A Proposed Model With Possible Implications for Safety and Technique Adaptations for Chiropractic Spinal Manipulative Therapy for Infants and Children

Aurélie M. Marchand, DC, MScACPP

Abstract

Objective: A literature review of tensile strength of adults and pediatric human spine specimens was performed to gather information about biomechanical forces and spinal differences of adults and children and to synthesize these findings into a scaling model to guide safety and clinical decisions for spinal manipulative therapy (SMT) for children and infants.

Methods: The literature search was performed using PubMed from inception to November 2012 with no filters or language restrictions. The search included terms related to pediatric spine biomechanics and tensile strength. Studies included those in which human tensile strengths necessary to create anatomical damage in the cervical, thoracic, or lumbar spine of pediatric human subjects were recorded. The pediatric population was defined as human subjects from birth to 18 years old. Biomechanical findings were used to propose a scaling model based on specimen age and differences in tensile strengths. A model of care was proposed using the scaling model and the existing literature on pediatric technique adaptations.

Results: Nine experimental studies were selected, 5 in the pediatric population (46 specimens) and 4 in the adult population (47 specimens). Mean tensile strengths were estimated, and ratios were used to describe differences between 4 age groups. The preliminary model of care proposed includes maximum loading forces by age group. From these studies, a model showed a nonlinear increase in the cervical spine tensile strengths based on specimen age.

Conclusions: The literature showed that tensile strength differences have been observed between pediatric and adult specimens. A preliminary model of care including pediatric SMT technique adaptation based on patient age is proposed, which may possibly contribute to further knowledge of safety and clinical implications for SMT for children and infants. (J Manipulative Physiol Ther 2015;38:713-726)

Key Indexing Terms: *Chiropractic; Children; Therapeutics; Manipulation; Spinal*

Spinal manipulative therapy (SMT) is currently used to treat and manage a wide variety of musculoskeletal conditions.[1] The application of precisely controlled high-velocity, low-amplitude thrust to a joint during SMT causes tissue deformation of the spine and surrounding tissue.[2] The thrust is designed to restore motion in the targeted joint by applying force to the area of segmental restricted motion.[2,3] Theoretically, the thrust is applied in the paraphysiologic space of joint motion[4] while taking care not to exceed the anatomical limit leading to joint trauma and pathology. The osteokinematic movements and arthrokinematic movements have guided the rationale and the application of SMT in adult patients by considering the mechanical forces introduced in a joint (tension, compression, shear, torque) in relation to tissue properties contributing to kinetic joint stability and integrity (muscles, ligaments, facet joints, intervertebral disks).[3] Spinal manipulative therapy and thrust application are based on aspects including anatomy, tissue properties, and spinal biomechanics, as is noted by the lower loads applied in the cervical spine compared with the stiffer thoracic spine.[2]

Chiropractic care of children is common, and it is estimated that between 5% and 20.5% of chiropractic patients are of pediatric age.[5-10] It is generally agreed that manual practitioners should adapt SMT techniques depending on the patient's size, structural development, flexibility, and preference.[11] Because pediatric spinal biomechanics

Doctor of Chiropractic, Private Practice, Padova, Italy.
Submit requests for reprints to: Aurélie M. Marchand, DC, MScACPP, Via Piastreto 1, 51011 Buggiano (PT), Italy
(e-mail: *aureliemarchand@hotmail.com*).

Paper submitted November 11, 2011; in revised form December 10, 2012; accepted January 14, 2013.
0161-4754

http://dx.doi.org/10.1016/j.jmpt.2013.05.015

differ from adults because of anatomical differences in tissue tensile properties (stemming from size and tissue organization variations),[12] it is logical that these factors are considered when addressing biomechanical conditions for various age groups. European chiropractic practitioners have reported technique modifications including adaptations of speed and force during the application of spinal manipulation and differences in obtaining cavitation sounds in 5 pediatric age groups[13]; however, these were observational only. Currently, technique adaptations such as the amount of force to use for SMT on infants and children are supported by little evidence.[11,13-15]

