Radiophobia Overreaction: College of Chiropractors of British Columbia Revoke Full X-Ray Rights Based on Flawed Study and Radiation Fear-Mongering

Paul A. Oakley¹, Joseph W. Betz², Deed E. Harrison³, Leonard A. Siskin⁴, Donald W. Hirsh⁵, and International Chiropractors Association Rapid Response Research Review Subcommittee

Abstract
Fears over radiation have created irrational pressures to dissuade radiography use within chiropractic. Recently, the regulatory body for chiropractors practicing in British Columbia, Canada, the College of Chiropractors of British Columbia (CCBC), contracted Pierre Côté to review the clinical use of X-rays within the chiropractic profession. A “rapid review” was performed and published quickly and included only 9 papers, the most recent dating from 2005; they concluded, “Given the inherent risks of radiation, we recommend that chiropractors do not use radiographs for the routine and repeat evaluation of the structure and function of the spine.” The CCBC then launched an immediate review of the use of X-rays by chiropractors in their jurisdiction. Member and public opinion were gathered but not presented to their members. On February 4, 2021, the College announced amendments to their Professional Conduct Handbook that revoked X-ray rights for routine/repeat assessment and management of patients with spine disorders. Here, we highlight current and historical evidence that substantiates that X-rays are not a public health threat. We also point out critical and insurmountable flaws in the single paper used to support irrational and unscientific policy that discriminates against chiropractors who practice certain forms of evidence-based X-ray-guided methods.

Keywords
radiophobia, X-ray, radiograph, chiropractic, clinical utility, guidelines

Introduction
Radiographic analysis is not only the first choice in imaging of the spine in all forms of clinical healthcare practice but it is the gold standard for the examination of patients presenting with spinal disorders.¹⁻¹⁰ In this context, X-rays can provide critical and immediate information to guide treatment decisions regarding further imaging (e.g., MRI), referral (e.g., surgical consult), indications for co-management (rheumatologist and pain specialist), to rule out or confirm a definitive diagnosis, help provide a timely diagnosis, ease the anxiety of the patient, and satisfy the doctors liability concerns.¹¹⁻¹³ In the current era of value-based healthcare,¹⁴ routine initial X-ray screening is,

¹Private Practice, Newmarket, ON, Canada
²Private Practice, Boise, ID, USA
³CBP NonProfit, Inc, Eagle, ID, USA
⁴Private Practice, Green Brook, NJ, USA
⁵Private Practice, Laurel, MD, USA

Received 20 April 2021; received revised 17 June 2021; accepted 22 June 2021

Corresponding Author:
Paul A. Oakley, Private Practice, 11A-1100 Gorham Street, Newmarket, ON L3Y 8Y8, Canada.
Email: docoakley.icc@gmail.com
in fact, encouraged as it reduces costs associated with more advanced imaging (i.e., CT and MRI). Last, the evaluation of biomechanical relationships of the spine and pelvis have direct consequences on patient pain, disability, quality of life, and spinal function, and patient outcomes can be altered with evidence-based spine rehabilitation procedures utilized by many manual therapists including doctors of chiropractic.

Within the profession of chiropractic, there has been recent controversy over X-ray use in clinical practice. For example, in 2017, the American Chiropractic Association (ACA) released a statement that it had joined the Choosing Wisely initiative and listed 5 practices that were discouraged. The first two points were associated with X-ray use: specifically, (1) to not X-ray a patient presenting with acute low back pain within the first 6 weeks of onset, and (2) to not X-ray a patient to assess response to treatment. Despite the fact that the ACA’s listed items are not supported by any valid or discipline-specific evidence, the promoted discouragement of X-ray use through the Choosing Wisely program has led to far-reaching and cascading consequences including the use of this list by insurance companies to deny reimbursement to practicing chiropractors using X-rays to diagnose and assess their patients.

Further examples of controversy over X-ray use in chiropractic include a debate between affiliates of Chiropractic Biophysics NonProfit and Anderson, Kawchuk and members of the Research Council of the World Federation of Chiropractic. The “scoping review” by Jenkins et al. for X-ray use in chiropractic that was heavily criticized, as well as most recently, a controversial “rapid review” on X-ray utility in chiropractic concluding there was no evidence for routine or repeat X-ray imaging in chiropractic practice beyond suspected “red flags” (i.e., serious medical conditions including cancer, infection, fracture, etc.). This last review attempted to assess the chiropractic literature from the inception of multiple databases to November 2019, but only included 9 papers in their final analysis and none dated from the last 15 years.

It is precisely this last article mentioned that underpins recent events regarding the College of Chiropractors of British Columbia (CCBC) to make sweeping policy changes to restrict chiropractors from taking X-rays practicing within the jurisdiction of the Province of British Columbia (BC), Canada. Legal adoption of this CCBC policy change would mean BC chiropractors have lost their full X-ray rights for use for treatment assessment and evaluation of spine disorders unless used strictly for the purpose of examining “red flags” only. So-called “red flag only” guidelines for the chiropractic profession have been heavily criticized as they rely virtually exclusively on data from allopathic medical practice (pharmacologic practice), they ignore the plethora of spine literature correlating spine alignment with health outcomes, they ignore the high-quality and evolving evidence for approaches validating spine-altering methods, they ignore studies showing high rates of bony anomalies/pathologies that may alter treatment approach, and they discriminate against chiropractors that practice alternative forms of evidence-based practice that utilize initial and repeat spine X-rays.

This article addresses the peculiar events that have rapidly occurred which seem to be motivated by misguided opinion and political policy over science. First, we highlight recent reviews substantiating diagnostic X-rays as harmless to public health as well as historical evidence about the pseudo-science surrounding the adoption of the linear no-threshold (LNT) model that underpins all radiation risk assessment. We discuss the many criticisms of BEIR VII that is proclaimed to be the primordial LNT support document as well as low-dose radiation as an effective treatment for human diseases. Next, we discuss critical and insurmountable flaws in the contracted “rapid” review invalidating the CCBCs X-ray policy changes. We point out the complete lack of transparency of the CCBC and highlight the Colleges’ failure to perform its role of “protecting the public” by speedily adopting unscientific and unethical policy based on a single flawed manuscript. Finally, we discuss how radiophobia has escalated and culminated into poor policy that neglects consideration of the bulk of existing science.

**X-Rays Are Not a Public Health Threat**

The first and foremost criterion that precludes definitive action toward dissuading, or in this case radical policy change to outright revoke, full X-ray rights is having belief in the conjecture that “X-rays cause cancer.” Today, this notion is understood to be false. For all intents and purposes, low-dose radiation in the amounts given from X-rays (and CT scans) offers no threat to public health as they have never been shown to cause harm and in fact, have only been shown to enhance health (aka radiation hormesis). Here, we briefly summarize the main findings from several recent studies, we show that the traditional events and science leading to the adoption and acceptance of the LNT model was based on pseudo-science, we present the multiple fundamental flaws which invalidate the use of the US National Academy of Sciences Biological Effects of Ionizing Radiation report (BEIR VII) for use in radiation risk assessment from X-rays, and discuss low-dose radiation as a successful treatment for human diseases.

**Contemporary Reviews Show No Harm from Low-Dose Radiation/X-rays**

Schultz et al performed a quantitative assessment on the methodologic quality of studies that had evaluated cancer risk from low-dose sources (i.e., X-ray and gamma radiation exposures less than 200 mSv) to determine the evidentiary strength supporting or refuting a causal relationship between low-dose radiation and cancer. The authors state that concerns exist that medical radiation from X-rays (CT scans) will cause thousands of malignancies, and that if this premise is false, the fears from patients and doctors leading to X-ray avoidance would be unfounded.
In their analysis, from an initial 4382 located studies between the years 1975–2017, 62 met all the inclusion/exclusion criteria. From these, 25 studies were deemed to be of high-quality, and importantly, 21/25 did not support cancer induction by low-dose radiation ($\rho = .0003$). Thus, fears from X-rays were determined to be unfounded; indeed, the authors stated$^{29}$:

> A clear preponderance of articles with higher quality methods found no increased risk of cancer from low-dose radiation. The evidence suggests that exposure to multiple CT scans and other sources of low-dose radiation with a cumulative dose up to 100 mSv (approximately 10 scans), and possibly as high as 200 mSv (approximately 20 scans), does not increase cancer risk. (p. 3)

Vaiserman et al performed a recent literature review to assess the validity of the LNT model of radiation damage, the basis of current regulation.$^{30}$ They reviewed medical occupational exposures including radiologists and technologists, radiation workers, nuclear workers, nuclear weapons test participants, radiation-based medical procedure participants who received diagnostic imaging and low-dose radiotherapy, environmental background radiation, residential radon exposure, and nuclear powerplant accidents including exposures given to residents exposed from the incidents at Three-Mile Island (1979), Chernobyl (1986), and Fukushima (2011).$^{31-39}$ They also included the comprehensive reviews from the joint report of the French Academy of Sciences and French Academy of Medicine (2005),$^{40}$ BEIR VII (2006),$^{41}$ and the United Nations Scientific Committee on Atomic Radiation (UNSCEAR) report (2016).$^{42}$

In their Table 1 ($^{30}$ adapted here as Table 1), it is shown that virtually all standard mortality ratios from radiation exposed occupational cohorts are less than 1.0 (i.e., same as background). The authors note that this data shows that the radiation exposures had “no effect whatsoever or may even be beneficial.”$^{30}$ The authors reiterate that no solid evidence exists showing any type of harm at doses of up to 500 mSv/y (2 mSv/d) and conclude that “there is a growing body of evidence that low-dose radiation, such as used in X-ray imaging including CT, actually promotes health rather than poses risk.” They also conclude that the regulatory burden should be reduced due to high costs of LNT-inspired regulations since the “epidemiological data provide essentially no evidence for detrimental health effects below 100 mSv.”$^{30}$

