THE UPPER CERVICAL
NUCCA MONOGRAPH

Vol. 2, No. 9 July, 1980

THE CENTER OF GRAVITY OF THE SKULL

by Daniel C. Seemann, Ph.D.

The Problem

Most segments of the body have been investigated as to weight, volume, and center of mass, except for the head. As a consequence there is no agreement as to the exact location of the center of gravity of the head or skull.

For chiropractors who adjust the atlas, locating the center of gravity of the head is critical for the adjustment, because knowing where the center of gravity is determines how the head is placed on the head piece. It is becoming apparent that for some types of adjustments slight change of head position determines whether the vertebra will move or not.

History

Interest in determining the center of gravity of the body dates back 300 years. Borelli (1679) found the CG of the body by having nude men lie on a rigid platform resting on a pivot. An approximation of the CG was acquired by moving the platform back and forth until the platform balanced.

More than 150 years later the Webers (1836) improved on the accuracy of the CG by using a platform that was fixed at the center. A body was then shifted in one direction until the platform tilted and then shifted in the other direction until the platform tilted. The CG was then calculated by taking the mean between the two tilt points.

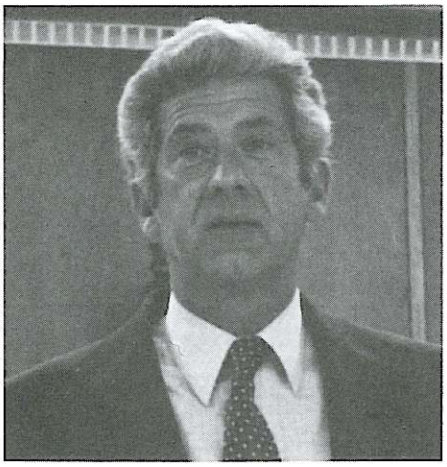
Harless (1860) continued the work of the Weber brothers using the shift technique to find the CG of body segments. He used two cadavers and divided the body into 18 major parts.

Von Meyer (1863) determined the CG along two axes. He was one of the first investigators to use the orthogonal axis system which is now used by anatomists and kinesiologists. Using

(Continued page two)

ANTHROPOMETRY AND SPINAL BIOMECHANICS

Robert T. Anderson, Dr. U.P., Ph.D.



Dr. Robert T. Anderson, lecturing at 1980 NUCCA Convention.

Director of Research, Pacific States Chiropractic College, Professor of Anthropology, Mills College

Read under the title, "From Physical Anthropology to Chiropractic," at the 14th Annual NUCCA Convention, Monroe, Michigan, May 3-6, 1980.

AN ANTHROPOLOGICAL FAILURE

From Winick's **Dictionary of Anthropology** we learn that anthropometry is "the branch of physical anthropology devoted to the measurement of humans. It includes measurements that are taken on both skeletons and living persons."[1] As a research field it took its start at the end of the eighteenth century when J.F. Blumenbach and others initiated the scientific study of human racial variation. Perhaps the earliest systematic exercise in anthropometry was carried out in 1794, when an early investigator found that the forearm of Blacks in proportion to the upper arm tends to be longer than is the case with Whites. By the first half of the nineteenth century, the small number of professional anthropologists then active succeeded in carrying out voluminous studies, including Morton's **Crania Americana** published in 1839 and his **Crania Aegyptica** in 1844.

By the opening of the twentieth century, anthropometry dominated the field of anthropology insofar as it was concerned with racial biology. In many ways, anthropometry had grown in sophistication. It started with efforts limited to **linear measurements.** The basic question seemed to be, "How long or wide is this bone?" By the end of the nineteenth century more complex **angular measurements** were com-

(Continued page six)

mathematical descriptions (ellipsoids and spheres), Von Meyer was able to estimate the CG for each of the major segments of the body.

Braune & Fisher (1889) used a different technique to find the CG of the body which was considered more accurate than the previous methods. They drove three rods into frozen tissue of a cadaver. Each segment was hung from an overhead from three different axes. The intersection of the planes gave the location of the CG. The Braune & Fisher work has been used extensively up to the present.

Braune & Fisher found that the weight of the head ranged from 3880 grams to 5350 grams. The average for the heads that they examined was 4300 grams or approximately 9.4 pounds. Dempster (1955) determined that the average weight of the head was 4600 grams or slightly over 10 pounds.

The Dempster study (1955) is considered the most comprehensive work about weight, volume and center of mass of the body up to the mid century. He used eight cadavers which doubled the number of subjects used previously. Despite the criticism that the cadavers were old and atypical of the population, the raw data that Dempster generated is the most widely used today.

Barter (1957) using information from Braune, Fisher and Dempster, prepared a series of regression equations for predicting segment weights from the body weights. The importance of these equations is that most designers and engineers still use these equations as anthropometric criteria in matching man with machine.

In 1966, Drillis & Contini published a detailed study of the body segments. They used two systems to determine weight and volume of living subjects. Volumes were found by emersion of the body segments in water and the weight of segments were determined by the reaction method using highly sensitive weighing apparatus.

During the 60's mathematical models became popular. Whitsett (1962) developed a model to approximate mass distribution, center of mass, moments of inertia, and mobility of the human body. His primary concerns were the biodynamics of the body to conditions of weightlessness. He used the data from Dempster (1955) and from Barter (1957). Another study of note was Santschi et al (1963) who found that the moments of inertia of the body in eight different positions correlated well with stature and weight. They found by using anthropometric data they could easily obtain the location of the subject's center of mass and moments of inertia. This information was used for space research.

A summary of the literature shows there has been a reasonable amount of research done on centers of mass and volume both with live subjects and cadavers. It is interesting to note how few cadavers were used in establishing the standards for the indexes used in man/machine design. What is lacking is that no one determined the center of gravity of the head. A computer search from 1966 to 1980, revealed that no articles dealt with the CG of the head. A further check with experts in the field of craniometry confirmed that the search was valid. No one had thought to determine the center of gravity of the head and skull.

THEORIES CONCERNING THE CG OF THE HEAD AND SKULL

Several anatomists and kinesiologists have theorized as to where the CG of the head is located. The following sources are cited.

Steindler (1977) "The foramen magnum occupies almost a horizontal plane (only 7-21 degrees slope with the horizontal), and the atlanto-occipital joint is situated precisely below the center of gravity of the head so that the latter is balanced upon it."

I.A. Kapandji (1976) "The head taken as a whole constitutes a lever system; the fulcrum lies at the center of the occipital condyles; the force G is produced by the weight of the head applied through its center of gravity lying near the sella turcica; the force F is produced by the posterior neck muscles which constantly counterbalance the weight of the head, which tends to tilt forward."

F.P. Jones (Alexander Technique) (1976) "In the system of forces acting on the head the center of gravity plays a major role. On the surface it is conventionally located in the Frankfort plane halfway between the tragon of the ear and the low point of the orbit. In the sagittal X-ray it is located in the sella turcica, a landmark that is defined as the 'depression in the superior surface of the body of the sphenoid bone which houses the hypophysis cerebri (pituitary gland)'".

E.R. Tichauer (Ergonomics) 1973 "This is exemplified by the arrangement of those musculo-skeletal structures as are involved in the head movement in looking up and down. The atlanto-occipital joint acts as the fulcrum of the first class lever because the muscles of the neck provide the force necessary to extend the head. This is counteracted by gravity on the center of mass of the head which is located on the other side of the joint, and hence constitutes an opposing flexing weight."

