THEORY

Hypothesis Formulation for Scientific Investigation of Vertebral Subluxation

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Abstract — Chiropractic research in recent years has more often focused on the effects of spinal manipulative therapy as a treatment for certain musculoskeletal conditions, than on the detrimental effects of vertebral subluxation on the body's ability to maintain its own health. Many practitioners and some institutions, however, maintain that vertebral subluxation, not the treatment of musculoskeletal conditions, should be the central focus of the chiropractic profession. Research into the phenomenon of vertebral subluxation has suffered due to a lack of well-defined operational definitions for elements of the phenomenon, and a framework for linking philosophical constructs, clinical observations, and scientific methods. The goal of this work is to develop a vertebral subluxation model that is grounded in a philosophy of science as applied to chiropractic, beginning with the abstract construct and branching out into diverse testable hypotheses in stages. The present authors liken this development to the structure of a tree, where the roots are the philosophy, the trunk the major principle and the branches particular versions of more defined, but still abstract theories. As development continues, specific quantifiable and testable hypotheses will be proposed that can be used to verify or falsify the theories. This article details the development of the hypothesis tree, and outlines some areas of fruitful research that might arise from its application in a concerted effort to investigate the aspects of the vertebral subluxation.

Key words: Vertebral Subluxation, Chiropractic, research strategy, research methodology

Introduction

Debate regarding practice objectives and methods is certainly nothing new in the chiropractic profession. A popular topic is the profession's continued focus on the correction of vertebral subluxation as a practice objective. The debate centers around the existence and importance of a subclinical lesion which chiropractors refer to as the vertebral subluxation. On the one hand, at least half of the practitioner's see benefit in continued study of the vertebral subluxation.[1] As recently as 1996, the Association of Chiropractic Colleges reaffirmed that chiropractic should be defined in terms of the vertebral subluxation.[2] On the other hand, researchers have pointed out that even though vertebral subluxation theories have not been refuted, there is little compelling published evidence that vertebral subluxation exists.[3] There are no generally accepted operational measures of vertebral subluxation, and hence no good way to study the phenomenon. Perhaps as a result, chiropractic research in recent years has more often focused on the effects of spinal manipulative therapy as a treatment for certain musculoskeletal conditions, than on the detrimental effects of vertebral subluxation on the body's ability to maintain its own health.

In this age of evidence-based health care, it is becoming increasingly important to be able to verify theories using scientific methods in order to justify their continued use. The present paper attempts to clarify and perhaps unify subluxation theories, and develop a hypothesis-generating framework that will be amenable to scientific investigation.

Much of the groundwork for this effort has already been done, presented in the form of commentaries in the Journal of Manipulative and Physiological Therapeutics, and as articles in the Journal of Chiropractic Humanities. Coulter, Keating and Marks have discussed at length the philosophy of science and its metaphysical nature.[4-10] Deductive and inductive methods work

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together in science. Deduction can be used to postulate metaphysical constructs, such as universal intelligence, which may be untestable. To complete the picture, though, an inductive process must be used to derive and test refined hypotheses that stem from the metaphysical construct. The authors all agree that any science of subluxation must consist of specific falsifiable hypotheses based on measurement and operational definitions. Keating has also offered practical advice on how to construct hypotheses and develop research to test their validity.

More recently, Nelson[11] and Leboeuf-Yde[3] have examined subluxation hypotheses in terms of particular tenets and principles, and discussed ways of evaluating them. Nelson critiqued the multicomponent descriptive models of subluxation and found them lacking in usefulness as the basis for scientific investigation. Nelson also laid down a number of guidelines for a subluxation theory: it should attempt to explain existing phenomena and observations, it should be consistent with current basic science, it should make predictions that lead to future discovery, it should bear some resemblance to historical antecedents, it should be clinically meaningful, it should present a distinct point of view, and it should be testable.

Both Nelson and Leboeuf-Yde appear to view the ultimate goals of vertebral subluxation research as the demonstration that vertebral subluxation can cause certain diseases, and that the correction of subluxation can alleviate them. This traditional model of vertebral subluxation would tend to restrict the use of chiropractic to care for sick individuals. Many chiropractors contend, though, that chiropractic care can be health enhancing even for the essentially healthy, and that vertebral subluxations should be corrected whether they are linked to any disease process or not. This view of chiropractic care as a health enhancement strategy creates special challenges for research from both philosophical and methodological standpoints.