In a recent review, Oakley and Harrison showed how the use of the radiation protection concept “ALARA” (As Low As Reasonably Achievable) results in more harm than benefit (Table 2).$^{43}$ Since ALARA is based on the LNT which is not valid for low-dose exposures, the use of dose as a surrogate for risk in radiological imaging is not appropriate and obsolete. In fact, it was shown that the forced adherence to over-restrictive radiological imaging avoidance campaigns (e.g., Image Gently$^{44}$ and Image Wisely$^{45}$) results in real harms over theoretical harms. Among the many potential harms presented,$^{45}$ the most damning included an increased liability to physicians who avoid, or have patients who refuse radiological imaging, potential missed diagnoses due to reduced image quality by using lower dose techniques in attempt to limit exposures, increased risks from alternate imaging procedures (e.g., sedation for MRI), and the propagation of continued radiophobia. It was concluded, “the ALARA principle, as used as a radiation protection principle throughout medicine, is scientifically defunct and should be abandoned.”$^{43}$ Many others have also advocated for the abandonment of the use of ALARA in medical imaging.$^{46-55}$

In another recent review, it was summarized why the long-held notion of X-ray carcinogenicity is not a valid argument.$^{56}$ It was shown the LNT is not valid for low-dose radiation exposures (including X-rays) as the Life Span Study (LSS) data, which is considered the main evidential support, shows a hormetic dose-response curve (non-linear)$^{57,58}$; the BEIR VII has been heavily criticized for having both faulty assumptions and analyses.$^{59-65}$ The original adoption of the LNT was based on faulty data and dubious agenda,$^{66-68}$ and that the LNT has evolved to become more political than scientific.$^{69,70}$ It was argued that the ALARA concept is obsolete as it relies on the invalid LNT model.$^{56}$ It was also illustrated that exposure levels shown to be carcinogenic have thresholds that are very high, for example, from the data presented from Doss (700 mGy)$^{57,58}$ as well as Cuttler (1100 mGy).$^{71}$ This last argument is of critical importance as it illustrates that X-ray exposures represent an infinitesimal fraction of the threshold for potential cancer induction. Cuttler also noted that, even in those exposed to above 1100 mGy from the atomic bomb, only .5% developed leukemia which he noted was “very surprising.”$^{71}$

Oakley and Harrison$^{56}$ also argue that low-dose ionizing radiation (LDIR) upregulates the adaptive protection systems of the body that repair any damage done by X-rays,$^{72-75}$ and that an X-ray would only equate to about one-millionth of the endogenous damage from breathing air on a daily basis. Also, LDIR treatments are based on the physiological response of the body and have been used to treat a variety of human ailments including inflammatory and neurodegenerative conditions, infections, and cancers.$^{75-77}$ It was argued the total collective dose (TCD) concept is invalid for LDIR due to the adaptive response mechanisms, as any DNA damage resulting from each exposure event (X-ray) would be mitigated prior to any subsequent exposure. It was also discussed that aged cohort studies purveying radiogenic cancers from prior X-rays are not generalizable to the wider population due to cohorts who were imaged in their youth having increased incidence of anomalies and other predisposing factors and, thus, increased susceptibilities to cancers.$^{78,79}$

It has recently been pointed out that the Radiation Effects Research Foundation (RERF) has recently been incorporating non-radiation factors into consideration for cancer incidence in the LSS cohort survivor data which has led to obvious suspicions about the merit of previous studies published by RERF that did not previously account for other such risk factors.$^{80}$ Indeed, cancer is understood to be a multifactorial...
disease process. In assessing two recent RERF studies (Sakata et al; Grant et al), Pennington found the LSS cohort input data and modeling had “extensive deficiencies and defects” and that “a best estimate of radiation-only cancers within the LSS cohort’s large population using current cancer risk factors offers a strong indication that A-bomb-blast LDIR could not produce such cancers.” He also questioned how the RERF “continues to find and assert that bomb-blast LDIR remains a distinguishable source of radiogenic cancer” when it was concluded that the “LDIR radiogenic cancer model is highly implausible if not improbable.”

A recent review by Ricci and Tharmalingam investigated the validity of LNT interpolations from high-dose atomic bomb data to the use for risk assessment at low-dose levels. Noting that LNT cancer risk modeling generally excludes co-exposures to chemicals, dietary, and socio-economic cancer risk factors, LNT radiation modeling always and incorrectly predicts cancers as solely attributed to ionizing radiation exposures. They point out that for the linear interpolation to be correct, there would have to be exact similar biological mechanisms that lead to cancer from high and low doses of radiation; however, this cannot be correct as both biological and epidemiological data show non-linearity and thresholds. They also show that the use of the LNT suffers from mis-specification errors, multiple testing, and other biases and “its use by regulatory agencies conflates vague assertions of scientific causation, by conjecturing the LNT, for administrative ease of use.”

Recently, a task group was organized by the Society of Nuclear Medicine and Molecular Imaging to assess the validity of the LNT, its use in risk assessment and radiation protection, and the risk of cancers from low-dose radiation exposures. The task group concluded “the evidence does not support the use of LNT either for risk assessment or radiation protection in the low-dose and dose-rate region” and that it is

---

Table 1. Overall Cancer Mortality in Cohorts Occupationally Exposed to Radiation (Adapted from Vaiserman).

| References | Country | n     | n (Reference population) | SMR   | 95% CI          | Sex |
|------------|---------|-------|--------------------------|-------|-----------------|-----|
| Radiologists |         |       |                          |       |                 |     |
| Matanoski | UK      | 2,698 | NA (general population)  | 0.63  | 0.67-0.77       | m   |
| Linet     | US      | 43,763| 64,990 (Psychiatrists)    | 1.00  | 0.93-1.07       | m   |
| Radiologic technologists |         |       |                          |       |                 |     |
| Cameron   | US      | 1,46,022| NA (general population)  | 0.73  | 0.7-0.8         | m   |
| Kitahara  | US      | 45,634| 64,401 (Psychiatrists)    | 0.92  | 0.85-0.99       | m   |
| Radiation workers |     |       |                          |       |                 |     |
| Tubiana   | US      | 46,970| 41,169 (Nonradiation workers) | 0.88  | 0.81-0.94       | mix |
| Boice     | UK      | 1,24,743| NA (general population)  | 0.82  | 0.79-0.85       | mix |
| Muirhead  | UK      | 1,74,541| NA (general population)  | 0.84  | 0.82-0.86       | mix |
| Nuclear workers |     |       |                          |       |                 |     |
| Muirhead  | Japan   | 1,20,000| NA (general population)  | 0.98  | 0.93-1.04       | m   |
| Iwasaki   | Russia  | NA    | NA (unexposed residents) | 0.89  | 0.78-1.01       | m   |
| Radiation workers |     |       |                          |       |                 |     |
| Tubiana   | US      | 46,970| 41,169 (Nonradiation workers) | 0.88  | 0.81-0.94       | mix |
| Boice     | UK      | 1,24,743| NA (general population)  | 0.82  | 0.79-0.85       | mix |
| Muirhead  | UK      | 1,74,541| NA (general population)  | 0.84  | 0.82-0.86       | mix |
| Nuclear workers |     |       |                          |       |                 |     |
| Muirhead  | Japan   | 1,20,000| NA (general population)  | 0.98  | 0.93-1.04       | m   |
| Iwasaki   | Russia  | NA    | NA (unexposed residents) | 0.89  | 0.78-1.01       | m   |

*Leukemia; NA, not available; CI, confidence interval.

Table 2. Synopsis of the Failure of the ALARA Radiation Protection Principle.

| Failure of ALARA Radiation Protection Principle | |
|------------------------------------------------|---|
| Reluctance of doctors to take X-rays | Constrains practice |
|  | Adds malpractice risks |
|  | Delayed diagnosis |
|  | Missed diagnosis |
|  | Alternate imaging has harms |
| Reluctance of patients from receiving X-rays | Shared decision-making leads to X-ray avoidance |
|  | Constrains medical management |
|  | Adds malpractice risks |
|  | Leads to more consultation time |
|  | Leads to more testing |
| Increased radiation exposures by aligning with ALARA | Repeated imaging |
|  | Missed diagnosis |
|  | Delayed medical procedures |
| Stifling of low-dose radiation research & treatment | Ignoring the body’s innate mechanisms |
|  | Ignoring historic evidence of efficacy |
| Propagation of radiophobia | Circular reasoning for continued ALARA |
|  | Never ending radiophobia narrative |
Pseudo-Science led to the Adoption of the LNT Model

The assessment of all radiation risks is through application of the LNT model. Soon after its first adoption in 1956, all the major regulatory agencies (e.g., NAS BEIR, National Council on Radiation and Protection [NCRP], and International Commission on Radiological Protection [ICRP]) used the LNT as the foundation for risk assessment from radiation exposures. The LNT implies that all radiation is harmful and also cumulative; in fact, it asserts that no radiation is without risk.58 The LNT model is a simple model of linear extrapolation from data at high radiation exposures down to the zero dose. As will be explained, this model seems to be more about politics than science.69,70 Despite the exponential emergence of data against the legitimacy for the use of LNT for low-dose exposures such as from X-rays and CT scans, these agencies continue to endorse the LNT.