There is agreement as to where the fulcrum is located in the head which is the atlanto-occipital joint, and there is agreement that the head acts as a resistance. But there is disagreement as to where the CG is located. Steindler feels that the CG is located beneath the foramen magnum; Kapandji and Jones think the CG is located at the sella turcica; and Tichhauer says the CG is located anterior to the atlanto-occipital joint. See Figure 1.

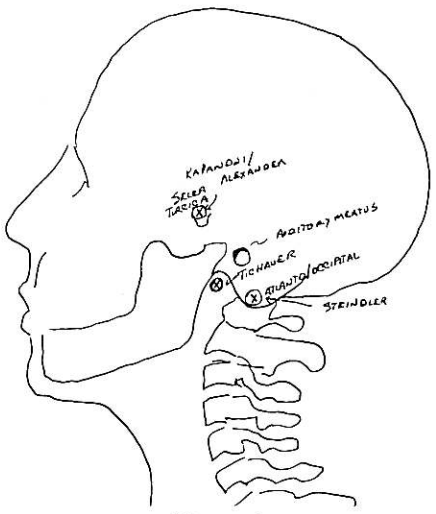


Figure 1
The center of gravity of the skull as proposed by various theorists.

Pilot Study

For the past year, NUCCA research has been focusing attention on head placement as an important aspect of the adjustment process. It has been noted that with some patients a slight realignment of the head on the head piece would enable the adjustor to move the vertebra where previously the vertebra would not move. It became apparent that head alignment was as important as the other facets of adjusting. Since the CG of the head seemed to be a crucial variable in the system and information about the CG was not available from the other disciplines, NUCCA decided to find out where the CG was located.

Method

Using the procedure suggested by Braune & Fisher (1889) a skull was hung from a vertical support along three positions from the mid-sagittal line of the skull. The intersection of the three planes was marked on the skull which determined the CG of the skull. See Figure 2.

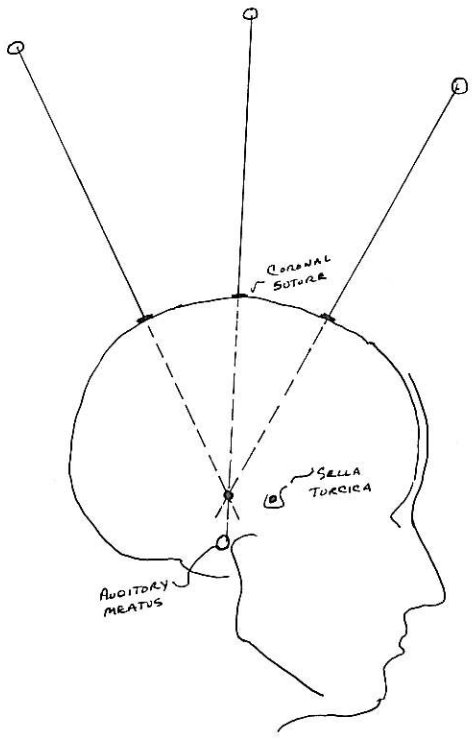


Figure 2
The center of gravity of the skull as proposed by NUCCA.

Two skulls were measured in this manner. The skulls were dissimilar in that one skull was smaller and rounder and the other skull was larger and elongated. It is thought one of the skulls is several hundreds of years older than the other.

Results

Both skulls were found to be in balance when the eye sockets and the Frankfort plane were horizontal. This would occur when the line from the vertical that was attached to the skull ran through the apex of the coronal sutures and the center of the auditory meatus. The intersection of the three planes fell on this line 2½ and 3 centimeters superior to the superior aspect of the auditory meatus of the small and large skull respectively.

Discussion

Determining the CG of the head cannot be confirmed reliably using two skulls as the standard. Obviously more research has to be done. Can it be assumed that the CG of the skull is the same as the head? Clauser et al (1969) states the differences between using live subjects and cadavers may be relative, that the relationship between the two is constant. If this is true, it may be possible to assume that the relationship between a dry skull and a skull with tissue may also be relatively constant. Earlier it was mentioned that an average sized head weighed about 10 pounds. The weight of the brain ranges from 3-5 pounds. It is possible that the boney structure of the skull is equal to the tissue of the head.

The notion that the CG of the head is located slightly above the auditory meatus and on a horizontal line at the mid-sagittal plane of the head seems to be logical because it is along this line that the semi-circular canals are located. The semi-circular canals maintain the body's equilibrium. It is possible that the true center of gravity lies equidistant between the two canals. See Figure 3.

The sella turcica does not seem to be a logical spot for the CG because of its anterior location in the head. It is possible that the sella was thought to be an easily identifiable landmark on a lateral X-ray. In anthropology, the

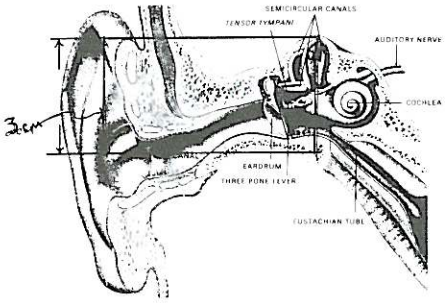


Figure 3
The Spatial relationship between the Auditory Meatus and the semi circular canals.

sella turcica is used as an important landmark when comparing different population groups (Colby & Cleall, 1976).

Steindler (1976) indicates that the CG of the head is directly over the atlanto-occipital joint, which is a few centimeters below the proposed CG of this paper. Most agree that the atlanto-occipital joint is the center of motion, but it does not necessarily follow that the joint is the center of gravity.

During the past year NUCCA has been testing this hypothesis. The new orientation has helped with some of the more difficult cases, especially with opposite to the kink cases. There is a positive feeling that this information will help with the adjustment. This change in the thinking about the CG will have some implications for chiropractic especially with resultants and excessive force.

Implications for Chiropractic

It probably would be appropriate to review the lever system which was described in the January 1978 Monograph (Vol. 2, No. 4). In this article it was written the goal of the adjustment was to reduce the misalignments and return the head to a state of equilibrium. Biomechanically, the head in relationship to the cervical spine, is either a first or second class lever. The head acts as a resistance to the adjustic force (resultant) which is transmitted by the transverse processes of the atlas. The fulcrum is located on the superior articulating surface of the axis. Opposite the kink subluxations are first class levers because the fulcrum is

(Continued page four)

between the resistance and the force. See Figure 4. Into the kink subluxations are second class levers because the resistance is between the fulcrum and the force. See Figure 5.

If the CG of the head is located higher somewhere on a line between the centers of the eye sockets then it is possible that the head should be placed slightly lower on the head piece. The present assumption is that the CG is somewhere on level slightly lower than the foram magnum or at the mastoid process. See Figures 4 and 5.

