, despite the fact that the MD^2 equation seems to adequately reflect biological separation of populations. Cybulski himself admits that his cranial samples are *very* small (6 from Hesquiat!) and this in itself reduces the confidence in his conclusions. He concludes that the lack of linearity in MD^2 distances when Hesquiat Harbour is compared to the four other Nootkan samples indicates that Hesquiat Harbour was not a distinct breeding population while the four other samples were. It seems to me he is pushing his conclusions a little too far. Nevertheless, this report is a useful adjunct to skeletal studies of prehistoric and early historic Northwest Coast populations.

S. R. Saunders
University of Toronto

LITERATURE CITED

Jurmain, R. D. 1977. Stress and etiology of osteoarthritis. Am. J. Phys. Anthrop. *46*:353-366.

ABSTRACTS OF PAPERS
PRESENTED AT THE SEVENTH ANNUAL MEETING OF THE CANADIAN ASSOCIATION FOR PHYSICAL ANTHROPOLOGY/ ASSOCIATION POUR L'ANTHROPOLOGIE PHYSIQUE AU CANADA
STE.-ADELE, QUEBEC, NOVEMBER 7-10, 1979

VARIATION DES NIVEAUX DE SANTE DANS UNE POPULATION DE TRAVAILLEURS QUEBECOIS - I

FRANKLIN AUGER
Université de Montréal

La santé et la securité au travail sont devenues des thèmes importants dans nos sociétés industrialisées. A ce stade-ci de nos analyses, nous ne pouvons présenter que quelques éléments descriptifs de la variation morphologique de deux échantillons de travailleurs québécois, de même que de la variation de certains indicateurs des niveaux de santé d'un seul de ces deux échantillons.

Le premier échantillon regroupe 438 individus (employés municipaux de la Ville de Montréal). Cet échantillon a été constitué par des chercheurs de l'Institut de Cardiologie de Montréal au début des années soixante. Notre deuxième échantillon est formé des employés d'une importante entreprise de la région de Sorel-Tracy. C'est cet échantillon qui constitue l'essentiel de la recherche que nous poursuivons présentement: 3 000 travailleurs ont été examinés.

Le poids, la stature et le pourcentage de tissus adipeux ont été analysés succintement en fonction de l'âge et de la catégorie socio-professionnelle chez les travailleurs de Sorel-Tracy et en fonction de l'âge et des niveaux de scolarité chez les employés municipaux de la Ville de Montréal.

Chez les travailleurs de Sorel-Tracy, nous avons retenu divers symptômes rattachés à des systèmes particuliers et calculés à partir de nombreuses réponses contenues dans le questionnaire pré-examen médical, réponses pondérées par le médecin lors de l'examen clinique. Quelques résultats ophtalmométriques, audiométriques et spirométriques, de même que la tension systolique et diastolique sont donnés. Les variables physio-pathologiques sont considérées comme des indicateurs de santé et ce, pour les diverses catégories socio-professionnelles. Les déviations présentées par les travailleurs d'une catégorie et ce, pour l'ensemble des variables considérées, le sont par rapport à la moyenne générale de notre population de travailleurs.

VARIATION DEX NIVEAUX DE SANTE DANS UNE POPULATION DE TRAVAILLEURS QUEBECOIS - II

DIANE BERTHELETTE
Université de Montréal

(Complete paper published in this number)

LES CONNAISSANCES ANATOMO-PHYSIOLOGIQUES DES ANGBANDI DU ZAIRE

GILLES BIBEAU
Université Laval

Depuis Ackerknecht (1946), historien de la médecine et anthropologues médicaux répètent que les médecines traditionnelles se caractérisent par une absence de connaissances anatomo-physiologiques. Cela expliquerait d'ailleurs pourquoi leur thérapie est d'abord symptomatique et leur étiologie magico-religieuse. Aprés avoir mis en évidence la base qui a permis l'émergence d'une véritable science du corps chez les Angbandi, je présenterai les structures organisatrices de leur système de connaissances physiologiques (os et organes internes principalement). Je terminerai en donnant les caractéristiques de la science du corps chez les Angbandi.