Surprisingly, there have been new revelations about the dubious origins of the LNT.63-68 The origins of the LNT model have recently been shown to have been surrounded by actions of scientific fraud and misconduct.63-68 The linearity concept without a threshold for mutation induction by radiation exposure came from Hermann J. Muller’s original fruit fly experiments and the historic 1927 publication in Science.65 Muller produced transgenerational phenotypical changes using very high radiation doses. He claimed they were gene mutations, though decades later these were shown to be gene deletions and other chromosomal rearrangements.67 Thus, at that time, the radiation research genetics field was misdirected for decades based on Muller’s false claims of producing gene mutations. It is also noted that his 1927 Science publication presented no data and was not peer reviewed.64 It appears he avoided peer review to claim primacy for discovering gene mutation that did lead him to receive the Nobel Prize for physiology or medicine in 1946 for “the discovery of the production of mutations by means of X-ray irradiation.”66

Calabrese revealed historical documentation that legitimate scientific evidence that directly opposed Muller’s LNT theory work was deliberately suppressed by the Nobel Laureate on his way to winning the 1946 Nobel Prize.68 Muller who gave his Nobel Prize Lecture on December 12, 1946, knew of high-quality data from a study by Casperi and Stern67 using low-dose radiation exposure that clearly showed a threshold and refuted the low-dose linearity concept that Muller endorsed. After Muller was asked for feedback, documented in a letter back to Stern dated November 12, 1946 (1 month prior to his Nobel lecture), Muller indicated “he received the manuscript, scanned through the entire document, saw its significance, knew that the findings were refuting the low-dose linearity concept, that the study was done by Caspari, whom he viewed as a very competent person, so he couldn’t challenge the findings.”68 Regardless, in his Nobel lecture Muller stated that there was “no escape from the conclusion that there is no threshold.”68

In 1957, extending on the work from Muller, Lewis published an important paper in Science generalizing the linear relationship from germ cells to somatic cells applying it to cancer.88 This inspired the NCRP in 1960 to adopt the LNT for cancer risk assessment. As Calabrese explains, “It was this sequence of events that propelled the LNT cancer risk assessment model into the public health arena, transforming the fields of environmental health, food safety, radiation health, and occupational health.”63 At this point, like dominos, “many other national advisory committees did copycat acceptances, and linearity became a done deal. The tide was turned. It was a paradigm shift within a very short time period.”68 To this day, the international and national radiation advisory agencies continue to endorse the LNT model for risk assessment.

Prior to the paradigm shift to the LNT model, there was a threshold model for which many argue that the early radiologist data89 shows that the first recommended dose limit of 0.2 R per day (approximately 70 rad or 700 mGy per year) adopted by the ICRP in 1934 represents a safe dose limit that should be re-adopted.33 Cardarelli and Ulsh argue that abandonment of the LNT model for low-dose radiation risk assessment by incorporating contemporary science into the regulatory processes could succeed to ensure that science would underpin decision making, that the public be educated on the lack of risks from low-dose radiation exposures, and to “harmonize government policies with the rest of the radiation scientific community.”90

BEIR VII Is Continually Endorsed as Primordial LNT Proof Despite Having Critical Flaws

LNT advocates always rely on the BEIR VII as the pinnacle of scientific consensus or proof of legitimacy of the linearity single hit theory that underpins all radiation risk assessment. Here, we discuss the many criticisms of BEIR VII that invalidate its use for risk assessment from X-rays.

Sutou recently summarized 5 main flaws of the BEIR report that relies heavily on the LSS data.62 First, the dose-response curve of leukemia is linear quadratic (i.e., non-linear), but because there was no statistical difference between a linear and linear-quadratic model, the BEIR committee adopted the linear model. As Sutou states, “this forced logic is unacceptable.”62 Second, the highest dose in the BEIR reports (Figure 4) is 2 Gy, but excess relative risk (ERR) typically shows a downward turn of exposures greater than 2 Gy since individuals highly exposed would die prior to any cancer development. Therefore, “concealing a downturn by limiting doses up to 2 Gy . . . is successful in giving the impression of linearity.”62 Third, the BEIR committee performed a statistical trick by combining all data points less than 100 mGy into 1 point, which again, conceals evidence of non-linearity. Fourth, the BEIR committee assumed a zero-exposure in
the not-in-the-city (NIC) controls of the LSS data; however, they were also exposed to residual radiation from black rain occurring for a few hours, 45 minutes after the detonation over Hiroshima. Sutou shows that a re-analysis accounting for the NIC exposures shows a threshold and hormetic dose response (i.e., non-linearity). Fifth, the BEIR report ignores the adaptive protection mechanisms “acquired through the evolution processes of billions of years” that innately attempt to mitigate DNA damage. Sutou concludes “LNT based on LSS is invalid… Indeed, A-bomb survivors live longer and get cancer less frequently… It is high time to admit beneficial effects of radiation hormesis and to establish a new paradigm for LDR [low-dose radiation] regulation.”

Siegel et al point to the limited literature included in the BEIR VII report, particularly the reliance on use of in vitro data that do not support the LNT. Importantly, they point to the fact that in vitro data cannot be used as proof of carcinogenesis for intact organisms. Siegel et al shows the BEIR report acknowledges epidemiological data linking cancer induction from low-dose radiation exposures is lacking, but then places major emphasis on a single study by Lloyd et al. This study is a collaborative effort from 6 laboratories that counted chromosomal alterations (dicentric chromosomes) in human lymphocytes induced in vitro resulting from radiation exposures in the range of 0–300 mGy. First, it is interesting that the BEIR report omitted the zero-dose data point that showed a value of 0.17 dicentrics per 100 cells. Importantly, Lloyd et al found the dicentrics per 100 cells to be .11, .12, and .11 for exposures of 3, 6, and 10 mGy. This damage rate is less than the zero-dose control and unequivocally demonstrates non-linearity (hormesis).

Even at the higher exposure doses of 20, 30, and 50 mGy, they remain relatively plateaued at 0.19, 0.24, and 0.24 dicentrics per 100 cells. Only the 300 mGy, the highest exposure dose in the study showed significantly increased damage at 1.28 dicentrics per cell. Siegel et al state “Linearity at the low doses does not exist (in this case 2-50 mGy and likely beyond, somewhere between 50 and 300 mGy); rather, it is forced by the high-dose extrapolation of the LNT model.”

Although the BEIR report claims that “a linear relationship between low-linear energy transfer dose and chromosomal mutation down to around 20 mGy” exists, Siegel et al points out that the Lloyd et al data do not support this statement. Further, and most importantly, “BEIR’s assertion that the link between initiation and clinical cancer had been ‘established’ is unsupported” as “Such studies (in vitro studies) can only suggest mechanisms of cancer initiation; they cannot by themselves provide evidence of clinical cancer development in whole organisms.” Siegel et al call for the establishment of a new BEIR VIII committee to “critically reassess the validity, and use, of LNT and its derived policies.”

In another BEIR critique, Doss reminds us that the recent updates to the LSS by Ozasa et al and Grant et al, show non-linearity and therefore, “the main epidemiological evidence quoted in the BEIR VII report no longer supports the LNT model.” Doss also states that although many commonly argue that because innate repair mechanisms are less than perfect, a threshold is not plausible (e.g., Duncan et al); however, when one considers the large amount of endogenous DNA damage, low-dose radiation would result in upregulation of the adaptive repair mechanisms so that overall, there would be less DNA damage. Thus, there would in fact be a reduced overall DNA damage and mutations as has been observed in mice. Doss states “even though DNA repair mechanism is imperfect, there would be reduction of overall DNA damage after low radiation exposures.”

In a detailed analysis, Calabrese and O’Connor demonstrate more critical flaws in the BEIR VII report. They note that some BEIR reports have disagreed with other BEIR reports, noting that “lifetime excess cancer risks” increased an order of magnitude from BEIR III to the BEIR V. This was from the committee choosing to switch from using a linear-quadratic risk model to a linear risk model (e.g., 42 vs 660 cancer deaths projected from an exposure of 100 mGy between the different reports). BEIR VII uses a combination of the 2 risk models. Regarding this changing of risk model use, Calabrese and O’Connor state “While the underlying scientific data reviewed by these committees had obviously been updated, there was and is nothing in the published literature indicating that the risks from ionizing radiation are an order of magnitude greater than previously thought.”

It is known that the BEIR committee examined data from many sources, but often data showing hormesis or threshold were excluded. For example, environmental studies show that residents living in unusually high background radiation exposures, those near nuclear reactor plants and those exposed to fallout from nuclear accidents (apart from increased thyroid cancers) show no evidence of increased cancers. The BEIR committee considered these types of studies to be of little use due to being “descriptive in nature” and “ecological in design.” Occupationally exposed workers involving nuclear powerplant workers (Cardis et al) initially showed an increased mortality risk for all cancers except leukemia; however, excluding invalid data involving one Canadian test site showed no increased cancer risk but, in fact, also showed an overall decreased risk of both all causes and cancers for nuclear workers versus expected. The BEIR report does acknowledge this trend but attributes it to the “healthy worker effect” and “unknown differences” between nuclear workers and general public and excludes the data for “not being suitable.”

The BEIR VII report almost completely relies on the data from the LSS cohort, and in doing so, they create risk models for calculating the risks of cancer. It is noted that an ERR model and an “excess absolute risk” (EAR) model was used by BEIR but resulted in great incongruence between the two. The “lifetime attributable risk” (LAR) model which is the difference in the rate of a condition between an exposed to unexposed population is used to estimate the probability of developing a premature cancer over a lifetime while accounting for the age of exposure, latency period, and the dose...
and dose rate effectiveness factor. It is pointed out that when the LAR is based on ERR versus EAR, significantly different risk estimates arise, even differing by a factor of 10.59 Calabrese and O’Connor argue that ideally all estimates should be identical and be within 1-2 standard deviations of each other—but the BEIR estimates are not. Further, the BEIR committee assigned weighting factors, and it is pointed out that the weighted mean risk coefficient factor from the included data was 0.05/Gy59; however, “the BEIR VII Committee chose a value of ERR = 0.86/Gy, which is 17 times larger than the weighted mean from all nine medical studies” (that the report included).59 Notably, the BEIR report itself even states “because of the various sources of uncertainty it is important to regard specific estimates of LAR with a healthy skepticism…” (p. 278).