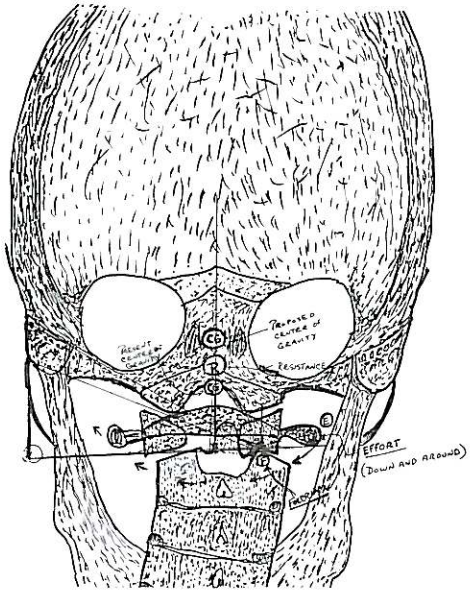


Figure 4
An opposite to the Kink Subluxation.

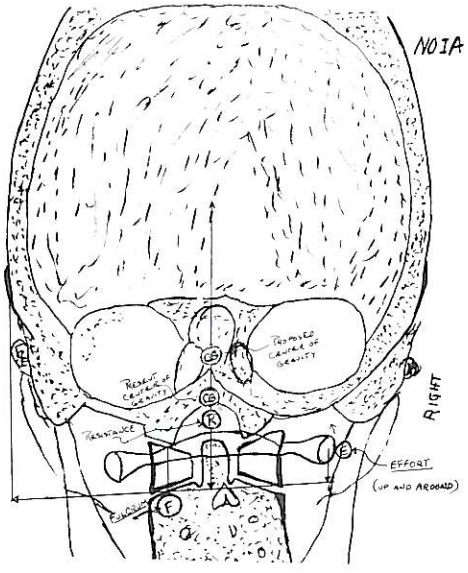


Figure 5
An into the Kink Subluxation.

The effect of the CG being higher in the head can influence how efficient the vertebra will move about the axial circle. If the resultant is too low with into the kink cases the head will not turn. With opposite to the kink cases lowering the head may give the adjustor a better mechanical advantage, especially when the lever arm is short.

With into the kink cases, head placement may not be as crucial as opposite to the kink cases because the adjustor vectors up and around the axial circle. The lever arm is reasonably long and gives a mechanical advantage to the adjustor. In this case the adjustor would need a force of less than 10 pounds to move the vertebra. The transverse process is lateral to the CG and should have sufficient advantage to move the head and the cervical spine.

With opposite to the kink subluxations the adjustor vectors down and around the axial circle. The lever arm is short and gives less of a mechanical advantage. By placing the head as low as possible on the head piece a further advantage is realized. This procedure seems to work in practice.

It is suggested that the head be placed slightly lower than normal on the head piece to compensate for the CG. The bottom of the head piece being located between the mastoid process and the center of the orbits of the eye sockets.

Proper head placement can be very helpful in moving the vertebra, especially when the adjustor feels he has read the film correctly, set his body correctly and has directed the resultant properly.

EXCESSIVE USE OF FORCE AND THE IMPROPER RESULTANT

With the previous discussion on the center of gravity it is appropriate to examine the use of excessive force and an improper resultant. It was indicated earlier that the head weighed approximately 10 pounds. The question is "How much force is necessary to move the head and the cervical spine into proper alignment?" It was indicated earlier to move vertebra in into the kink subluxations a force of 10 pounds was needed and that to move an opposite to the kink, a force of about 30 pounds is needed. Excessive force if the resultant is correct, would result in driving the head and vertebra through their prescribed orbit resulting in a subluxation that is probably worse than the original listing. It is important for adjustors to realize that proper vertors and appropriate force will move vertebra. It is unlikely that excessive force will reduce subluxations properly.

The earlier discussion about the CG of the head also illustrates the need for the adjustor to be extremely precise with the resultant. If the resultant is wrong the head will resist the force. If the force is excessive the head will be forced into a position which will hurt the patient.

NUCCA's understanding of the biomechanics of the upper cervical spine are scientifically valid. It is no longer chiropractically sound to teach that only 12 basic subluxations occur in the upper cervical spine and that these subluxations can be reduced using unlimited and non-specific force. No wonder that 90% of the chiropractors refuse to take post X-rays. They would be horrified at the results. Using the NUCCA listing system, the possible combination of subluxations exceeds 10,000.

In summary, the literature has been reviewed concerning the center of gravity of the body; theories about the center of gravity of the head have been discussed, and a new theory as to the location of the center of gravity of the skull has been offered. Out of all of this the real value may be in alerting the reader that an understanding of the biomechanics of the cervical spine and the head is imperative. Non-specific adjusting and excessive force with the adjustment are the basic reasons why the profession is divided. On the other hand, a system that attempts to abide by scientific rules should, in the long run, pave a better way for all of us.

References

Barter, J.T., 1957. **Estimation of the Mass of Body Segments,** Wright Air Development Center TR-57-260, Wright-Patterson Air Force Base, Ohio. (AD 118 222) (*)

Braune, W. & Fischer, O. 1889. **The Center of Gravity of the Human Body as Related to**

the German Infantryman, Leipzig (ATI 138 452. Available from Defense Documentation Center) (*)

Borelli, G.A. 1680-1681. **De Motu Animalium,** Lugduni Batavorum (*)

Clauser, E., McConville, J.T., & Young, J.W., **Weight, Volume, and Center of Mass of Segments of Human Body,** AMRL Technical Report 69-70, Wright-Patterson Air Force Base, Ohio, 1969.

Colby, W.B., & Cleall, J.F., Cephalometric Analysis of the Craniofacial Region of the Northern Foxe Basin Eskimo, **Am J. of Physical Anthropology, 44,** 1976 (159-170).

Dempster, W.T., 1955. **Space Requirements of the Seated Operator,** Wright Air Development Center TR-55-159, Wright-Patterson Air Force Base, Ohio (AD 87 892) (*)

Drillis, R., & Contini, R., 1966. **Body Segment Parameters,** Office of Vocational Rehabilitation, Department of Health, Education and Welfare, Report 1166-03. N.Y. University School of Eng. and Sci. New York. (*)

Harless, E. 1860. The static moments of the component masses of the human body., **Trans. of the Math-Phys.,** Royal Bavarian Acd. of Sci., 8(1,2); 69-96, 257-294. Unpublished English Translation, Wright-Patterson Air Force Base, Ohio (*)

Jones, F.P., **Body Awareness In Action,** New York: Schocken Books, 1976.

Kapandji, I.A., **The Physiology of the Joints,** London: Churchill Livingston, 1974.

Santschi, W.R., Dubois, J., & Omoto, C., 1963. **Moments of Inertia and Centers of Gravity of the Living Human Body,** AMRL-TDR-63-36, Aerospace Medical Research Laboratories, Wright-Patterson Air Force Base, Ohio. (AD 410 451)

Seemann, D.C., **Biomechanics of the Upper Cervical Vertebrae,** The Upper Cervical Monograph, Vol. 2, No. 4, Jan., 1978.

Steindler, A., **Kinesiology of the Human Body,** Fifth printing, Springfield: Charles Thomas, 1977.

Tichauer, E.R., **Ergonomic Aspects of Biomechanics,** The Industrial Environment—Its Evaluation & Control, U.S. Government Printing Office, 1973. S/N 017-0001-00396-4

Weber, W., Weber, E., 1836. **Mechanik der menschlichen Gehwerkzeuge.,** Gottingen. (*)

Whitsett, C.E. 1962. **Some Dynamic Response Characteristics of Weightless Man, Master of Science,** Air Force Institute of Technology, Wright-Patterson Air Force Base, Ohio. (AMRL-TR-63-18 AD 412 541) (*)

White, A.A., & Panjabi, M.M., **Clinical Biomechanics of the Spine,** Philadelphia: J.B. Lippincott Company, 1978.