INTER-RELATION DE LA CROISSANCE DES DIFFERENTES COMPOSANTES DU CORPS, MUSCLES ET TISSUS ADIPEUX, ET LA CONSOMMATION ALIMENTAIRE CHEZ DES ENFANTS CANADIENS-FRANCAIS DE 6 A 19 ANS

MICHELINE BRAULT-DUBUC et ARTO DEMIRJIAN
Université de Montréal

Dans le cadre d'une étude longitudinale, deux cohortes d'environ 200 garçons et 200 filles agés de 6 ans et de 10 ans en 1967 ont été examinées annuellement jusqu'en 1976. Les paramètres utilisés pour l'analyse présentée ici sont: la stature (squelette), la circonférence du bras maigre (muscles), la somme de trois plis cutanés (tissus adipeux), la valeur de la diète en calories, protéines, lipides, glucides et au calcium, basés sur un relevé alimentaire de 7 jours. Les courbes de grandeur et de vélocité ont été utilisées sur des échelles d'âge chronologique et d'âge de vélocité maximale de la stature (VMS). On a pu décrire les changements dans la composition du corps pendant l'adolescence à partir de simples mesures anthropométriques. Le dimorphisme sexuel observé est plus important que pour d'autres populations. La croissance staturale se fait parallèlement à la croissance musculaire chez les garçcons et leur vélocité maximale concide; tandis que chez les filles, il y a un an de différence. Les corrélations établies à des âges donnés chez les garçcons entre la croissance staturale et musculaire n'existent plus lorsqu'on retire le facteur de la maturation, ce qui n'est pas le cas chez les filles. On a pu, d'autre part, observer une augmentation peu importante mais réelle de la consommation alimentaire, jusqu'à 12 ans chez les filles et jusqu'à 15 ans chez les garçcons; mais aucune corrélation pour les grandeurs ou les vélocités n'a pu être établie entre les différentes composantes du corps et l'ingestion alimentaire. (Octrois nos. 605-1388-41 et 360-29-000-305 du Ministère de la Santé et Bien-être Social)

LATERALISATION ET DIFFERENCES ENTRE LES SEXES

YVON DESJARDINS
Université de Montréal

(Complete paper published in this number)

PREDICTION DE LA TENSION ARTERIELLE PAR ANALYSE DISCRIMINANTE MULTIVARIEE D'ECHELLES PSYCHOSOCIALES COGNITIVES CHEZ L'HOMME

SHIMON DOHLAN et ANDRE ARSENAULT
Université de Montréal

Dans le cadre d'un projet de recherche sur le stress au travail réalisé auprés des travailleurs du milieu hospitalier, les auteurs ont testé une hypothèse générale voulant que la perception consciente du contenu et du contexte de la tâche, de même que les symptômes et des signes ressentis par l'individu, pouvaient permettre de prédire la réponse du système cardio-vasculaire, telle que mesurée objectivement par la mesure de la tension artérielle. En utilisant un modèle multi-dimensionnel, on a cherché à discriminer les individus ayant une tension artérielle diastolique au repos inférieure à 75 ml de mercure des individus dont la diastolique était supérieure à ce même seuil. Des résultats préliminaires obtenus à partir de l'étude de 60 cas indiquent que l'on peut discriminer correctement dans 82% des cas les individus qui se situent au-delà et en-deça du seuil à partir de quatre facteurs dont deux sont liés au contexte de la tâche et les deux autres à la symptomatologie psychologique consciemment perçue. Si ces résultats sont confirmés dans les analyses ultérieures, ils indiqueraient que la réaction physiologique objective et inconsciente chez l'humain pourrait être prédite à partir de la psychè consciente.

PROGRESSION ORDER IN BONNETS AT BANNERGHATTA

GEORGE ELLIS
Université de Montréal

The spatial and temporal patterning of food resources in Bannerghatta National Park provide the bonnet macaque with a productive mosaic environment which they utilize in a fine-grained manner. Distinctive patterns of group dispersion and social behavior appear as the monkeys exploit alternative resource commodities. Group progression order is one such pattern. This paper examines changes in one-dimensional group geometry associated with movements within and to the outskirts of the troop's home range. The social and communicative matrix of such progressions is described. The implications of this study for the "protective function" hypothesis of spatial organization of moving troops are discussed.