Boone and Dobson have proposed a modernized model that attempts to reintegrate B.J. Palmer's concept of interference to mental impulses as an essential element of vertebral subluxation.[12-14] In their view, the mental impulse is a description of nerve function that is not restricted to the action potential, but might include other modalities of interaction between the nervous system and the tissue cells. In part three of their series of articles, the authors evaluate research methods that might be used to assess vertebral subluxation, challenging the appropriateness of the randomized controlled trial (RCT) for complementary and alternative medicine research. RCTs focused on the causes of and relief from disease may not be an appropriate research design to detect the impact of chiropractic care on quality of life or general health.[14]

Mealing points out the limitations of using a quantitative reductionist paradigm, investigating the whole by studying its parts, in understanding complex systems.[15] He goes on to describe several qualitative paradigms that might be complimentary in developing the science of chiropractic, such as positivism and emergence. The approaches of Boone and Dobson, and Mealing hold out promise for a scientific investigation of the straight chiropractic concept that the correction of vertebral subluxation may be of benefit to anyone, regardless of their state of health.

The goal of this work is to develop a vertebral subluxation model that is grounded in a philosophy of science as applied to chiropractic, beginning with the abstract construct and branching out into diverse testable hypotheses in stages. The present authors liken this development to the structure of a tree, where the roots are the philosophy, the trunk the major principle and the branches particular versions of more defined, but still abstract theories. The fruit of the tree, if buds can be formed, will be the quantifiable and testable hypotheses that can be used to verify or falsify the theories.

Discussion

Philosophical development

A goal of this work was to develop hypotheses consistent with chiropractic tradition. Thus, this presentation started with a philosophic construct described by B.J. Palmer, and reported in Stephenson's text as the major premise.[16] The major premise has been slightly altered here to reflect the more recent appreciation of Einstein's realization that matter and energy are interconvertible.

There is a universal intelligence acting through all matter/energy, continually giving it all its properties and actions, thus maintaining matter/energy in existence and giving this universal intelligence its expression.

Although many construe the major premise to be a reference to a governing consciousness or god, that is not the intent here. Universal intelligence is presumed to exist, based on the observation that organization exists in the universe. The development of increasingly complex organisms seems to be a violation of natural law. In a closed system driven by entropy, the second law of thermodynamics demands that the system should eventually devolve into a uniform level of disorganization. Living systems, however, are self-organizing, energetically open systems that increase complexity and organization and that emerge from the prior organization of the universe itself. Universal intelligence is the construct that there exists a source of information that drives the process of organization.

Gold expounded on this major premise in *The Triune of Life.*[17] The triune is the philosophic model that nature can be divided into three interdependent parts: the matter itself, the intelligence that creates information determining how that matter is organized and the force that allows the information intelligence creates to interact with the matter. So, the different properties of chemical elements, for instance, do not derive so much from the matter of which those atoms are composed — all atoms are proposed to be made from the same building blocks — but instead from the pattern of organization, the number and distribution of the subatomic particles. With increasing levels of complexity, the same pattern is true — the organization of constituent parts, which is an expression of the information being created within the structure, gives the structure its properties and functions.

Theory development

A subluxation theory arises at a very basic level from this major premise, and starts with the abstract notion that informa-