Von Meyer, H. 1873. **Statics and Mechanics of the Human Body.** Engelmann, Leipzig. Unpublished English Translation, Wright-Patterson Air Force Base, Ohio. (*)

(*) These references were all cited in Clauser et al. The original sources are cited to assist interested researchers.

CHIROPRACTIC DIALOGUE

In the last issue of the Monograph, the **National Upper Cervical Chiropractic Research Association, Inc.** (NUCCRA) discussed some of its reasoning based on its research findings. The purpose of this discussion was to stimulate an exchange of ideas within the profession.

For several years, NUCCRA has supported the theory that a C1 subluxation is the most damaging subluxation that can occur in the spinal column. NUCCRA has presented neurological and biomechanical evidence through its own research that a subluxated C1 is a stressor—a harmful factor—which is always accompanied by a syndrome: over-innervation of the motor neurons of the spinal cord, spastic contracture of the extensor musculature of the spinal column, imbalance of the pelvic girdle, distortion of the spinal column, and the short or contractured leg.

NUCCRA has demonstrated through years of research that the C1 syndrome can be corrected only from the occipital-atlanto-axial area of the cervical spine; that a corrective adjustment of C1 restoring balance between the inhibitory and excitatory neurological mechanisms in the reticular formation of the brain stem is essential to alleviation of the syndrome. A subluxation in any other area of the spinal column can not cause a facilitated spinal cord, nor can an adjustment in any area of the spinal column other than C1 normalize nervous flow through the spinal cord.

Because of the results of the rigorous measurement procedures used by NUCCRA, the theory becomes a law. Webster defines a law as "a statement of an order or relation of phenomena which, so far as known, is invariable under given conditions". Thousands of cases analysed and tested support the theory, and correlations between the C1 subluxation and the syndrome reinforce it.

The law may be stated: Every subluxated person has a subluxated C1 that stresses the central nervous system and produces a subluxated (facilitated) spinal cord and is manifested by a syndrome that is proportionate to the degree of the C1 subluxation-stress.

The majority of chiropractors are apparently not in agreement with NUCCRA research findings. Yet, how many chiropractic systems have been, or are being, subjected to sufficient or acceptable research? How many have the built-in degree of predictability that NUCCA techniques have?

These questions presuppose another valid question: How many chiropractic techniques have undergone adequate testing procedures that assure benefit to and safety for the patient? In this age of increased consumer protection, this question goes to the protection of the profession as well as the patient.

NUCCRA functions for the benefit of the patient, the profession, and the chiropractor. That benefit can be greatly enhanced by a sound expression and positive interchange of ideas among practitioners. From this interchange, all parties will be enriched. NUCCRA invites your comments.

DONATIONS TO NUCCRA

THE NATIONAL UPPER CERVICAL CHIROPRACTIC RESEARCH ASSOCIATION, INC. (NUCCRA) is indebted to those who have generously contributed to its research program. These donations profit the patient, the doctor, and the profession by helping to pay for the release of educational data, by keeping the doctor abreast of the latest research findings, and by helping to finance research.

Listed below are the names of recent donators:

Dr. C. F. Aumann	Indiana
Mr. B. L. Bushman	Oklahoma
Dr. John Clark	Texas
Dr. T. R. Elliott, Jr.	Oklahoma
Dr. M. Farris	California
Dr. Helen Fair	Texas
Dr. John Houtman	California
Dr. Christopher Kemper	California
Dr. Andrew Miller	Michigan
Mr. J. Peter McNerney	Ohio
Dr. Donald K. Moon	Ohio
Dr. Kazuo Nakano	California
Mr. John Savage	Ohio
Dr. Louis H. Tiscareno, Jr.	California

Contributions to NUCCRA are deductible under the scientific status that has been granted NUCCRA by the Internal Revenue Service.

puted. This allowed investigators to describe prognathism of the face in numerical terms, for example, and represented a sharp advance over earlier qualitative assessments. Finally, the technique of description by means of **indices** emerged in which relationships between parts could be expressed arithmetically. The most famous of these is undoubtedly the cephalic index (CI) which defines the shape of the cranium. To compute the CI of a subject, the width of the skull (from euryon to euryon) is divided by the length (from glabella to opisthocranium) and multiplied by 100. This yields a classification of head shapes.

Dolichocephalic (long headed)—
CI 75 or less
Mesocephalic (medium headed)—
CI 75 to 80
Brachycephalic (round headed)—
CI 80 or more

Two centuries of energetic research in anthropometry produced an enormous amount of information. When Garrett and Kennedy summarized this achievement in 1971, it required two volumes, each the size of a San Francisco telephone book, to condense it.[2] Yet this vast compilation of data is marred by shortcomings which make it virtually useless for most purposes. Among these, as concerns the healing arts, is the fact that it includes scarcely any measurements of the vertebral column. In addition, it reports almost solely on static osseous relationships. How one part moves in relationship with another eluded, if indeed it even interested, several generations of researchers.

Even with respect to basic static structures, investigators seemed defeated by the complexity of the spine. Older anthropologists, some of whom are still active today, were trained with **A Laboratory Manual of Anthropometry** compiled by Harris H. Wilder. Wilder was clearly puzzled by the problem of measuring variation in the curvature of the spine.[3] "The ideal and only complete method of studying this and other curves of the vertebral column is by means of accurately made sagittal sections taken through frozen bodies," reasoned Wilder, "but owing to the obvious difficulties, this has been done in only a few cases." Obviously not disheartened, Professor Wilder concluded, "Much can be done, however, by the study of the separate vertebrae, since the character of the curve is conditioned largely by the proportions of the bodies of the vertebrae involved."[4]

This cumbersome method, of questionable validity for the spine as a whole, lost any semblance of usefulness by being applied only to the lumbar spine on the unexamined assumption that variation in the dimensions of these five vertebrae expressed variations in the complex S-curve of the axial skeleton as a whole. Following the same principles that were used in developing the Cephalic Index, Sir William Turner developed a General Lumbar Index (GLI) by dividing the dorsal vertical diameters of L1-L5 by the ventral diameters and multiplying by 100. And just as a classification of head shapes was devised using CI, a typology of spines emerged out of the GLI.[5]

Curtorhachic (kyphotic)—
GLI 98 or less
Orthorhachic (straight)—
GLI 98 to 102
Coelorachic (lordocic)—
GLI 102 or more

The absurdity of this approach becomes even more evident as Turner categorizes human populations on this basis.

12 Europeans curtorhachic	Mean GLI 96
5 Australians coelorachic	106
2 Andamanese orthorhachic	99
3 Negroes orthorhachic	99
3 Hawaiians coelorhachic	104

Not only did Sir William make no effort to exclude pathology in his characterizations of racial variation, or to relate differences to cultural practices which can affect spinal biomechanics, he did not even examine living subjects, since this method, unlike the CI, can only be used with skeletal material. From start to finish, in short, this one major anthropometric effort to cope with mensuration of the human back failed both in concept and in application. It documents the failure of anthropology as a profession to quantify variation in spinal dimensions, in spinal movement, and in spinal pathology. Anthropometry was defeated by the complexity of the problem.