One final critique worthy of mention by Calabrese and O’Connor was the use of the dose and dose rate effectiveness factor (DDREF). This is a factor built into the BEIR estimation of radiation risks that modifies or reduces the dose-risk relationship as estimated by the model to specifically account for the level of dose/dose rate for which the radiation dose was exposed to a population. Importantly, the BEIR committee assigned a value of 2 for the DDREF; however, as Calabrese and O’Connor state “use of any value of the DDREF greater than 1 essentially converts the LNT into a linear-quadratic or biphasic model, and provides a means of modifying the linear model without officially abandoning the LNT hypothesis.” In the end, Calabrese and O’Connor conclude: “Collectively, the uncertainties in the derivation of the BEIR VII risk estimates, and the intrinsic speculative nature of the risk estimates themselves, cause predictions of cancers and cancer deaths to be more hypothetical than real in populations exposed to medical imaging.”59

**Low-Dose Ionizing Radiation Is an Effective Treatment for Human Illnesses**

As mentioned, LDIR treatments have been used to treat a variety of human ailments including inflammatory and neurodegenerative conditions, infections, and cancers (Table 3).75–77,97–119(114–119) Recently, Calabrese et al have summarized evidence from historical data on therapeutic efficacy suggesting that LDIR treatment had an efficacy rate of 75–90%.76 This is based on radiation exposures estimated to be between 30 and 100 roentgen76 which is much greater exposure than one would receive from spinal X-rays (1-3 mGy) or CT scans (10 mGy). We43 reiterate “radiation doses that are healthful cannot simultaneously be harmful; it is the LNT mythology that continues to perpetuate false notions of low-dose radiophobia that only stifles the research and acceptance of using LDI for treating human disease” (p. 5). LDIR therapy is also proving successful in treating patients with COVID-19.112,113

| Table 3. Human Diseases, Infections, and Conditions Successfully Treated by Low-Dose Radiotherapy.75–77,97–119 |
|---------------------------------------------------------------|
| **Non-cancerous Conditions**                                  | **Cancers**                          |
| Alzheimer’s disease                                          | Breast                               |
| Arthritis                                                    | Colon                                |
| Bronchial asthma                                             | Hematological                        |
| Bursitis                                                     | Liver cell                           |
| Carbuncles                                                   | Lung                                 |
| Cervical adenitis                                            | Non-Hodgkin’s lymphoma               |
| COVID-19                                                     | Ovarian                              |
| Deafness                                                     | Prostate                             |
| Diabetes Type I                                              | Uterine                              |
| Diabetes Type II                                             |                                       |
| Furuncles                                                    |                                       |
| Gas gangrene                                                |                                       |
| Necrotizing fascitis                                         |                                       |
| Otitis media                                                 |                                       |
| Parkinson’s disease                                          |                                       |
| Pemphigus                                                    |                                       |
| Pertussis                                                    |                                       |
| Pneumonia                                                    |                                       |
| Rheumatoid arthritis                                         |                                       |
| Sinus infection                                              |                                       |
| Tendonitis                                                   |                                       |
| Ulcerative colitis                                           |                                       |

LDIR therapy to prove effective for conditions that have no successful treatment approach such as for Alzheimer’s disease.119 It must be stated that although the mechanisms for the therapeutic benefits of LDIR are not fully elucidated, it is understood that LDIR upregulates the innate adaptive protection systems (Figure 1).72–74 Generally, any initial damage caused by radiation exposures will be prevented, repaired and/or removed by very efficient biological systems that results in a net decrease in DNA damage; an increase in health benefit. Thus, knowledge of the innate adaptive protection systems and how they can be stimulated to treat disease at radiation doses far above those from spine X-rays should serve as enough evidence to abandon the notion of low-dose carcinogenicity fears from X-rays.

As discussed, the underpinnings of all X-ray restriction stem from the traditional notion of carcinogenesis of low-dose radiation exposures that does not exist. Thus, if the fundamental carcinogenesis conjecture surrounding X-ray utilization is eliminated, what is left to be of concern for the taking of innocuous X-rays? Next, we overview the great deficiencies of the recent review paper contracted to Côté (Corso et al23).

**Methodological Deficiencies Invalidate the Contracted Côté Paper**

Here, we point out critical and insurmountable flaws in the single paper by Corso et al23 used to support the irrational, unscientific policy change by the CCBC that discriminates
against chiropractors that practice alternative forms of evidence-based practice that utilize initial and repeat X-rays for the analysis and treatment of spinal disorders outside of the exclusive use for screening for “red flags.”

Rationale for Review

Aside from the radiation fear from X-rays as discussed, the rationale for this review is unfounded. In the introduction, Corso et al.23 cite Mizrahi et al.120 to argue that the rate of X-ray use by “chiropractors and podiatrists increased by 14.4% between 2003 and 2015.”23 They go on to state: “this occurred despite the publication of several evidence-based clinical practice guidelines and clinical prediction rules to assist chiropractors in determining the indication for spine radiographs to assist with diagnosing a pathology.”23 For this statement, they readily show their bias by not even considering X-ray use for biomechanical assessment and reference five citations,121-125 problematically 3 of the 5 citations were published after 2015121-123—a “time-machine oversight.”126 Of the 2 citations prior to 2015,124,125 one was exclusively for cervical spine trauma.125 The only citation that supports Corso’s rationale is the 2008 Bussieres et al radiographic guidelines,124 though these have been criticized as being recycled allopathic medical care guidelines (i.e., for the practice of general medicine)17,18,25 that are declared to be modeled after the UK Royal College of Radiologists “Referral guidelines for imaging”125 (i.e., red flag guidelines) where one of the stated purposes of the “chiropractic guideline” is for use in the hospital emergency room (i.e., medical practice).124 The Bussieres guideline has been heavily criticized for not including chiropractic-specific X-ray uses17,18,25 (e.g., screening for anomalies and/or pathologies that alter manipulative techniques) or for biomechanical analysis which is indeed the universally accepted standard for investigating the integrity of the spine structure and function throughout the spine care literature.1-10,12,13,25,128-135

Corso et al.23 further state “To our knowledge, approximately 23 chiropractic techniques use spine radiography (including full spine radiography) to guide the clinical management of patients.” First, this statement shows recognition that many different chiropractic technique factions practice X-ray-guided methods; there are at least 23 radiography-based chiropractic techniques and this represents the great diversity within the profession (Table 4136). Corso et al argue that although proponents of the X-ray-based technique methods “claim that the use of routine and repeat radiographs is supported by scientific evidence… these claims have not yet been evaluated for their clinical utility” (i.e., patient benefits from X-ray guided treatments are not known).23 This main argument is factually preposterous as there is an abundance of high-quality randomized controlled clinical trials (RCTs), non-randomized controlled trials (nRCTs), and a plethora of evolving evidence (e.g., case reports, case series, and cohort studies) to the contrary which we will discuss.

In several recent publications, evidence-based X-ray-guided treatment by chiropractors and other manual therapists have been summarized.4,8,9,12,13,17,21,25,137-139 It needs to be noted that the evidence-base for the manual therapy sciences in general is lacking,40 and that chiropractors use a broad and diverse range of patient treatments, whether specifically studied by chiropractors or other healthcare specialties (This is important to note as we discuss later, the Corso paper inclusion criteria only included studies where treatment was exclusively
Table 4. X-ray based Chiropractic Technique Systems.136

| Upper Cervical Techniques                  | Full Spine Techniques                  |
|-------------------------------------------|----------------------------------------|
| Advanced Orthogonal                       | Aragona Spinal Biomechanics Engineering |
| Atlas Orthogonality                        | Chiropractic BioPhysics                |
| Applied Upper Cervical Biomechanics        | Logan Basic                            |
| Blair                                      | Palmer-Gonstead                         |
| Duff Method                                | Pierce-Stillwagon                       |
| Grostic                                    | Spinal Stressology                      |
| Kale                                       |                                        |
| Knee Chest Upper Cervical Specific         |                                        |
| Mears                                      |                                        |
| NUCCA                                      |                                        |
| Orthospinology                             |                                        |
| SONAR                                      |                                        |
| Sutter Specific Atlas Correction           |                                        |
| Upper Cervical Orthogonal                 |                                        |
| Zimmerman                                 |                                        |
| Toggle Recoil (Hole-in-One)                |                                        |

Abbreviations: NUCCA, National Upper Cervical Chiropractic Association; SONAR, Spinal Orthopedic Neurological Advancement and Research.

“done by chiropractors” which automatically excluded 100s of otherwise eligible studies). In brief, for spine radiographic assessment and outcomes, there exists the highest quality evidence (RCTs) for methods shown to decrease forward head posture,141-149 increase cervical lordosis,141,142,144-151 decrease thoracic hyperkyphosis,152-160 increase lumbar lordosis,137,161-163 and decrease/stabilize scoliosis deformities.164-166 It is noted that although some of the RCTs assessing thoracic hyperkyphosis used surface contour instead of imaging, imaging is the most appropriate method to assess the exact type or cause of kyphosis (fracture, postural, senile, congenital, Scheuermann’s, etc.) as well as the segmental location of any deformity. Furthermore, regarding these spine displacements with RCT evidence, chiropractors are intimately trained in the evaluation of these, are intimately trained in these specific treatment protocols and interventions used, and chiropractors are legally licensed in the clinical application of these protocols and practices.

There are also multiple non-randomized clinical control trials (nRCTs) and hundreds of case reports/series showing X-ray-guided chiropractic treatment leads to positive patient outcomes.169 Several recent case reports/series document the improvement in several different spine displacement patterns (i.e., spinal deformities/subluxation patterns170-175) that are only precisely diagnosed and quantified by radiography including reduction of anterior whole-spine sagittal balance,176,177 reduction of cervical pseudo-scoliosis,178-180 reduction of lumbar pseudo-scoliosis,181,182 improving thoracic hypokyphosis (straight back syndrome),183-185 reduction of thoracolumbar kyphosis,186 correcting lumbar kyphosis (flat back syndrome),187 reduction of lumbar hyperlordosis and pelvic tilt,188 reduction of cervical spondylolisthesis,189,190 and reduction of lumbar spondylolisthesis.191-193

As illustrated, even prior to critically debunking the Corso review, it can be seen that the rationale for inquiry is based on misplaced bias. There is an underlying assumption that X-ray-guided chiropractic techniques and practices are not “evidence-based” methods and that the chiropractors who do utilize radiography outside of allopathic “red flag” use are practicing negligence and are a public health threat. As will be illustrated, this is farthest from reality.