IMPLICATIONS OF CERTAIN HAND-WRIST VARIATIONS FOR SEX AND GROWTH

C. E. EYMAN
University of Calgary

(Complete paper published in this number)

METHODOLOGIE DE LA MESURE DE L'AGE BIOLOGIQUE

FRANCIS FOREST et URSULA FOREST-STREIT
Université de Montréal

(Complete paper published in Vol. 1, No. 2)

ETUDE ANTHROPOBIOLOGIQUE D'UNE POPULATION FEMININE CANADIENNE-FRANCAISE DU QUEBEC

GLORIA FRAPPIER
Université de Montréal

Au Canada, il existe relativement deu d'études anthropobiologiques de la population, et notamment en ce qui concerne la population féminine canadienne-française.

Au cours des années 1978-79, nous avons recueilli de nombreuses informations auprés d'un échantillon de 206 femmes canadiennes-françcaises de la région de Sorel-Tracy, dont l'âge variait entre 18 et 65 ans. Les informations obtenues à l'aide d'un questionnaire socio-démographique et médical ainsi qu'à partir de mesures anthropométriques et physiologiques, nous ont permis de créer une banque de données qui constitue, à notre connaissance, la première et la seule disponible à ce jour pour ce type de population.

Dans un premier temps, nous avons analysé de façon descriptive l'échantillon féminin québécois tant au niveau des variables socio-démographiques qu'anthropométriques et physiologiques. Par la suite, nous tenterons d'évaluer l'état de santé général de la population féminine de la région Sorel-Tracy ainsi que d'en étudier les facteurs de variation.

ETUDE DE L'AUDIOMETRIE CHEZ UNE POPULATION DE TRAVAILLEURS

NORMAND LAPLANTE
Université de Montréal

L'étude portera sur les résultats au test d'audiométrie effectué auprés d'une population de travailleurs en milieu industriel. Les fréquences analysées vont de 250 Hz à 8000 Hz et le seuil d'audition est évalué par intervalles de 5 dB. Une première analyse démontre une forte variabilité des données, caractéristique d'une population soumise à des niveaux de bruit assez élevés. L'analyse en composante principale des huit fréquences étudiées permet d'identifier deux facteurs principaux responsables de la plus grande partie de la variation. Le premier facteur, expliquant 66% de la variation semble être un facteur d'exposition au bruit. Le second facteur, responsable de 16% de la variation serait un facteur de vieillissement physiologique.

L'étude du seuil d'audition en fonction de l'âge démontre des différences importantes entre les classes socio-professionnelles. Ces différences sont les plus marquées pour les fréquences supérieures à 1000 Hz. La classe la plus élevée, soit celle des cadres, se rapproche d'une population standard non-exposée à des sources de bruits élevés. Les employés manuels et les contremaîtres présentent les résultats les moins bons tandis que les employés de bureau se situent dans une position intermédiaire. Ces différences entre classes peuvent s'expliquer par une exposition à des niveaux de bruits différents et sans doute également par un vieillissement physiologique différentiel.

RAPPORT PRELIMINAIRE SUR UNE ETUDE DES CRANES DU SITE DAWSON

ROBERT LAROCQUE
Université de Montréal

(Complete paper published in this number)

DEVELOPPEMENT DE L'INTELLIGENCE CHEZ LE CHIMPANZE

MIREILLE MATHIEU
Université de Montréal

(Abstract not submitted)

EVOLUTION DE LA STRUCTURE GENETIQUE D'UNE POPULATION OUVERTE

FRANCINE MAYER
Université de Montréal

L'étude de la migration et de ses mécanismes opérationnels constitue un défi: la migration impliquant une mobilité constante des individus, elle ne peut être que difficilement mesurée. Cette recherche a tenté d'évaluer la nature et l'intensité du flux migratoire d'une communauté des Cantons de l'Est fondée en 1875 en faisant l'analyse socio-demographique et l'analyse génétique.

Une méthode de recoupements des sources d'information a permis une analyse plus complète de la migration. L'approche méthodologique utilisée dans l'analyse génétique est basée sur le calcul des probabilités d'origine des individus estimées à partir des contributions génétiques respectives des ancêtres fondateurs.