Independently of anthropometrists, Doctors of Chiropractic, struggling to learn more about the functioning of the spine in order better to succeed in their healing profession, moved in three separate, yet interrelated ways, to measure functional relationships in the spine. Clinicians rather than scientists, they succeeded where scientists failed. They developed techniques for visualizing the spine in dynamic rather than static terms, and for quantifying their findings. This they achieved through (1) roentgenography, (2) heat measuring devices, and (3) instruments which measure osseous relationships within the axial skeleton in living subjects, and which, unlike x-ray, are not harmful.

X-RAY AS AN ANTHROPOMETRIC INSTRUMENT

Professor Wilder, in his laboratory manual of anthropometry, did not even mention the possibility of using x-ray as a research tool. That was in 1920. Yet the x-ray tube had been known since 1895. B.J. Palmer brought the first x-ray machine to Palmer School of Chiropractic in 1910 and took his first spinal x-ray in 1913. The year 1920 was the year in which he made the first full-spine radiograph. It is understandable, given the time and circumstances, that Wilder did not learn of the experimental work of Dr. Palmer. But why, we may ask, did he and his colleagues in anthropometry fail to show some of the initiative that characterized chiropractic?

This question remains especially perplexing in view of the fact that in the decades before and after the turn of the century, European scholars led the field in anthropometry. European physical anthropologists, then as now, normally held their appointments in schools of medicine rather than the liberal arts, where cultural and social

anthropologists were appointed. European physical anthropologists, as a result, rubbed shoulders professionally with professors of medicine. Medical radiologists, for their part, did develop techniques for mensuration. Chamberlain, McGregor, McRae, Fergusson and others come immediately to mind as medical innovators who systemized radiography in this way. Yet we find very little use of x-ray by anthropometrists, and none that led them to cope better with the baffling problem of measuring and describing the spine.

Chiropractors, on the other hand, built substantially upon the pioneering efforts of B.J. Palmer. We see this for the spine as a whole in the refinements of C.S. Gonstead. It became even more refined in the upper cervical work of Ralph R. Gregory and John Grostic. Designated as NUCCA, it is especially striking that the cervical work presently carried on by Dr. Gregory succeeds so well, because medicine confirms what chiropractors and anthropologists know, that this area of spine constitutes an exceedingly difficult area in which to work with x-ray. "Radiology of traumatic injuries to the upper cervical spine continues to be a perplexing problem to all physicians," observes Robert Shapiro, M.D., Clinical Professor of Radiology at Yale University School of Medicine, writing with two of his associates in that department. "Nothing is more confusing (either to the resident in the emergency room at 3:00 a.m. or to the attending radiologist later in the day) than a myriad of poorly exposed, poorly positioned views of the atlanto-axial joints. Fracture or no fracture? Subluxation or no subluxation? Normal or abnormal? There are few areas," concludes Shapiro and his associates, "where correct, on-the-spot radiologic interpretation is more crucial to the management of the patient. Although much has been written on this subject, considerable confusion remains."[6]

It is not the purpose of this paper to examine the clinical value of NUCCA x-ray analysis. Rather, it is the scientific usefulness of this radiographic technique that is of interest. This we may illustrate from an investigation carried out by the Research Department of Pacific States Chiropractic College in which we utilize NUCCA film analysis as a technique for the examination of movement at the atlanto-occipital articulation.[7]

Chiropractors and osteopaths agree with medical authorities that rotation takes place at the atlanto-axial joint. They also assert, however, that rotation occurs between atlas and the occiput. This completely contradicts medical findings, which consistently report that no rotation (0°) takes place at the atlanto-occipital articulation. Each of the five medical works cited below asserts categorically that no rotation occurs at this site.[8] The only medical authority to state differently is I.A. Kapandji, who describes 12° rotation between atlas and occiput.[9] Yet the Kapandji book is designed as a teaching aid for students and does not cite sources, so we are not told what research lies behind this solitary deviation from medical lore. We can, however, report our own research, which confirms the findings of Kapandji.

An examination of the initial, pre-adjustment, vertex radiographs of 804 patients, taken from the files of NUCCA practitioners, and measured according to NUCCA standards, revealed the following amount of rotation between atlas and occiput.

0°	12.50%
1°	28.50%
2°	22.00%
3°	16.00%
4°	10.50%
5°	6.00%
6°	2.50%
7°	1.00%
8°	0.40%
9°	0.50%
10°	0.05%
11°	0.05%

(NB: 12° or less rounded off to the next lower degree. N = 804.)

Although these films represent a momentary, static view of the atlanto-occipital articulation, it seems reasonable to assume that they represent the amount of rotational movement that is possible. This assumption finds additional support in a second set of films. From 309, patients for each of whom we had four sets of x-rays (one initial set and three post-adjustment sets), we could document actual movement. That is, for each set we calculated the amount of change in degrees from the initial finding (listing) to each of three subsequent findings. Combining all of these for a total of 883 individually measured shifts from a documented initial position, we found as follows.[10]

Degrees of movement	Percentage of Radiographe Examples
0°	28.00%
1°	31.50%
2°	18.50%
3°	8.00%
4°	5.00%
5°	3.00%
6°	2.00%
7°	1.50%
8°	0.50%
9°	0.50%
10°	0.50%
11°	0.25%
12°	0.25%
13°	0.25%
14°	0.25%

(NB: 1/2° or less rounded off to the next lower degree. N = 883.)

On the basis of this investigation, and of others not reported upon here, we conclude that chiropractic x-ray techniques can be highly useful as tools of analysis in the study of spinal biomechanics.

HEAT SENSING DEVICES AS ANTHROPOMETRIC INSTRUMENTS

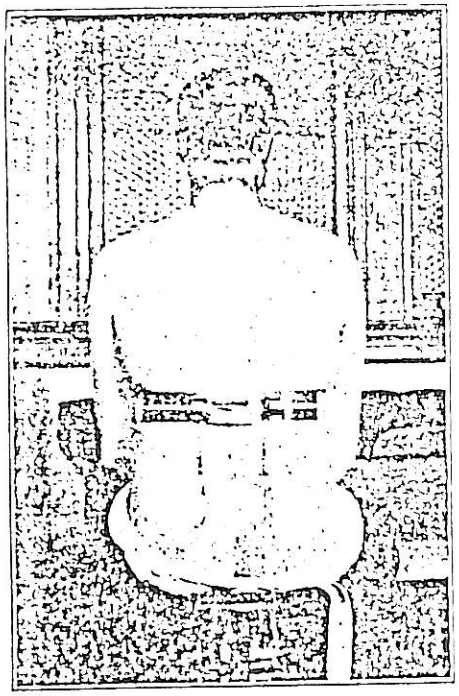
In 1924 B.J. Palmer shocked the chiropractic world—not for the first time and not for the last—when he introduced the concept of measuring thermal variation along the spine by means of a thermocouple-gauge device which he termed the neurocalometer. Based upon a method of measuring heat differentials by the thermoelectric method developed by T.J. Seebech in Germany in 1822, the neurocalometer exists today in a number of versions and spinoffs. A NUCCA method for the analysis of the graph readouts of devices of this sort seems clearly to have a good research potential, but since we have not yet had the opportunity to explore this poten-

tial ourselves, we pass on to the third category of the chiropractic devices capable of anthropometric application.