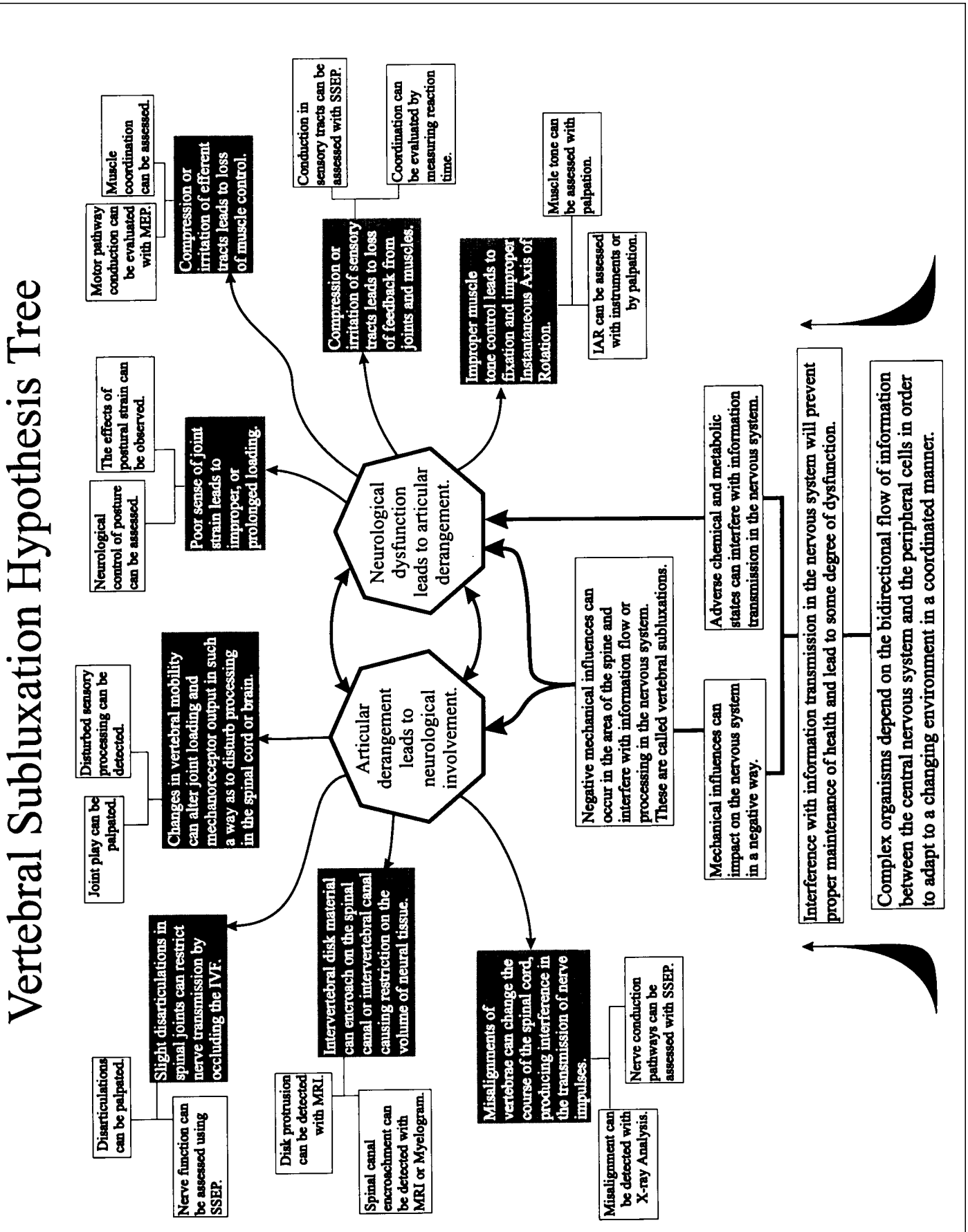

Figure 1. A graphic representation of the vertebral subluxation hypothesis tree. Philosophical constructs form the roots and trunk, leading to theories in the major limbs. Specific hypotheses lead to testable phenomena at the periphery.

tion flow is necessary to maintain the function and organization of complex organisms.

Complex organisms depend on the bidirectional flow of information between the central nervous system and the peripheral cells in order to adapt to a changing environment in a coordinated manner.

Essentially, it is remarked here that information flow is critical to the proper functioning of higher organisms. Information allows the organism to perceive internal and external changes in the environment and to devise and execute appropriate adaptive responses. Hence the matter of the organism can be reorganized to meet new challenges.

Interference with information transmission over the nervous system will prevent proper maintenance of health and lead to some degree of dysfunction.

Distortion of information, then, would be expected to lead to some degree of dysfunction in the organism. If we think of the central nervous system as one of the main generators and conduits of information in the body, any factor that effects nerve function could distort the information content in the system.

Adverse chemical and metabolic states can interfere with information transmission over the nervous system.

Mechanical influences can impact on the nervous system in a negative way.

A host of factors can interfere with nerve function, including adverse metabolic, chemical and mechanical states. Chiropractors have carved a niche by considering the mechanical effects in the area of spinal joints that might have a negative impact on nerve function.

Hence, the present authors arrive at a definition of vertebral subluxation with the first hypothesis in the theory development to deal directly with the spine. This is a very general definition and does not specify the way in which the mechanical influences the neurological.

Negative mechanical influences can occur in the area of the spine and interfere with information flow or processing within the nervous system. These are called vertebral subluxations.

Just as it is proposed that interference to information processing or transmission is, in and of itself, deleterious to the human, the vertebral subluxation is seen as a distinct phenomenon worthy, in and of itself, of research independent of any disease process to which it may be related.

The hypothesis tree takes an interesting turn here: it could not be decided which was the primary component at this level, distortion of the information content, or the mechanical disturbance. Indeed, by the present definition, the vertebral subluxation does not exist unless both components are present simultaneously. Hence the tree split into two branches, one in which the distortion of information leads to adverse mechanical effects, and another in which adverse mechanical effects lead to nerve interference. It was also noticed that in such a state where the cause can also be an effect, a positive feedback loop was being described.

Articular derangement leads to neurological involvement.