PRELIMINARY EVIDENCE FOR AN ALTERNATIVE MODEL OF RHESUS MONKEY SOCIAL STRUCTURE ON CAYO SANTIAGO

CAROL McMILLAN
State University of New York, Buffalo

Although much excellent research has been done on the rhesus macaques of Cayo Santiago, most of it has been fit into a model of social structure based on a dominance hierarchy. Even after kinship was seen to be a primary organizing factor, as much emphasis has been placed on how matrilineages fit into the dominance hierarchy as on a more branching view of kinship itself. Many studies have been primarily *etic*, based on categories defined by researchers previous to their contact with the monkeys. The model I propose in no way invalidates previous research, but merely offers an alternative framework for the organization and analysis of data.

Using Gearing's (1958) human ethnographic model and his current (1979) methodology, video tapes were made on the monkeys in a month-long pilot study on the island. Behavioral routines were sought which, by their patterning, could be seen to define *emic* categories of the monkeys. Preliminary evidence indicates that rhesus monkey social structure on Cayo Santiago may be explained by a nesting series model based on *emic* categories of activities and kinds of individuals.

DEMOGRAPHY AND PATHOLOGY OF THE GANJ DAREH POPULATION: EARLY NEOLITHIC OF IRAN

C. MEIKLEJOHN
University of Winnipeg
P. LAMBERT, C. BYRNE, and M. H. REED
University of Manitoba

The site of Ganj Dareh lies in the Kermanshah district of the Inner Zagros zone of Iran at an altitude of 1400 m. It is a small mound of ca. 40 m diameter with five levels, dating primarily from the 7th and 8th millennia B.C. It appears to span the boundary from hunting and gathering to a food producing economy and has yielded among the earliest dated ceramics in the Middle East.

The site has particular interest in the recovery of the skeletal remains of 49 individuals, one of the largest reported collections of early Neolithic remains from the eastern flank of the fertile crescent. Both sexes and all age classes are represented, though it is evident that few individuals reached old age. Study of the postcranial skeleton suggests a relatively low degree of sexual dimorphism in the sample, as compared to other regional groups. The dentition is characterized by a relatively large surface area, as especially seen in large maxillary molars and mandibular premolars. There is general size equivalence to contemporary Natufian samples. Human interference is noted in the presence of artificial cranial deformation.

Pathology is most evident in *hyperostosis symmetrica*, found in over 50% of the adult series. Postcranial changes and traumatic injury occur infrequently. A radiological study of the 26 most complete individuals confirms the generally healthy status of the population. Harris lines are present but in relatively low numbers. One individual, a 9 mo. old child, shows evidence of generalized metabolic disorder.

The relatively young age at death and good health profile is similar to that of hunter-gatherers and differs from later proto-urban and urban populations.

MANDIBULAR TORUS: A SYNTHESIS OF NEW AND PREVIOUSLY REPORTED DATA AND A DISCUSSION OF ITS CAUSE

N. S. OSSENBERG
Queen's University

Since publication of Hrdlicka's (1940) treatise on mandibular torus, theories concerning its cause have shifted emphasis from masticatory stress and mucosal irritation to heredity. Pedigree studies have clearly shown that genetic factors influence torus development. Yet despite numerous investigations, this continues to be one of the most controversial and poorly understood of skeletal traits.

Using original data on 1,500 mandibles, but mainly previously published data, I present an overview of the distribution characteristics of mandibular torus and a hypothesis concerning its cause. Extrinsic factors are strongly implicated by: prevalence among Arctic peoples, effect of dietary change, age regression, preponderance in males and on the right side, influence of cranial deformation, concurrence in individuals with palatine torus and maxillary alveolar exostoses, and clinical evidence. I propose that the primary factor is masticatory stress. According to a mechanism suggested by orthodontic research, the horizontal component of bite force tips the lower C to M, so that their root apices exert pressure on the periodontal membrane, causing formation of new bone on the lingual cortical plate of the alveolar process. Once formed, the hyperostosis is vulnerable to trauma and its periosteal covering becomes bruised, causing additional deposition of bone. Genes influence torus development indirectly through their effect on occlusion. A pattern of increased expressivity with incidence suggests that a quasi-continuous model may provide a better fit to pedigree data than single-locus models previously tested.