INSTRUMENTS TO MEASURE RELATIONSHIPS WITHIN THE AXIAL SKELETON IN LIVING SUBJECTS

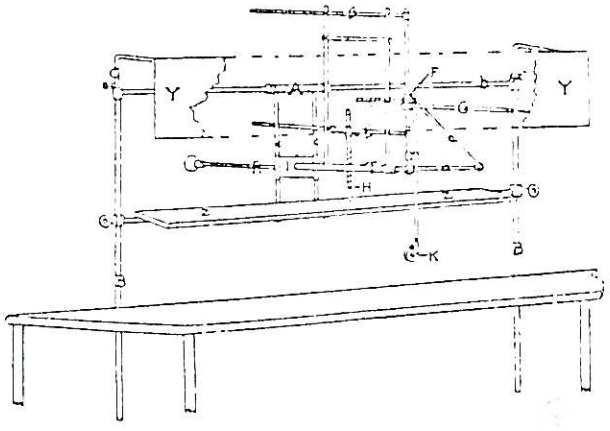
Although x-ray provides an excellent tool for accurate visualization of relationships and movement in the human spine, the dangers of x-ray exposure make it inappropriate for many kinds of research. Alternative devices, however, have proven extraordinarily difficult to devise. This becomes clear as we examine early efforts in this direction.

Anthropometrists did not even attempt to make measurements of this kind. Clinicians did, however. As early as 1906, an osteopath, Frank M. Vaughan, D.O., constructed what he termed an Iliometer to measure the amount of deflection in innominate lesions.[11] By means of two spirit levels attached to a metal belt strapped around the midsection of the body, differences between the two posterior superior spines of the ilia could be calculated (figure 1).



(Figure 1)

Far more elaborate was another osteopathic device, the **Spinograph** of Herman F. Goetz, D.O. (figure 2). Looking much like a Rube Goldberg contraption, it was designed ". . . for the purpose of recording graphically all spinal curvatures, that is, recording anterior, posterior, right and left lateral spinal curvatures simultaneously."[12]



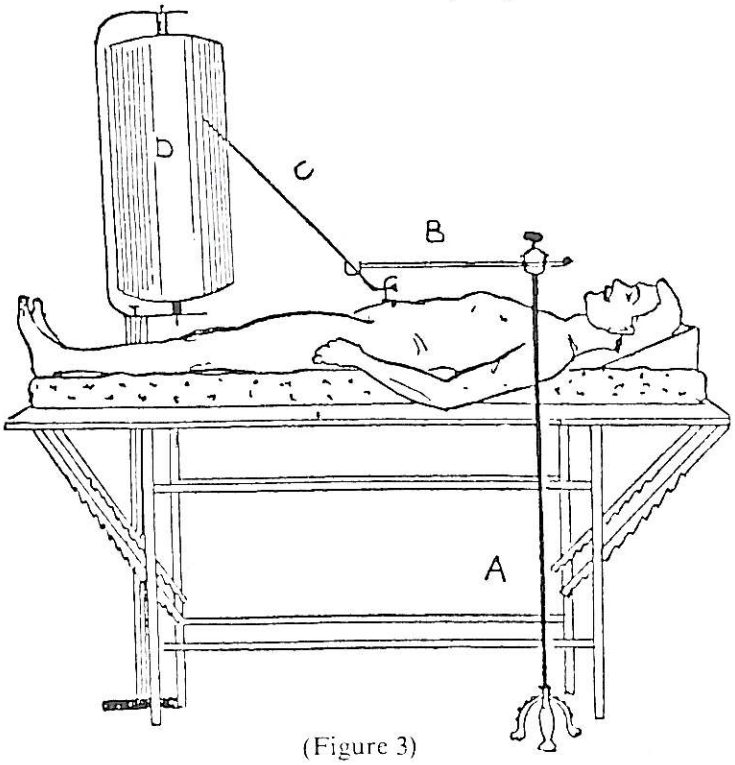
(Figure 2)

Perhaps the biggest failure of these early efforts was designed by Albert Abrams, M.D., a one-time professor of pathology at Cooper Medical College (later to become Stanford University Medical School). His 1910 "apparatus for taking a spondylogram" produced tremulous graph readouts purported to represent vertebral mobility, but recorded ventrally from the abdomen and chest (figure 3).[13] It is hard to accord them any significance whatsoever.

The purpose in looking at these old devices for measuring relationships in the spine is to indicate that the effort started three-quarters of a century ago, that the complexity of the problem is enormous, and that early efforts necessarily floundered and failed. So far as we can determine, osteopaths and allopaths gave up the effort. Chiropractors persisted. Without question, the most elaborate product of this persistence is the Anatometer developed by Ralph R. Gregory, D.C., in collaboration with Daniel C. Seemann, Ph.D.

Because an anatometer is not available to the PSCC Department of Research, we explored the potentiality of this kind of instrument by resorting to the simpler but related device developed by Lyman Johnson, D.C., and produced now by Larry Allen, D.C., under the name of Gravity Stress Analyser (GSA).[14]

With the assistance of two anthropology students at Mills College, we used the GSA in a pilot study to determine the extent to which pelvic misalignments and other spinal distortions may occur in populations that are presumed in every way to be physically healthy and normal. As a pilot study, these findings are suggestive rather than definitive. Our subjects, a cohort of 43 young women, all be-



(Figure 3)

tween the ages of 17 and 23 and without symptomotology, insisted that they felt well and considered themselves normal as concerns musculoskeletal health. Yet in 74% of these subjects we could measure some form of misalignment in the axial skeleton. Pelvic rotation was identified in 51% of the sample. These findings are dramatic, and provide a basis for preparing a research program to identify more precisely the extent to which various populations, both of the United States and in other parts of the world, deviate from that condition of bilateral symmetry that is generally assumed to prevail.[15] With chiropractic instruments such as the anatometer and the GSA, this type of research can be undertaken without posing any threat to the health of the human subjects involved.

CONCLUSION

Chiropractors at this time look to scientific researchers to test their claims and explore the implications of these claims. It is heartening to learn that while chiropractic expects to profit from science, it also has contributions of its own to make to science. As concerns anthropology, x-ray analysis, heat sensing devices and non-intrusive instruments such as the anatometer illustrate that while chiropractic and the other healing arts may expect to benefit from ongoing and anticipated anthropometric research, that research itself may be expected to build substantially upon instrumentation developed by chiropractors.