Selection of “Rapid Review”

The contracted review (Corso et al23) was initially registered with the PROSPERO (International prospective register of systematic reviews) on November 12, 2019, and the “start date” was listed as November 4, 2019.194 In its filing under the section “Type and method of review,” it was listed as a “systematic review” (SR). The completed manuscript was submitted to the journal Chiropractic & Manual Therapies on March 31, 2020, accepted on May 24, 2020, and published online on July 9, 2020.23

According to the PROSPERO website, planned prospective reviews may be considered prospective until the point of data extraction from included studies. This means that most of the work on the Corso manuscript occurred over the course of less than 5 months. Considering the average SR takes 6 months to 2 years for completion,195 this project was performed remarkably quick. Also noted is that despite being registered as an “SR,” the final published review was actually a “rapid review” (RR). According to Tricco et al, a RR is “a form of knowledge synthesis in which components of the systematic review process are simplified or omitted to produce information in a timely manner.”196 For such an established aspect of clinical practice (taking X-rays), it is questioned why a RR was performed and not a standard SR (which was officially registered but not actually performed). What was the urgency to evaluate a common practice that has existed for decades and specifically been practiced without public health concern for 87 years in BC, Canada?197 As mentioned previously, at least 23 chiropractic technique systems and many other rehabilitation practices are X-ray-guided.136

In a review of RR methods, 50 different methodological approaches were identified.196 In other words, RRs are abstruse as there is no consensus to their make-up. Interestingly, the main unifying theme of RRs is that they are performed with significant and purposeful methodological “shortcuts” as compared to the standard SR.196 In actuality, a RR allows the investigator to introduce bias by electing which procedures to eliminate in order to expedite the process. The methods naturally become vulnerable to vast criticism for being “shotty” or “suspect” depending on the intent of the study. Because no universal definition for RR methodology exists (i.e., remains underdeveloped), many experts question their validity.198,199
As we will show with the Corso study,\textsuperscript{23} the inferences from this RR are as what all RRs are understood to be; that is, “their scope is limited.”\textsuperscript{199} In fact, RRs should be read with a cautious interpretation of findings as there are “gaps in transparency and knowledge about the trustworthiness of rapid reviews.”\textsuperscript{195} Indeed, RRs have been found to be incongruent with standard SRs.\textsuperscript{196} We question what time-sensitive demand could have made the authors choose a RR on the utilization of X-ray by chiropractors in British Columbia, Canada, that again, we note, has been competently practiced without prior public health concern for 87 years?

**Inappropriate Referencing of WHO Guidelines**

Corso et al cite the World Health Organization’s overview of RR uses.\textsuperscript{200} According to this report, “Policy-makers require valid evidence to support time-sensitive decisions regarding the coverage, quality, efficiency and equity of health systems” and that “There is also a need for capacity strengthening in low- and middle-income countries in the field of evidence synthesis and rapid reviews more specifically.” Thus, it seems the purpose of a RR as described by the WHO appears to be in situations where a “time-sensitive” matter is at hand and/or when decisions need to be made by low- and middle-income countries (where a proper systematic review of the literature may not be feasible) for which Canada is definitively not.

The WHO document is also specifically designed for a “new” diagnostic test, but X-rays are the gold standard for evaluation of spinal disorders and have been used for this purpose for over 100 years! According to the WHO report, a SR would be a standard necessary to properly assess healthcare policy; therefore, as stated in the WHO report: “generally accepted standards for study selection, data abstraction, and quality assessment for systematic reviews” is to “use two or more reviewers, working independently, to screen and select studies.” The lead author (Corso) was responsible to identify and screen all eligible articles.\textsuperscript{23} The authors validated the quality of screening by this single author by randomly screening only ten percent of all eligible articles by a second investigator. The decision to use only one reviewer (Corso) introduced potential bias in the study design and goes against the recommendations made by the WHO.\textsuperscript{200}

**Eliminating Valid Studies If Not “Performed by Chiropractor”**

One of the most condemning flaws of the Corso et al review is the inclusion criteria being “studies of patients presenting to chiropractors who received spinal radiographs of the cervical, thoracic or lumbar spine region, in the absence of red flags.” Knowing that literature of the manual therapy sciences is lacking\textsuperscript{140} and that in particular, chiropractic specific literature is limited,\textsuperscript{201} setting this inclusion criteria to be strictly studies “done by chiropractors” automatically excludes hundreds if not thousands of otherwise relevant studies where the interventions are part of a practicing chiropractors legally licensed armamentarium!

An illustration of the tragic flaw of strictly requiring “chiropractic patients” involves the exclusion of multiple recent RCTs from the Chiropractic BioPhysics (CBP) and related groups,\textsuperscript{141-150,161-163} which, of course, represents the highest level of scientific evidence. Several high-quality RCTs show that X-ray-guided structural rehabilitation procedures (which were invented by and are routinely practiced by a significant faction of chiropractors) definitively leads to improvement of spine alignment as measured from X-rays and most importantly, superior long-term patient outcomes (Figures 2-5).\textsuperscript{4,137,139,141-150,161-163,202} The inclusion of even one of these RCTs would have reversed the conclusion of the review; in fact, these RCTs alone refute their findings of no clinical utility of X-rays as the RCT is level 1 evidence versus the Corso et al\textsuperscript{23} rapid review (i.e., deficient review) which we believe, should be considered level 5 evidence equivalent to expert opinion.

**Missed and Excluded Reliability Studies**

Of the 8 total studies included in their review pertaining to the reliability of X-rays, 6 of the 8 were from the CBP chiropractic group.\textsuperscript{203-208} Surprisingly, Corso et al missed 8 other papers on reliability/repeatability of X-ray mensuration procedures also published by the CBP authors.\textsuperscript{209-216} Further, although they included a chiropractic clinical outcome study by Plaugher, et al\textsuperscript{217} on the Gonstead analysis system, they missed a reliability study on same system for the pelvis by the same author\textsuperscript{218} as well as they missed the study by Burk, again on the same Gonstead analysis system.\textsuperscript{219}

Surprisingly, a 1997 study published in Spine by Côté et al, the co-author contracted to perform the manuscript in question, found, “Measuring the magnitude of the sagittal curve from C2 to C7 had excellent interexaminer agreement, with an intraclass correlation coefficient of 0.96 (95% confidence interval, 0.88-0.98) and an interexaminer error of 8.3 degrees.”\textsuperscript{220} Oddly, this study was not included by Corso et al.\textsuperscript{23}

Additionally, we found 12 other articles that included analysis of reliability of X-ray mensuration procedures, published by chiropractors and missed by Corso et al.\textsuperscript{221-232} This makes 23 missed papers, that should have been included according to their own inclusion criteria that limited papers to being published by chiropractors. This is very concerning considering these are more papers than they included in their review.\textsuperscript{23} We believe these citations alone would have altered their findings regarding reliability/validity of X-ray mensuration analysis.

Many more studies (we reference >130 here) were excluded merely because the reliability study was published by non-chiropractors, although the mensuration analyses are taught in chiropractic school and used by chiropractors on a
daily basis (e.g., Cobb method for scoliosis analysis), and published in chiropractic radiography guidelines.170,233-370

**Missed and Excluded Clinical Outcome Studies**

Only 9 total papers were included in their rapid review; 7 of these papers were investigations on CBP chiropractic technique methods.203-208,371 Additionally, it is unbelievable that the most recent of these included papers was published in 2005 and no studies were included in the evaluation of X-ray utility for the entire chiropractic profession from the last 15 years!23

An inquiry to the CBP NonProfit website lists over 150 papers published since 2005.372 This includes spinal modeling studies, the sum of which has been described in recent publications.138,171

---

**Figure 2.** Data from 2 RCTs demonstrates patients receiving lumbar extension traction as well as conventional treatments have lordosis improvements that are sustained for 6 months after stopping treatment versus the lumbar curve in comparative groups (controls) remain unaffected by conventional treatments (weighted averages from 2 RCTs161,162). *Indicates a significant group difference as specified in each of the 2 trials; brackets represent weighted standard deviation.

**Figure 3.** Data from 2 RCTs demonstrate patients achieving lumbar lordosis improvement (via extension traction) as well as conventional treatments have pain reductions that are sustained for 6 months after stopping treatment versus comparative groups (controls not achieving lordosis improvement) who show a regression (increase) of pain intensity toward baseline after stopping treatment (weighted averages from 2 RCTs161,162). *Indicates a significant group difference as specified in each of the 2 trials; brackets represent weighted standard deviation.
The CBP research group has modeled the normal human spine where the cervical curve is a portion of a circle and the thoracic and lumbar spinal curves are portions of ellipses that meet at the thoracolumbar junction at their straightest sections. Importantly, the Harrison normal spinal model has been validated in multiple ways. Simple analysis of alignment data on samples of the normal, asymptomatic population has been done.\textsuperscript{373-380} Comparison studies between normal samples to symptomatic samples,\textsuperscript{371,375,380} as well as between normal samples to theoretical ideal models have been done.\textsuperscript{373,374,376-379}

Two studies even showed that pain patients and asymptomatic persons can be successfully identified by discriminant statistical analysis based on spine alignment parameters; that is, the presence of cervical or lumbar hypolordosis\textsuperscript{375,380} which is consistent with systematic literature reviews and meta-analysis findings from the current literature.\textsuperscript{7,381,382}

These modeling papers\textsuperscript{373-380} are important for the profession and add great weight to the clinical utility of radiography use in chiropractic and the manual therapies.