PASSIVITY AS AN ADAPTIVE RESPONSE

ANDREW J. PETTO
University of Massachusetts

Various ethnographers of Canadian Native Peoples have noted that a common response to new stressors is passivity or inaction. Explanations of the frequency of this behaviour have centred upon the psychological make-up, the need for cooperative behaviour for survival, or the restraints of the native belief systems. Environmental factors have generally been treated by noting the harshness of the conditions the Native Peoples must face. Focusing especially upon the Athapaskan peoples of the MacKenzie Drainage, this study illustrates the high predictability of resources throughout the year based upon native reports and observations of ethnographers. Using both least risk and expected cost to benefit ratio models, it is the very predictability of the environment which makes nonaction a viable strategy in the face of unfamiliar and/or short-term stressors. The organisational and behavioural aspects of such a generalist strategy can be contrasted with those of anadromous fish specialists. Responses similar to the latter would be predicted as the focus for the subsistence strategy in response to external demands for intensive harvesting of single, seasonally available resources.

A STUDY OF POSSIBLE INFLUENCE OF ENVIRONMENTAL POLLUTANTS ON CHILD GROWTH

SUSAN PFEIFFER
University of Guelph

Members of the St. Regis (Akewasasne) Mohawk band, St. Regis, Quebec, have solicited the co-operation of the scientific community to quantify what they believe to be a serious problem of high pollution levels. Of the three local industrial pollutants, PCB's, Mirex and air-borne fluorides, the latter has received the most attention. A study of cattle on Cornwall Island substantiated the presence of chronic fluoride poisoning on at least that part of the reserve. Early in September, 1979, I collected anthropometric and dental emergence data from 235 randomly chosen children, aged 2 to 14 years, who live on the reserve. Subsamples from high-, moderate- and low-pollution areas of the reserve were compared to one another. Preliminary results indicate that the external indicators of fluoride poisoning seen in the cattle (short stature, delayed dental emergence) are not apparent in Cornwall Island children.

INFANT MORTALITY AMONG THE SEPHARDIC JEWS OF GIBRALTAR: 1869-1977

L. A. SAWCHUK and L. E. FLANAGAN
University of Toronto

(Complete paper published in Vol. 1, No. 2)

DENTAL ERUPTION SEQUENCES IN FOSSIL HOMINIDAE

MARK SKINNER
Simon Fraser University

Recently, it has been suggested by a number of palaeoanthropologists that comparative dental eruption sequences amongst recent and fossil Hominoidea, particularly in regards to molar retardation, may be utilized as an indirect means of documenting when, during hominid phylogeny, there occurred a prolongation in the absolute time required for our ancestors to mature.

Because of the significance in humans of prolonged maturation for the acquisition of

culture, it was decided to undertake a study of the fossil evidence for dental eruption sequences in the Hominidae (N = 133). Comparison was made to 90 *Pan* and 71 *Gorilla* as well as to published data on various primates.

Results strongly suggest that within the Hominoidea, despite striking differences in the dental maturation interval (ca. 12 years for pongids and 20 years for recent humans), molar retardation is trivial. It is concluded that dental eruption sequences cannot be used to infer maturation rates in fossil hominids and that, rather, molar retardation reflects the genetic consequences of posterior molar reduction in a lineage evidencing diminution of the craniofacial complex.

Support for this research was provided by National Research Council, Boise Fund (Oxford), and Canada Council Small Grants.

DEMOGRAPHIC CONSIDERATIONS IN HUMAN BIOLOGICAL FIELDWORK

LOUISE K. STEIN
State University of New York, Buffalo

Thorough demographic analysis is critical to many areas in human biological research. Much of the research in human biology, however, does not give sufficient weight to the subjects' responses as indicators of the cultural rules that structure the human biological framework. As an example of this problem, Polish village women (N = 120) were asked birthdate, age at marriage, and age at birth of first child. In order to obtain more complete information, village records were used to supplement informants' responses. During this process, a significant number of discrepancies between the informants' replies and the village records were discovered. The discrepancies indicate the villagers' varying reactions in reporting the dates of these events to different institutions. The discrepancies also indicate that a scientific researcher should check written records (if they exist) of vital events. This check will provide additional information for scientific research.