References

1. Charles Winick, **Dictionary of Anthropology,** Ames, Iowa: Littlefield Adams and Company, 1958, pg. 30.
2. J.W. Garrett and K.A.R. Kennedy, **A Collation of Anthropometry,** Wright-Patterson Air Force Base, Ohio: Aerospace Medical Research Laboratory, Aerospace Medical Division, 1971.
3. Others did even less well. See Ales Hrdlicka, **Practical Anthropometry.** Philadelphia: Wistar Institute of Anatomy and Biology, 1939; Georges Oliver, **Practical Anthropometry.** Springfield, Illinois: Charles C. Thomas, 1969.
4. Harris H. Wilder, **A Laboratory Manual of Anthropometry.** Philadelphia: P. Blakiston's Son and Company, 1920.
5. Sir William Turner. "Report on the Human Crania and Other Bones of the Skeletons Collected During the Voyage of H.M.S. Challenger in the years 1873-76. Part II. The Bones of the Skeleton." **Zoology,** Vol. XVI, pp. 1-136.
6. Robert Shapiro, Arne S. Youngberg, Stephen L.G. Rothman, "The Differential Diagnosis of Traumatic Lesions of the Occipito-Atlanto-Axial Segment." **Radiologic Clinics of North America,** Vol. XI, No. 3, December 1973, pg. 505.
7. We are indebted to George E. Anderson, D.C., Chairman of the Board of Regents of PSCC, for encouraging us to undertake this research and for help in carrying it out.
8. J.W. Fielding, "Cineroentgenography of the Normal Cervical Spine," **Journal of Bone and Joint Surgery,** Vol. 39-A, No. 6, December, 1957, pg. 1282; M.D. Jones, "Cineradiographic Studies of the Normal Cervical Spine," **California Medicine,** Vol. 93, No. 5, November, 1960, p. 295; M. Hohl, "Normal Motions in the Upper Portion of the Cervical Spine," **Journal of Bone and Joint Surgery,** Vol. 46-A, No. 8, December, 1961, pg. 1777; R. Shapiro, **et al.,** "The Differential Diagnosis of Traumatic Lesions of the Occipito-Atlanto-Axial Segment," **Radiologic Clinics of North America,** Vol. XI, No. 3, December, 1973, p. 514; A.A. White, III and M.M. Panjabi, **Clinical Biomechanics of the Spine.** Philadelphia: J.B. Lippincott, 1978, p. 65.
9. I.A. Kapandji, **The Physiology of the Joints. Volume Three: The Trunk and the Vertebral Column.** New York: Churchill Livingstone, 1974, pp. 182, 212, 214-5.
10. For a complete report, see Robert T. Anderson, "Rotation in the Atlanto-occipital Articulation." **MSS.**
11. Frank M. Vaughan, "Description of the Iliometer." **Journal of the American Osteopathic Association,** Vol. 13, No. 1, September 1913, pp. 18-19.
12. H.F. Goetz, "The Graphical Representation of Spinal Curvatures: A New Spinograph." Journal of the American Osteopathic Association, Vol. 6. No. 6, February, 1907, p. 209; see also, H.F. Goetz, "Graphic Representation of the Curves of the Spinal Column." **Journal of the American Osteopathic Association,** Vol. 7, No. 5, January, 1908, pp. 193-200.
13. Albert Abrams, **Spondylotherapy: Spinal Concussion and the Application of Other Methods to the Spine in the Treatment of Disease.** San Francisco: Philopolis Press, 1910, pp. 42-44.
14. We are grateful to Dr. David Stewart of San Bruno, California, for his generosity in making a GSA available to us, and for his counsel in interpreting our findings.
15. As in, for example, H.M. Moran, **et al.,** "Spinal Mobility in the Adolescent." **Rheumatology and Rehabilitation,** Vol. 18, 1979, pp. 181-185.

ANNOUNCEMENT

Dr. Teresa A. Denton

Dr. Teresa A. Denton announces her association in practice with Dr. Ralph R. Gregory, 217 West Second Street, Monroe, Michigan.

Dr. Denton graduated cum laude from the Sherman College of Chiropractic in Spartansburg, South Carolina in December of 1979. A native of Oklahoma, she received her undergraduate education at the University of Oklahoma and Northeastern Oklahoma State University.

In addition to attending the educational conferences and seminars of the National Upper Cervical Chiropractic Association, Inc. (NUCCA), Dr. Denton interned with Dr. Thomas R. Elliott, Sr. of Tulsa, Oklahoma.

Dr. Denton is a diplomate of the National Board of Chiropractic Examiners. In January of 1980, she received her Michigan State License.

Dr. Denton plans to make Michigan her permanent home.

The Upper Cervical
MONOGRAPH
Published by
THE NATIONAL UPPER CERVICAL CHIROPRACTIC ASSOCIATION, INC.
EDITOR:
Dr. Ralph R. Gregory
221 West Second Street
Monroe, Michigan 48161

NUCCA Scholarship Awards

At its October 22, 1977 meeting, the NUCCA Board received with thanks the $500.00 donation sent by Mrs. Upton X. Furman of Neenah, Wisconsin in memory of her late husband, Dr. Upton X. Furman, who died April 22, 1977. Dr. Furman was a supporter and long time member of NUCCA. The NUCCA Board voted to use the donation to help fund the Scholarship Awards as Dr. Furman often expressed his interest in college students and their financial problems. This is also in accordance with Mrs. Furman's wishes.

The NUCCA Board approved a continuation of the $250.00 scholarship grant-in-aid for the next three years, and that this sum be paid to any chiropractic student currently enrolled in a chartered college of chiropractic who submits to the **Monograph** editor an acceptable article pertaining to the upper cervical spine.

Submitted articles may deal with any aspect of the Occipital-atlanto-axial area of the cervical spine: mechanics, neurological manifestations, analyses of cervical subluxations, corrective techniques for cervical subluxations, detrimental effects of upper cervical subluxations on the human organism, and the like.

All entries will be judged by the NUCCA Directive Board and by Professor Seemann. Their judgment will be final. Accepted articles become the property of the National Upper Cervical Chiropractic Association, Inc. Winners will be announced at the following NUCCA Convention.

NUCCA will attempt to return all manuscripts that are accompanied by a self-addressed, stamped envelope. NUCCA will not be responsible for lost or mislaid material. Further information is available by writing the **Monograph** Editor, 221 West Second Stree, Monroe, Michigan 48161

ANNOUNCEMENT

Dr. Steven Goodman

Dr. Steven Goodman announces the opening of his office at 349 North Duke Street, Lancaster, Pennsylvania 17602.

Dr. Goodman became interested in chiropractic through the late Dr. H.L. Kenmore of New York while engaged in undergraduate studies.

While at the National College of Chiropractic, Dr. Goodman studied NUCCA procedures under the guidance of Dr. Marshall Dickholtz of Chicago. He received further instruction by making Saturday trips to Monroe.

After he graduated from the National College of Chiropractic, August, 1975, Dr. Goodman interned with Drs. James and George Coder of Lancaster, Pennsylvania for a year. In February of 1977, he continued his internship with Dr. R.R. Gregory of Monroe, Michigan. While in Monroe, Dr. Goodman built a private practice. In December of 1979, Dr. Goodman left Monroe to engage in practice at his present location.

A NUCCA member since 1973, Dr. Goodman was elected to the NUCCA Board of Directors, and served as NUCCA secretary from 1978 until the NUCCA convention of May, 1980.

Dr. Goodman is a 1975 Diplomate of the National Board of Chiropractic Examiners. He is licensed to practice chiropractic in Pennsylvania, Michigan, New York, New Jersey, and Delaware.

CHIROPRACTIC IN HEALTH MANPOWER BILL

ICA staff were on hand to witness the inclusion of chiropractic colleges in the language of the Health Manpower authorization bill at a hearing of the Senate Labor and Human Resources Subcommittee in May. The full committee will be considering the bill this month.

In addition to the unlimited assistance of Senator Harrison Williams (D-NJ), who formally requested chiropractic's inclusion in the bill, ICA staff and officials have been keeping close tabs on the issue for the last six months by attending hearings and meetings with key legislative aides and Senators. This legislation is the first step towards acquiring equal status for chiropractic colleges with other health professions schools included in the Health Manpower Act.