Neurological dysfunction leads to articular derangement

This is a positive feedback loop because the initial conditions lead to an effect that tends to reinforce those initial conditions. The feedback loop helps to answer the question beginning chiropractic students always ask, "Why can't innate intelligence correct the subluxation?" Maybe it sometimes can, but if the information that the body needs in order to perceive the subluxation is lacking or distorted, then the adaptive response will not be appropriate or sufficient. Even if the adaptive response is appropriate, if the neuromuscular impulses are distorted or interfered with, then, again, the corrective response will be insufficient. Hence, the subluxation can exist as a self-perpetuating phenomenon in the body.

At this stage of hypothesis development, while it may not be able to be said exactly what is a vertebral subluxation, some of its critical features can be seen: it is significant in the deleterious effects it may have on the nervous system, it may be initiated by unknown factors, but once present is self-perpetuating. It may also be able to be said at this level what a vertebral subluxation is not. It is not equated with joint dysfunction alone, but must include a wider effect on the nervous system. For example, a fixation of C5 might be noted with respect to C6 with palpation or on videoflouroscopy. By the present definition, this would not necessarily be a vertebral subluxation, unless some other signs of the fixation's effect on physiology or neurology could be detected as well. In an inverse example, a sensation loss might be noted over the region of the deltoid muscle during a neurological exam. Would this be a sign of vertebral subluxation? Only if a vertebral articular problem could be detected that might reasonably be related to the nerve supply of that area of the body.

Figure 1 shows the current development of the hypothesis tree. Note that the tree begins at the bottom, and rises in stages. At the center of the tree can be seen the two parallel statements that comprise the positive feedback loop. Notice also at this level that the "Adverse chemical...," extra-mechanical influences on nerve function can re-enter the tree here, if the interference can produce mechanical loading on the vertebrae. The present authors were thinking particularly of metabolic influences that might produce muscular hyper- or hypotonus.

Hypothesis formulation

The next step in hypothesis development is to take the left and right branches of the feedback loop and elaborate on particular, more specific mechanisms by which the vertebral subluxation could be observed. The goal of the hypothesis development is two-fold here: to try to open up the vertebral subluxation definition to include several of the currently held theories

of subluxation mechanism, and generate concrete testable hypotheses, with proposed measures and outcomes.

Kent surveyed the extant vertebral subluxation hypotheses for the inaugural issue of JVSR in 1996.[18] He describes five major divisions of models: the component approach, subluxation degeneration, nerve root compression, dysafferentation and neurodystrophic models. Several elements of these models were used as general hypotheses in the next level of the tree development. Note in figure 1 that four general hypotheses are presented on each side of the tree as darkened boxes.

Direct mechanical influences on the nervous system include the possibility of compressive and tensile effects either on nerve roots or the spinal cord, or both. The manner in which restricted joint mobility can reduce segmental mechanoreceptor output leading to disturbed nerve information processing is another possible direct mechanical influence to consider.

To render any of these hypotheses researchable, they must be refined into more specific testable forms. For instance, if it is suggested that vertebral misalignment is an important aspect of the model, then the misalignment must be able to be quantified, perhaps with a particular type of x-ray analysis. Similarly, ways of measuring specific changes in nerve function, such as conduction rates, must be investigated.

When neurologic dysfunction is considered as an initiating mechanism for vertebral subluxation (the right branch in figure 1), hypotheses develop around the effects of neurological disturbance reflecting back on the articulations. The general hypotheses envisioned so far derive from effects on the muscles and their control of joint position or movement. Distortion of sensory and motor information as well as the integration of that information in the central nervous system could play a role in these subluxation models. Following these branches to create testable hypotheses is a matter of developing techniques for measuring such things as muscle tone, joint position sense, coordination and postural strain.

Most of the hypotheses depicted so far have been looking at the mechanisms relating articular function and nerve function. Another class of hypotheses can also be developed that are less related to possible subluxation mechanisms and more devoted to real-life outcomes. Study in this area is crucial to establish the impact of the correction of vertebral subluxation on the lives of patients. These hypotheses would be amenable to testing using practice-based studies and clinical case series. The measures used might include patient surveys of quality of life or specific tests of physical performance, for instance.

Subluxation detection methods

Much of the work at higher levels in this hypothesis tree will lead to development and testing of subluxation detection measures. There are already many methods that have been developed for use in many of the named chiropractic techniques. Various techniques have particular methods for determining the presence of nerve interference and related articular dysfunction. Perhaps the most often used analysis techniques are palpatory, relying on the doctor's sense of vertebral mobility or position, tissue texture and muscle tone. Leg checks, the estimation of functional leg length inequality, is also very common. Not as well recognized are procedures for measuring vertebral alignment using x-ray analysis, and assessments of skin temperature or galvanic resistance patterns.