Regarding CBP literature, there were also 4 clinical trials “done by chiropractors” also missed by Corso.\textsuperscript{178,181,383,384}

Most importantly, and as mentioned, there were 7 RCTs also not included (excluded by strict inclusion criteria) by Corso.\textsuperscript{143-145,147,150,161-163} The results of these trials demonstrate that patients who receive spine traction methods (invented by chiropractors) based on radiographic measurements (Posterior tangent method invented by Don Harrison, DC) as a part of spine rehabilitation programs show statistically better long-term improvement in pain, disability, and other functional outcomes as well as spinal kinematics and other physiological measures at long-term follow-up with improvement in radiographically measured spine alignment. The RCTs met all the inclusion criteria of the authors, except that the care was provided at a physiotherapy department by physiotherapists despite the fact that many of the trials were co-designed and co-authored by a chiropractor.\textsuperscript{143-145,147,150}

Non-surgical management of spinal deformities (e.g., scoliosis and thoracic hyperkyphosis) are also within the scope of practice of Doctors of Chiropractic. Three studies were missed by Corso et al that were conducted by chiropractors in chiropractic settings and published in “chiropractic” journals for treatment of scoliosis.\textsuperscript{385-387} The bulk of research on the conservative approach to the management of

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure4.png}
\caption{Data from 5 RCTs demonstrates patients receiving cervical extension traction as well as conventional treatments have lordosis improvements that are sustained for 1 year after stopping treatment versus the cervical curve of comparative groups (controls) remain unaffected by conventional treatments (weighted averages from 5 RCTs\textsuperscript{141,142,144,147,149}). *Indicates a significant group difference as specified in each of the 5 trials; brackets represent weighted standard deviation.}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure5.png}
\caption{Data from 5 RCTs demonstrate patients achieving cervical lordosis improvement (via extension traction) as well as conventional treatments have pain reductions that are sustained for 1 year after stopping treatment versus comparative groups (controls not achieving lordosis improvement) who show a regression (increase) of pain intensity toward baseline after stopping treatment (weighted averages from 5 RCTs\textsuperscript{142,144,147,149}). *Indicates a significant group difference as specified in each of the 5 trials; brackets represent weighted standard deviation.}
\end{figure}
scoliosis/hyperkyphosis has been performed by and published from other disciplines (Physical Medicine and Rehabilitation, Physical Therapy and Physiotherapy). These studies report on treatment methods commonly used in chiropractic practice, including exercises and the provision of thoracolumbosacral orthoses (TLSOs). Results across these disciplines show that scoliosis specific exercises with and without bracing is effective in the management of scoliosis, as well as the sagittal spine deformity of thoracic hyperkyphosis.

**Failure to Include Upper Cervical, Full-Spine, Pelvis, and Leg Length Inequality**

Chiropractors have utilized unique X-ray views of the joints of the spine and pelvis for over 100 years, including upper cervical specific views, full-spine views, pelvic views, and views specific for evaluation of leg length inequality (LLI) (e.g., femoral head view or modified Risser-Ferguson view). All these chiropractic specific views and their analyses are presented in the ICA X-ray guidelines. Importantly, the Corso et al review did not consider these unique X-ray views or their treatment by chiropractors as their search strategy only included the terms “cervical,” “thoracic,” and “lumbar” spine.

It is widely known that many specialty chiropractic techniques utilize upper cervical X-ray views including Atlas Orthogonality (AO), Blair, Grostic, NUCCA, Kale, Toggle recoil, and others (Table 4). Dedicated upper cervical chiropractic X-ray views are unique to chiropractic and are not typically performed within allopathic medicine, and these include the anterior-posterior (AP) open mouth, nasium, vertex, base posterior, and Blair protracto views. Regarding these views, there are both reliability studies and clinical outcome studies. Again, these studies should have been included by Corso et al.

Regarding full spine X-ray analysis, many technique systems in chiropractic utilize the AP or posterior-anterior (PA) full spine radiographic view routinely such as Gonstead technique. This is also the standard radiographic view throughout all healthcare for the analysis of scoliosis. Regarding the lateral full-spine radiograph, it is well known that the full spine view is the standard for biomechanical assessment and much information can be gained such as:

- A global view of the sagittal balance of C1, T1, T12, and S1;
- An evaluation of forward/backward head translation;
- An evaluation of forward/backward ribcage posture;
- An evaluation of sagittal posture (from the postural examination) and spinal coupling on the radiograph;
- An evaluation of cervical lordosis;
- An evaluation of thoracic kyphosis;
- An evaluation of lumbar lordosis;
- An evaluation of pelvic tilt;
- An evaluation of pelvic morphology;
- An evaluation of any retro- or spondylolisthesis;
- An evaluation of spinal degeneration (vertebrae, discs, and spinal ligaments);
- Spinal canal dimensions; and
- A number of other anomalies, fractures, and instabilities.

The pelvic X-ray view is a popular view for some chiropractic approaches including the Gonstead system. Many pelvic and sacral listings (i.e., thrust vector trajectories) can be determined as well as insight into pelvic anomalies and pathologies that may alter treatment approaches. Radiographic screening for suspected LLI is also a common practice by chiropractors. An LLI can induce full-spine postural adaptations and be implicated in the pathogenesis of spinal disorders. Again, there are reliability studies on radiographically measuring LLI and outcome studies on use of shoe lifts for treatment of LLI. These should have been considered by Corso et al.

**Failure to Include Studies on Anomalies/Pathologies that Alter Manipulative Treatment**

As discussed previously, chiropractic treatment is unique and often involves imparting high-velocity, low-amplitude forces into the body of patients. As has been studied, albeit not enough, every study done in chiropractic on assessing the prevalence of bony anomalies and pathologies that may alter the adjusting and treatment approach within chiropractic has found alarmingly high rates.

In other studies, it was determined that in a population of almost 11,000 so-called “healthy” air force recruits, 97% had pathological findings. Another study determined that the average number of radiographic anomalies, degenerative changes, and deviations of posture was 3.5 per screened person. This latter study was performed on healthy air force candidates, and the authors stated “Since the population is highly selected, the figures we present may be minimum numbers in a western industrialized society.”

These types of studies are of critical importance for chiropractors and the implications of how different radiographic anomalies and pathologies play into how they alter spine manipulative approaches is an understudied area. Anecdotally, these types of radiographic findings are important and have implications to patient care and outcomes.

**Failure to Define “Red Flags”**

Despite the fact that Corso et al mentioned the word “red flags” 18 times throughout their review, they failed to specify the precise definition of the term in their paper. This is a critical flaw. For example, all spine guidelines, even “red flag” chiropractic guidelines (e.g., Bussieres et al and Jenkins et al), allow for the routine and repeat use of X-rays in the
diagnosis and monitoring of scoliosis of the spine. Scoliosis is not considered to be a traditional “red flag” per se. So, if Corso et al do not consider scoliosis to be considered in their interpretation of a “red flag” then this just adds to the invalidation of the scope and findings of their review as scoliosis assessment and treatment is a major emphasis in the education of chiropractors and is commonly managed by chiropractors.

Eliminating Valid Studies Based on “Bias”

In the Corso paper, all clinical trials that were located and included in their risk of bias scoring were thrown out due to “risk of bias.” In fact, no clinical trials were considered in their formal assessment of X-ray utility. Several of the trials we argue were of sufficient quality. For example, the Harrison nRCT (2002) documenting X-ray-guided improvement in lumbar curve and pain levels after spinal manipulative therapy and extension traction methods as compared to no changes in spine alignment or pain level in a control group was considered by Corso et al to be at high risk of bias, although in a recent systematic review this same trial was scored a low risk of bias and the results of this initial nRCT were later found to be consistent with the results of RCTs on the topic.

Another Harrison nRCT (2003) was scored similarly to the previous trial and considered as having a high risk of bias (their Table 1). As mentioned, Corso et al missed 4 other CBP trials “done by chiropractors” that should have been included in their analysis. Importantly, if one of these trials were included in Corso et al’s final assessment, it would have reversed their conclusions. Corso et al mention that they included a “quality control step” in the critical appraisal of studies; the lead author presented a summary of appraised papers to 4 co-authors who “validated” the outcome of the appraisals. Indeed, the final internal validity rating of the papers was determined through “discussion” (p. 4).

It seems despite using a risk of bias scoring system, the actual allocation of uncertainty remained up to the assessor and we argue was conveniently extra critical, particularly when the study was performed by those who hold a pre-existing bias against X-ray use in practice, as we will discuss.

Conclusions Defies Impairment Rating Guidelines

According to the American Medical Association (AMA), “repeat” X-rays are required to be taken at “maximal medical improvement” (MMI) to determine intersegmental vertebral instability for impairment ratings.

According to the fifth edition of the AMA Guidelines to the Evaluation of Permanent Impairment, Chapter 15, The Spine, there are 2 methods to determine permanent impairment of the spine: (1) Diagnosis-Related Estimate (DRE) and (2) Range of Motion (ROM). “The DRE method is the primary method used to evaluate individuals with an injury” (p. 374). The guideline references White and Panjabi560 and Shaffer441 to make the statement “Motion of the individual spine segments cannot be determined by a physical examination but is evaluated with flexion extension roentgenograms.” Impairment is rated only when the patient has reached MMI as defined as the “date from which further recovery or deterioration is not anticipated, although over time there may be some expected change” (p. 19).

According to the sixth edition of the AMA Guidelines to the Evaluation of Permanent Impairment (AMA Guides) Chapter 17, The Spine and Pelvis, uses Diagnosis Based Impairment (DBI) regional grids. As is the case with the fifth edition, impairment ratings are only to be made when

---

### Table 5. Incidence of Anomalies, Pathologies and Postural Changes That Could Alter Treatment, and Relative and Absolute Contraindications to Provide Chiropractic Treatment.

| Author         | Region   | n   | Age Avg (SD) | Sex | Cohort/Setting          | Postural Changes | Congenital Anomalies | Contraindications | Serious Pathology | Anomalies/Pathologies |
|----------------|----------|-----|--------------|-----|-------------------------|------------------|----------------------|-------------------|------------------|---------------------|
| Jenkins        | Cervical | 2814 | n/r          | n/r | Macquarie University    | 28.5%            |                      |                   |                  |                     |
|                | Thoracic | 695  | n/r          | n/r | Chiro Clinic            | 0.7%             |                      |                   |                  |                     |
|                | Lumbar   | 1052 | n/r          | n/r | 18.3%                   |                  |                      |                   |                  |                     |
| Young          | Lumbar   | 262  | >/=50        | mix | Chiro Radiologist       | 94%              |                      |                   |                  | 44%                 |
| Pryor          | Cervical | 413  | n/r          | n/r | Chiro College           | 91%              |                      |                   |                  |                     |
|                | Thoracic | 403  | n/r          | n/r | Clinic                  | 70%              |                      |                   |                  |                     |
|                | Lumbar   | 402  | n/r          | n/r | 79%                     |                  |                      |                   |                  |                     |
| Beck           | Full spine | 847   | 33 (12)     | mix | New Zealand Chiro College Clinic | 68.1% | 6%                     | 0.6-6.6%          |                  |                     |
| Bull           | Full spine | 1698 | 36          | n/r | Macquarie University Chiro Clinic | 33% | 14%                    | 66%               |                  |                     |
the patient has reached MMI. Four of the five defining variables dictating the Class in which the severity is determined for impairment ratings, including “alteration of motion segment integrity” (AOMSI) require radiographic investigation, again at MMI.439

Healthcare providers including chiropractors, therefore, cannot perform an impairment rating in accordance with the AMA Guides438,439 without repeat X-rays performed after treatment methods have been exhausted. Assuming initial X-rays were obtained on an injured patient, these “repeat” X-rays are required in the determination of most cases of permanent impairment of the spine, and the CCBCs new policy runs counter to the long-established AMA Guides.