If the legislation is passed by Congress, the National Incentives Grant program will replace the existing "capitation grants" program. Under the grant program, medical schools, health professions schools, and chiropractic colleges would be eligible to apply for $250 per student for each of the following four criteria the institution meets: 1) The school provides remote site training for ten percent of the students (This would be either in medically underserved areas or in a clinic located off the school grounds.); 2) The school provides curriculum so that graduates have significant educational experience in two of these areas: geriatrics, rehabilitation, health care economics or health policy, and nutrition; 3) The school increases minority enrollment (over December 30, 1979 figures) by 25 percent or ten students, whichever number is greater; and 4) The school has a significant number of students who seek careers in clinical research.

Other features of the health manpower assistance program are outlined in the following paragraphs.

*Students at chiropractic colleges and other health professions institutions would be allowed to participate in the Health Educational Assistance Loan program (HEAL). This program makes it possible for students to borrow full tuition plus up to $2500 for expenses per year, at low interest rates. Also available would be the Guaranteed Health Professions Program that allows students to borrow directly from the Treasury Department the cost of tuition.

*Chiropractic colleges and other health professions institutions would be eligible to apply for special project grants that provide Federal funding for improvement of facilities or curriculum.

*Schools would be eligible to apply for funds for organizing an interdisciplinary approach to health care with other health professions schools.

*Schools would be eligible to apply for funds to set up clinics in medically underserved areas or in locations away from the school.

*Schools would be eligible to apply for funds for educational program development. This money could be used to start a department or improve curriculum in one of five areas—geriatrics, nutrition, disease prevention/health promotion, physical medicine and rehabilitation, and health care economics (health planning).

*Schools would be eligible to apply for funds for improvement of post-doctoral education programs and continuing education programs.

*Schools would be eligible to apply for funds to bring in management experts to determine how education costs and management costs could be cut or controlled.

*Schools would be eligible to apply for funds to set up departments for recruitment of students from disadvantaged backgrounds and for recruitment of women and minorities.

The legislative maneuver used to get chiropractic into the language of the bill was a technical amendment, offered by Senator Williams, chairman of the full Labor and Human Resources Committee. The amendment was not to add money to the program so that chiropractic colleges could be included (a move that may have a difficult time finding support in this cost-cutting Congress). The amendment was instead to include chiropractic colleges into the language already written to cover medical schools. This move does not add on cost for chiropractic colleges, but makes them eligible for the same money that medical schools can receive. Because chiropractic schools are included in the subcommittee language of the bill, the committee will not have to vote to approve Williams' amendment. Chiropractic colleges will remain in the language unless a special amendment to remove them from the program is introduced and gets a majority vote from the committee. Such an amendment is not expected, since it would be against the wishes of the committee chairman.

After consideration of the bill by the full Labor and Human Resources Committee in June, the Senate is expected to act on the bill in early July. It will then be considered by a House Senate Conference Committee. Whatever the outcome, the new Health Manpower Program will become effective October 1, 1981.

Those Senators who participated in the subcommittee markup session when Williams offered his amendment were: Williams, Claiborne Pell (D-RI), Gaylord Nelson (D-WI), Howard Metzenbaum (D-OH), Richard Schweiker (R-PA), Jacob Javits (R-NY), and Orrin Hatch (R-UT). Other subcommittee members are: Edward Kennedy (D-MA), Alan Cranston (D-CA), and Gordon Humphrey (R-NH).

ICA Executive Vice President Bruce Nordstrom, D.C., Christopher Luis, staff counsel, Director of Special Projects Dan Rose-Redwood, D.C. and John Fanburg, legislative assistant were on the Hill for the Subcommittee markup session.

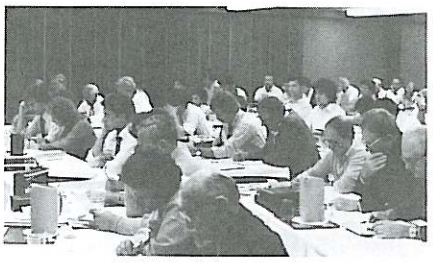
ICA will continue to follow and push for chiropractic in the health manpower issue and will keep the profession informed of any new legislative events.

—I.C.A. RELEASE

1980 NUCCA CONVENTION

From May 3, 1980 through May 6, 1980, the National Upper Cervical Chiropractic Association, Inc. (NUCCA) held its Fourteenth Annual Convention and Educational Conference. The Convention was ably chaired by Dr. Donald K. Moon of Ohio.

NUCCA presented a basic course in upper cervical film analysis and adjusting. Two academicians, Dr. Robert T. Anderson, Department of Anthropology, Mills College, Oakland, California; and Dr. Daniel C. Seemann, University of Toledo and research adviser, delivered papers related to chiropractic (The Anderson and Seemann papers are printed in this issue of the **Monograph**).



A cross-section of doctors and students at the 1980 NUCCA Convention.

David J. Lieberman, M.D., M.P.H., Director of the Monroe Health Department, addressed the convention. His subject was **Public Health and Chiropractic.**

On Monday evening, May 5th, a banquet was held at the Colonial House which featured Judge Andy Devine of Toledo, Ohio. Judge Devine's address was highly interesting and instructive.

The Convention was the largest ever held by NUCCA. Doctors from three foreign countries attended as well as from several states. Students were present from several Chiropractic Colleges.

NUCCA VISITS WASHINGTON

Left to Right: Dr. R. Gregory, Dr. Joseph Howells, Dr. Daniel Seemann.

The Chiropractic Society of the State of Washington held a continuing Educational Seminar at the Doubletree Inn in the South Center, near Seattle. Despite the "threats" of Mount St. Helens, which caused many cancellations, the NUCCA Seminar was well attended.

Dr. Joseph Howells of Enumclaw, Washington ably chaired the meeting. Representing NUCCA were Daniel C. Seemann, Ph.D. of the University of Toledo, Ohio, and Ralph R. Gregory, D.C., NUCCA president.

Dr. Seemann delivered papers on the history of NUCCA, mechanical levers encountered in the C1 subluxation, the skull center of gravity and its significance in analysing and adjusting the C1 subluxation.

Dr. Gregory discussed NUCCRA concepts such as the production of forces that originate the C1 subluxation, the basic types of C1 subluxations, subluxation patterns, and case histories.

The theme of the seminar was "Research as it applies to the cervical spine". Questions were encouraged from the doctors and students, and many participated.

New NUCCA Policy

For several years, NUCCA has sent the MONOGRAPH and other materials, including booklets and pamplets, to non-member doctors and students enrolled in chiropractic colleges throughout the world without charge. Up to now, NUCCA wrote off the publishing, handling, and postage costs to public relations. Because of the increased costs, NUCCA can no longer offer this free service to non-members.

A yearly subscription of ten ($10.00) dollars, therefore, to non-members will be charged for the MONOGRAPH. Booklets and pamplets of a technical nature will be priced according to cost of printing and handling. NUCCA members will, of course, receive the MONOGRAPH and other publications, without charge as part of their membership privileges.

Many requests are received from doctors and students for past issues of the MONOGRAPH, because of the NUCCRA research and academic articles. There are 16 past issues which can be obtained from NUCCA for a cost of ten ($10.00) dollars by ordering them from the NUCCA Editor, 217 West Second Street, Monroe, Michigan 48161. Single issues of the MONOGRAPH can be obtained for one ($1.00) dollar.

This offer holds as long as past issues are available.