Reliability and validity testing needs to be done on all of these methods in order to determine their objectivity, sensitivity and specificity in locating vertebral subluxations. Some methods have passed recent tests of reliability: leg length difference measurement,[19] and an upper cervical x-ray line drawing procedure in particular.[20]

Reliability is a necessary condition for validity, but is not sufficient to guarantee it. Validity is most often assessed by comparing the results of testing to a known standard. Since we are hampered in this respect by the lack of a gold standard against which to compare our methods, other tests of validation need to be agreed upon. Perhaps validation can be found by looking at our definition of vertebral subluxation itself. The definition requires both an articular dysfunction and a neurological component. You would not expect measures of two dissimilar phenomena to covary in a population over time unless there were some underlying mechanism linking them. When a tight linkage is found between two measures of subluxation, perhaps this can be used as evidence for the concurrent validity of the measuring system.

A fertile ground for subluxation measures is the 'pattern' analysis developed by B.J. Palmer, and taught at several chiropractic colleges. In pattern analysis, the physiology of the body is considered to represent an optimally adaptive state when it is constantly changing in response to changes in the environment. When a pattern of consistent unchanging findings in a set of measures appears, the physiological system is considered to be in a maladaptive state. In pattern analysis, the detection of a static pattern of responses indicates that the nervous system is not functioning properly, the first condition for a possible vertebral subluxation. Further analysis is used to detect spinal anomalies that might be related to the aberrant physiology.

Paraspinal skin temperature is the classic measure used in pattern analysis, particularly in upper cervical chiropractic techniques. Any physiological factor, however, can potentially be used in pattern analysis. Functions directly related to the spinal column (for example, intrinsic heat patterns, electromyography, and muscle tone patterns) may be particularly relevant and may also simultaneously provide other useful information regarding spinal function.

Practical application of the model

Ultimately, clinical verification of the validity of specific subluxation detection/analysis systems will need to be done, comparing the reduction or elimination of subluxation indicators through adjustment with clinical outcomes. A time-series experimental design would be appropriate for this type of clinical study.[21, 22] Blinded assessments of some specific set of functional measures in conjunction with chiropractic analysis of spinal and articular function can be performed on three or more occasions before care is begun. This establishes a baseline for the functional and vertebral subluxation measures. The baseline period is followed by the actual chiropractic care, during which time both the functional and subluxation measures are monitored on a regular basis. After correction of any structural aberrance, the

patient can be monitored for improvement or degradation of function, whether continued adjustment is indicated or not. Here, the functional measures could be of neurological or physiological function, performance measures on standard cognitive tests, or perhaps sports performance.

A time-series analysis would allow inferences to be drawn between the presence of vertebral subluxation as indicated by chiropractic measures, and the changes in function. If researchers use a common set of vertebral subluxation measures, it may be possible to compare results of a number of such studies, regardless of what chiropractic adjustive techniques are used.

Further development

The hypothesis tree could benefit by the addition of more limbs. As it is, only eight different types of mechanisms are represented here. Each of the perhaps 200 or more chiropractic techniques has at its core a hypothetical framework regarding how its indicators relate to vertebral subluxation, and how best to correct the varieties of articular dysfunction detected. Many of those technique systems will fit within this vertebral subluxation hypothesis framework.

The process of researching a particular vertebral subluxation hypothesis should start with systematic literature reviews to uncover basic and clinical science that might support or refute the hypothesis. Research programs then could be directed at further testing of the hypothesis, by applying experimental and descriptive methods. In the tree shown in figure 1, note that only one experimental approach is offered for each of the eight general hypotheses shown. In practice, each general hypothesis should be the source of several null hypotheses that each needs to be falsified in order to support the major hypothesis. The research task is daunting and will certainly take time to accomplish. This formulation is just one way of approaching the whole process in an organized manner.

Ultimately, the scientific investigation of vertebral subluxation should be of use to practitioners. The goal is not simply to justify existing methods of chiropractic practice, but to determine the effectiveness of that work as it is done now. Future developments, then, could be compared with the *status quo* to find out if changes in technique provide improvements in outcome. It would also be useful to survey chiropractors for hypotheses that arise from a clinical perspective, and that might be overlooked utilizing a philosophically driven theory development. Certainly a theory is only good if it helps explain reality, and reality in this case is what happens when a person undertakes a program of chiropractic care aimed at detection and correction of those spinal dysfunctions that impact on the function of the nervous system — namely vertebral subluxations.

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