Co-Authors Hold Anti-Imaging Bias

It seems ironic that a review that concludes there is “no evidence” of X-ray utility in the entire chiropractic literature when, as we have indicated this is completely contrary to hundreds of missed studies, is made by at least 2 authors who have known biases against routine X-ray use. Côté has vocalized anti-imaging sentiment at scientific conferences attended by some of the present authors (e.g., verbal exchange during platform presentation question and answer session441) and Corso has expressed anti-imaging bias on social media outlets (Figure 6). Notably, a critical validity concern of RRs is “author bias,” and notably, Corso was the sole researcher responsible for the article review using their version of RR methodology.

Strong Conclusions Based on Little/Conflicting Evidence

Corso et al23 stated that “No relevant studies assessed the clinical utility of routine or repeat radiographs (in the absence of red flags) of the cervical, thoracic, and lumbar spine for the functional or structural evaluation of the spine. No studies investigated whether functional or structural findings on repeat radiographs are valid markers of clinically meaningful outcomes.”23 Despite these claimed findings, the authors draw the conclusion “we found no evidence that use of routine or repeat radiographs… improves clinical outcomes and benefits patients.” and therefore “recommend chiropractors do not use x-rays.”23 This is not a scientific statement. A basic tenant of evidence synthesis is that one cannot make conclusive statements when the evidence is limited (which in this case is not, just ignored) or when the evidence is inconclusive (which again in this case is not, just ignored). The Corso et al23 findings are opinion and at odds with scientific reality.

It has already been mentioned that many have questioned the validity of RRs since the methods involve “shortcuts,” and we pointed out that it would be easy for an investigator to adjust the methods to suit an agenda. It is questionable that based on only 9 papers, the authors could draw such a strong conclusion, especially concerning that only two papers addressed the validity of X-ray use, and one of these papers clearly support X-ray use. The McAviney et al371 paper showed powerful results in conflict with Corso’s conclusions. Within the Corso paper,23 they did mention McAviney et al371 found that patients having a neck curve less than 20° had twice the odds of having cervicogenic symptoms. Importantly, McAviney et al371 also determined that patients having a straightened or reversal of the normal neck curve had 18 times the odds of having cervicogenic symptoms. This latter finding within the included McAviney et al371 paper was not mentioned by Corso et al.23 Thus, 50% of the included validity evidence (1 of 2 papers) showed X-rays to be very useful in the assessment of sub-acute and chronic neck pain patients. Conceivably, Corso et al stated that “these studies provide no evidence of clinical utility.”23

The volume of literature is much larger than the 9 articles included in the Corso et al analysis.23 It is our contention that the exclusion of at least the 64 missing studies meeting their own inclusion/exclusion criteria that we mention here,178,181,209-232,373-377,379,380,383-387,390-401,413-424,429,430,432, as well as about 180 studies we also referenced that were excluded based on “not performed by a chiropractor,”143-145,147,149,152-160,233-370,388-411,423-428 would have undoubtedly led to the scientifically accurate conclusion that routine and repeat X-rays are very much an evidence-based practice for chiropractors who specialize and practice various X-ray-guided approaches to spine care.

It is noted that the journal in which they selected to publish their RR has also published many papers with dissenting views of the chiropractic profession in which reviews/commentsaries are known for overreaching and generalized conclusions,442-451 and also for which the long-time chief editor has anti-imaging views.452 Regarding the Corso et al23 manuscript, several authors of the present paper submitted letters-to-the-editor
(LTE) to point out many critical flaws; however, surprisingly, these letters were “peer reviewed” and finally rejected without ever making it to the Corso et al authors. It is noteworthy that some of the current authors who have published multiple previous LTEs453-462 had never previously experienced a journal formally ‘peer reviewing’ an LTE. In the end, the Corso review is pseudo-science and should have failed peer review.

CCBC Rapidly Reviews and Changes the 1934 Policy (Figures 7-9)

Chiropractors in BC have had full and unrestricted use of radiography rights since they were established in 1934.197 The Corso et al paper23 was published online on July 9, 2020, and the CCBC announced to its members that it was reviewing the policy of full X-ray rights one week later on July 15, 2020 (Figure 7). After collecting member and public feedback as of September 8, 2020, it was stated that “A summary of comments will be posted after the consultation period.” (Figure 7)463

As of July, 2021, 6 months after the CCBC instituted radical policy change discriminating against chiropractors who utilize X-rays for reasons other than diagnosing serious medical pathology (i.e., “red flags”), there has been no disclosure of the comments from its members and the public.24 On a September 25, 2020, “update” the CCBC did acknowledge that they had received over 1000 responses to the proposed changes including themes related to463

- Ensuring that any policy changes more clearly include the clinical judgment of the chiropractor;
- A request that the College further define “red flags” that a chiropractor may use in determining the need for radiography and what factors are necessary in leading to determining the need for radiographs;
- Factors such as a thorough history and examination leading to a determination of the necessity of further testing and/or radiographs.
- Clarifying the literature/studies that were considered by the independent researchers, and why other studies were not included in the rapid review;
- Providing more information about and safety concerns regarding the use of radiography.

As shown, the issues raised in these themed responses are important and to this day have not been addressed. The entire timeline from when the CCBC first informed its members that it was reviewing a well-established and important policy of full radiography rights to revoking these full rights to parallel medical practice “red flag” use was over a period of only 6 months (Figures 7-9).

It is suspect when a governing College makes such rapid and radical policy change to a practice that had been in place for 87 years (1934). Particularly concerning is that the CCBC have not posted the member/public comments, they contracted to an individual with known anti-radiology bias and implemented the “draft amendments” (Figure 8) citing radical restrictions 1 month after the publication of the flawed review.

Figure 7. Message from CCBC to its members (August 11, 2020). This notice signified the board was collecting member and public feedback to “anticipated amendments” (“red flag” only X-ray use) between the dates August 11, 2020, to September 8, 2020. This message also indicated the research to support this effort was the Corso et a23 rapid review.
that were unchanged (Figure 9) after apparent consideration of over 1000 member/public feedback letters of concern, admittedly most being critical to the proposed policy change.463

As mentioned, reliability studies are important, and the 8 included studies showed good reliability that provide legitimacy for X-ray use in practice. The validity studies are of utmost importance to address the clinical utility of X-ray use in practice, and regarding these, we question how such a radical and discriminatory policy change could occur so quickly after 87 years and also hinge on only 2 validity papers when one (McAviney et al371) clearly supports X-ray use.

This new CCBC policy, that restricts full X-ray use including for analysis of biomechanical parameters as well as screening for anomalies and pathologies that may alter treatment approach, is clearly neither evidence-based nor ethical. In fact, the new policy may be a threat to public health as spine care patients will unknowingly be limited to subpar clinical investigation (no X-ray for biomechanical assessment) and management (no biomechanical outcome goals—i.e., scoliosis, etc.). Undoubtedly, this may have dire and cascading consequences to countless patients and their clinical outcomes.
Discussion

The many criticisms of the Corso et al\textsuperscript{23} rapid review illustrate how flawed methodology results in flawed conclusions. It is suspect that the CCBC contracted an individual to conduct a systematic review on a well-entrenched aspect of chiropractic clinical practice that ended up as an incredibly limited and fatally flawed, “rapid” review with sweeping and generalized conclusions condemning routine/repeat X-ray use. In fact, the conclusion of the Corso et al\textsuperscript{23} paper is based on only two validity papers. One of the two validity papers very clearly powerfully supports X-ray utility in clinical practice. It is concerning that the authors of the contracted Côté paper concluded there is “no evidence” for X-ray use in chiropractic (outside of “red flag” screening) when literally dozens of chiropractic-specific papers\textsuperscript{178,181,209-232,373-380,383-387,390-401,413-424,429,430,432} and 100s of other papers were clearly missed.

The Corso et al\textsuperscript{23} statement “We found no evidence that the use of routine or repeat radiographs to assess the function or structure of the spine… improves clinical outcomes and benefits patients” is factually false, it is antithetical to scientific reality, and it is based on a fatally flawed review that was written by biased researchers who hold anti-imaging ideology. It is ironic that Corso et al\textsuperscript{23} attempted to assess the “clinical utility” of X-ray use in chiropractic when there is no unequivocal answer to the meaning of clinical utility; in fact, “Clinical utility will always be in the ‘eyes of the beholder,’ and the answer will therefore be different depending on the interests and goals of the stakeholder.”\textsuperscript{464} Lesko et al\textsuperscript{464} remind us that the evidence of clinical utility will be judged differently by equally qualified peers to the usefulness of the diagnostic (in this case X-rays) as applied to patients to their real-world clinical practice settings.

It is irresponsible that the CCBC, a formal regulatory body made a fundamental policy change so rapidly, basing its decision on a single flawed review, all while acknowledging over 1000 feedback responses were mostly critical of the change. The member and public feedback were obviously not considered as the draft for the policy change released prior to the open feedback period (Figure 8) did not change following public/member feedback (Figure 9); in fact, it was more strictly specified. To this day, the CCBC has not released the content of the 1000+ feedback responses.