Both sources of information, that from informants and that from documents, give valuable information. What anthropologists bring to the study of human populations is an understanding of the legitimacy of data from either source, and anthropological insight allows for the interpretation of the varying responses in the light of the cultural context.

Fieldwork was supported by a DHEW/Fulbright-Hays Doctoral Dissertation Fellowship. Most of the data were gathered while the author was a member of the field research group of the Department of Human Ecology, Polish Academy of Sciences, Warsaw.

GLUCOSE INTOLERANCE AMONG DOGRIB INDIANS OF THE NORTHWEST TERRITORIES

EMOKE J. E. SZATHMARY
McMaster University

Maturity-onset diabetes has reached epidemic proportions in North American native populations of the United States. The rise in the incidence of this disease is sudden, for diabetes appears to have been unknown 2 to 3 generations ago. Studies suggest that both environmental and genetic factors are involved in the onset of the disease. Of these, obesity and the inheritance of a major gene have been singled out as important variables in the etiology of MOD.

This study reports preliminary findings of a survey designed in part to determine the current status of glucose tolerance in an Indian population of the Northwest Territories, and to determine the association of obesity and glucose tolerance.

Approximately 25% of adult Dogrib Indians (159 persons) were given oral glucose

tolerance tests. Of these, 3 presented with fasting hyperglycemia (plasma glucose ≥ 140 mg/dl). Thirty-five persons were abnormal on two-hour values (plasma glucose ≥ 160 mg/dl), yielding a prevalence estimate of 22% for glucose intolerance. Clinical diabetes is unknown in the Dogrib, and glucose intolerance among northern Athapaskans has until now been reported to be negligible.

Skinfold measurements were obtained on 159 persons at eight different body sites. Significant correlation occurs with 2-hour glucose values > 160 mg/dl in men at subscapular, suprailiac, abdominal, forearm and lower neck sites, and in women at all of the former plus triceps, medial calf and midaxillary sites. No correlations occur in men between any skinfold and 2-hour glucose values ≤ 160 mg/dl. Similar findings occur for the women, except that the lower neck skinfold value was still significant. These results indicate that in this group, as in many though not all others, obesity and hyperglycemia are associated.

VARIATIONS IN THE VERTEBRAL COLUMNS OF AUSTRALIANS AND POLYNESIANS

WILLIAM D. WADE
University of Manitoba

The vertebral columns of 454 native Australians and 73 Polynesians were examined for anomalies associated with the inter-segmental borders. These are hypothetically attributed to the general phenomenon of "caudal shifting", a model that serves to relate a profusion of variations in the vertebral column that have been interpreted in rather disparate and unrelated ways, hopefully serving the end of explanatory simplification. Several consequent conclusions of the proposed model are supported, in varying degree, by the reported data from the Pacific and other skeletal samples. Other propositions of the model are essentially untested and require verification.

CUSP SIZE IN PONGIDS

LAUREN R. WILLIAMS
University of Toronto

(Complete paper published in Vol. 1, No. 2)

1981 ANNUAL MEETING

The ninth annual meeting of the Canadian Association for Physical Anthropology/l'Association pour l'Anthropologie Physique au Canada will be held 10-13 December 1981 at the Banff Centre. Registration will cost $20, and room rates will be $39/day (single) or $30/day (shared). These rates will include three meals a day. Session information, titles and abstracts of papers, and requests for further information should be addressed to:

Dr. James D. Paterson
Department of Anthropology
University of Calgary
2500 University Drive
Calgary, Alberta T2N 1N4

NEW JOURNAL

Dr. P. Dash Sharma, Executive Secretary of the Sarat Chandra Roy Institute of Anthropological Studies, Ranchi, India, has informed us of the imminent appearance of a new journal, *South Asian Anthropologist.* It will publish on South Asian regional topics in all fields of anthropology and will appear biannually in March and September. It has an international editorial board. Annual subscription rates are $8.00 (U.S.), $11.00 (U.S.) for institutional subscriptions, including surface mailing. All correspondence should be directed to Dr. P. Dash Sharma, Executive Secretary, SRIANS, 18 Church Road, Ranchi – 834001, Bihar, India.

CANADIAN REVIEW OF PHYSICAL ANTHROPOLOGY
REVUE CANADIENNE D'ANTHROPOLOGIE PHYSIQUE

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