The safety of chiropractic treatment for young infants (1-12 months old) was raised in a study observing vegetative responses (bradycardia and apneoa) after a thrust ranging from 30 to 70 N of force (average of 50 N) applied to the upper cervical spine.[14] The study suggested that in the prone sleeping position, "the possibility that a minor mechanical irritation of the cervical region may trigger the first step in the events that lead to SID," or sudden infant death syndrome, and "the chiropractic impulse that triggers a bradycardia and apnea suggests that comparable mechanical stimuli associated with the prone position may result in similar adverse responses."[14] In other words, this study suggested that death secondary to sudden infant death syndrome might occur after chiropractic SMT of the cervical spine in pediatric patients younger than 1 year. On the other hand, the same study reported that 20 000 children were treated with chiropractic manipulation without reports of serious adverse reactions,[14] while a literature review reported 9 cases of serious adverse reactions in the pediatric population (from 1900 to 2004), of which 2 cases were not attributed to chiropractors.[16] Other studies reported adverse effects and nonserious adverse reactions secondary to pediatric SMT, with occurrences ranging from 0.23% to 9% of the pediatric population.[13,17-19] Because the application of force and responses have been linked,[14] it is important to consider how much force should be used in SMT for the pediatric population to inform practitioners and decrease the likelihood of adverse reactions. Scaling models of the adult and pediatric cervical spine currently exist,[20] and 2 studies reported pediatric SMT technique adaptations in patients.[11,13] To the author's knowledge, scaling methods have so far not been applied to the clinical practice of pediatric SMT.

Because it would not be appropriate to conduct a trial testing SMT that would cause tissue failure in children and infants and to address the gap of knowledge of SMT force and children, it was decided to conduct a literature review. The purpose was to identify the amount of force necessary to create damage in the pediatric spine, which could be used as a limit of force that should never be exceeded during pediatric SMT. Adult data were identified to compare with pediatric data to evaluate differences between pediatric and adult spines so that scaling models could be proposed. A model of care is discussed to address the gap of knowledge concerning pediatric SMT technique adaptations to prevent the occurrence of safety incidents.

Methods

Parameters of anatomical damage (tensile strength) were used as a reference point considering the principle that SMT occurs in the paraphysiologic zone in the end range of joint motion while not exceeding the anatomical barrier where damage occurs.[4] The tensile strength and stiffness of tissues are defined as the amount of force required to obtain a certain deformation of a tissue and may apply to any tissue tested—bones, ligament, or muscle.[21]

Pediatric

A literature search was performed on the PubMed database from inception to November 2012 with no filters or language restrictions. The search used the following terms: "pediatric spine biomechanics," "tensile strength spine pediatric," "tensile spine pediatric," "pediatric spine mechanics," "pediatric cervical spine strength," "pediatric cervical spine properties," "pediatric thoracic spine properties," "pediatric lumbar spine properties," and "pediatric lumbar spine strength." Screening of article was based on studies reporting pediatric tensile strength. Studies were included if they provided human tensile strengths necessary to create anatomical damage in the cervical, thoracic, or lumbar spine of pediatric human subjects. The pediatric population was defined as human subjects from birth to 18 years old. Exclusion criteria were studies providing tensile strengths on other areas than the spine, the absence of primary data related to anatomical damage, animal data, and computer model data. The process of identification, screening, eligibility, and inclusion is presented in the results section. Risk of bias was assessed by reviewing the limitations of the selected studies.

The reported values of tensile strength were obtained from the results section of peer-reviewed articles. The values of tensile strength included during the calculation of the means were based on the lower thresholds reported when both initial and ultimate failure loads were reported. The initial failure load was considered a more appropriate threshold because it reflected initial tissue damage and may be a better value for extrapolations into clinical practice, as the aim would be to identify a threshold and to prevent tissue damage. The values of tensile strength on premature specimens were not included for analysis because the age range of the premature specimens was from 20 to 37.5 weeks' gestation[22,23] and may have skewed the result for full-term infants.

When possible, the tensile strength values were grouped per spinal level and by specimen age: occiput to C2, then segmentally from C2 to C3, ending at C6 to C7. Other