Perhaps the most tragic outcome to the policy change that discriminates against chiropractors who practice evidence-based, X-ray-guided methods is the fact it actually discriminates against the healthcare consumer (ie, patient) by not allowing them to make health choices based on education provided within a risk-to-benefit ratio by clinicians. In fact, it is known that certain spinal disorders can predispose affected patients to future undesirable outcomes, including greater injury rates,\textsuperscript{465} greater injury severity (e.g., during motor vehicle collisions),\textsuperscript{466-469} development of future pain and disability (e.g., having lumbar hypolordosis\textsuperscript{470}), having lingering pain and disability after a sustained injury (e.g., nonrecovery after whiplash\textsuperscript{466}) and even early mortality (ie, from thoracic hyperkyphosis\textsuperscript{471-477}). Most of these spine deformities have established or evolving evidence for their non-surgical treatment and reduction. It is an honest and ethical practice to screen and inform appropriate patients of the pathognomonic consequences of certain spinal conditions.

As discussed, it is a well-framed and evidence-based practice to routinely assess a patient’s spine and pelvis for biomechanical assessment that is linked to procedural treatment approaches and patient outcomes. In a recent synopsis of the clinical utility of X-rays in chiropractic and the manual therapies,\textsuperscript{25} it was determined X-rays are uniquely required by chiropractors and manual therapists specializing in spine-altering techniques and practices for three main purposes:

1. To assess spinopelvic biomechanical parameters;
2. To screen for relative and absolute contraindications to spine care;
3. To re-assess a patient’s progress to some types of spine rehabilitative treatments.

We would add an obvious fourth reason; that is, to rule out “red flags” or serious medical conditions (i.e., malignancy, infection, and fracture) unrelated to spine care that would warrant immediate referral. The recent restriction of X-ray rights by the CCBC increases the liability to the doctor who, in many instances, is now “handcuffed” and forced to treat patients “blindly.”

Discrimination against the consumer of spine care will subject them to limited (in many cases inadequate) clinical investigation and therefore limit management options (e.g., restrict spine-altering options including specific vectored spine adjustments, spine corrective traction, spine corrective bracing, and spine correcting exercises). Patient care planning requires the consideration of patient goals, needs, and values. Indeed, when clinical opinion varies, lawmakers and policy makers must weigh consumer values and desires into policy decisions taking into account therapeutic risks, and in the case of diagnostic ionizing radiation, the risks are shown to be negligible. Full evidence-based practice (EBP), in fact, consists of three separate arms: (1) clinical evidence, (2) practitioner experience, and (3) patient preferences.\textsuperscript{478} To not consider practitioner experience or patient preference is to not follow true EBP. The CCBCs new policy change to restrict full radiography use directly opposes modern EBP principles 2 and 3 and is clearly based on only a pre-select “drop” of the actual ocean of scientific evidence available on the topic.

Conclusions

Radiation exposures from X-rays used in the assessment and monitoring of patients receiving particular forms of chiropractic and manual therapy treatments are not a public health threat. These low-dose radiation exposures have not been
shown to cause harm; in fact, all recent evidence shows it reduces carcinogenic effects. The rationale to avoid X-rays based on LNT-based mythology is perpetuating radiophobia surrounding carcinogenic fears that will not occur. Outdated misinformation of the dangers of medically warranted X-rays should cease.

The radical policy change by the CCBC to restrict chiropractors in British Columbia, Canada, from utilizing X-rays for biomechanical screening and re-assessment purposes harms the spine care consumer by limiting their choice and discriminates against practitioners who have enjoyed EBP freedom since 1934. The new CCBC X-ray policy restrictions oppose EBP. The CCBC actions in creating this recent policy change are suspect as it is based on a single paper that is proven to be fatally flawed and that over 1000 mostly critical feedback letters were not considered or even released to the members.

Herein, we have cited dozens of chiropractic studies that should have been included in the contracted Côté review and hundreds of others that directly apply to modern, evidence-based, and radiography-guided chiropractic clinical practice. We recommend the CCBC to reverse its unscientific policy regarding the unprecedented restrictions of licenced chiropractors to take X-rays. Public health policy changes based on scientific misinformation through faulty and biased study design are a major threat to the safety and health of the public.

Acknowledgment

We thank Drs Gregory Plaugher, David Beaudoin, Surdeep Dhaliwal, Mark Foullong, Dustin Freund, Brad Gage, Melody Jesson, and Franchesca Lee for their invaluable input. We also thank the reviewers for their feedback.

Declaration of Conflicting Interests

The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: PAO is a paid consultant for CBP NonProfit; DEH teaches spine rehabilitation methods and sells products related to the treatment of spine deformities.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: The APC charge was funded by the International Chiropractor’s Association.

ORCID iD

Paul A. Oakley https://orcid.org/0000-0002-3117-7330

References

1. Scheer JK, Lau D, Smith JS, et al. Alignment, classification, clinical evaluation, and surgical treatment for adult cervical deformity: a complete guide. Neurosurgery. 2021;88(4):864-883. doi:10.1093/neuros/nyaa582
2. Diebo BG, Shah NV, Boachie-Adjei O, et al. Adult spinal deformity. Lancet. 2019;394(10193):160-172. doi:10.1016/S0140-6736(19)31125-0.
3. Le Huec JC, Thompson W, Molinsalny Y, Barrely C, Faundez A. Sagittal balance of the spine. Eur Spine J. 2019;28(9):1889-1905. doi:10.1007/s00586-019-06083-1.
4. Oakley PA, Elsani NN, Harrison DE. Repeat radiography in monitoring structural changes in the treatment of spinal disorders in chiropractic and manual medicine practice: evidence and safety. Dose Response. 2019;17(4):1559325818981043. doi:10.1177/1559325819891043.
5. Patwardhan AG, Khayatzadeh S, Havey RM, et al. Cervical sagittal balance: a biomechanical perspective can help clinical practice. Eur Spine J. 2018;27(suppl 1):25-38. doi:10.1007/s00586-017-5367-1.
6. Afolayan JO, Shafafy R, Maher M, Moon KH, Panchmatia JR. Assessment and management of adult spinal deformities. Br J Hosp Med. 2018;79(2):79-85. doi:10.12968/hmed.2018.79.2.79.
7. Ling FP, Chevillotte T, Leglise A, Thompson W, Bouhors C, Le Huec JC. Which parameters are relevant in sagittal balance analysis of the cervical spine? A literature review. Eur Spine J. 2018;27(suppl 1):8-15.
8. Oakley PA, Cuttler JM, Harrison DE. X-ray imaging is essential for contemporary chiropractic and manual therapy spinal rehabilitation: radiography increases benefits and reduces risks. Dose Response. 2018;16(2):1559325818781437.
9. Oakley PA, Harrison DE. Radiophobia: 7 reasons why radiography used in spine and posture rehabilitation should not be feared or avoided. Dose Response. 2018;16(2):1559325818781445.
10. Lee S-H, Son E-S, Seo E-M, Suk K-S, Kim K-T. Factors determining cervical spine sagittal balance in asymptomatic adults: correlation with spinopelvic balance and thoracic inlet alignment. Spine J. 2015;15(4):705-712.
11. Esslemont I. X rays for back pain. Br J Gen Pract. 2002;52(483):853-854.
12. Oakley PA, Harrison DE. Radiogenic cancer risks from chiropractic x-rays are zero: 10 reasons to take routine radiographs in clinical practice. Ann Vert Sublux Res. 2018;48:56. https://www.researchgate.net/publication/323687677_Radiogenic_Cancer_Risks_from_Chiropractic_X-rays_are_Zero_10_Reasons_to_Take_Routine_Radiographs_in_Clinical_Practice
13. Oakley PA, Harrison DE. Selective usage of medical practice data, misrepresentations, and omission of conflicting data to support the ‘red flag only’ agenda for chiropractic radiography guidelines: a critical review of the Jenkins et al. article: “current evidence for spinal X-ray use in the chiropractic profession. Ann Vert Sublux Res. 2019;14:141-157. https://www.vertebralsubluxationresearch.com/2019/10/07/selective-usage-of-medical-practice-data-misrepresentations-and-omission-of-conflicting-data-to-support-the-red-flag-only-agenda-for-chiropractic-radiography-guidelines-a-critical-review-of-the/.
Accessed January 25, 2021.
14. Value-based Health Care. Institute for Strategy and Competitiveness, School. https://www.isc.hbs.edu/health-care/value-based-health-care/Pages/default.aspx. Accessed January 25, 2021.

15. Kim J, Dong J, Brener S, Coyte P, Rampersaud Y. Cost-effectiveness analysis of a reduction in diagnostic imaging in degenerative spinal disorders. Healthc Policy. 2011;7:e105-e121.

16. American Chiropractic Association. Five things physicians and patients should question. 2017. http://www.choosingwisely.org/societies/american-chiropractic-association/. Accessed January 25, 2021.

17. Oakley PA, Harrison DE. Are restrictive medical radiation imaging campaigns misguided? it seems so: a case example of the American chiropractic association’s adoption of “choosing wisely”. Dose Response. 2020;18(2):1559325820919321.

18. Oakley PA, Harrison DE. American chiropractic association’s participation in choosing wisely: close inspection shows no evidence to support its anti-imaging points 1 and 2. a review. Asia-Pac Chiropr J. 2020. https://apcj.rocketsparkau.com/choosing-wisely-and-the-aca-oakley-and-harrison/. 1.2:online only.

19. Anderson B. Critical analysis of “x-ray imaging is essential for contemporary chiropractic and manual therapy spinal rehabilitation: radiography increases benefits and reduces risks” by Oakley et al. Dose Response. 2018;16(4):1559325818813509.

20. Kawchuk G, Goertz C, Axén I, et al. Letter to the editor re: Oakley PA, Cuttlar JM, Harrison DE. X-ray imaging is essential for contemporary chiropractic and manual therapy spinal rehabilitation: radiography increases benefits and reduces risks. Dose Response. 2018;16:161559325818811521.

21. Oakley PA, Cuttlar JM, Harrison DE. Response to letters from anderson and kawchuk et al: x-ray imaging is essential for contemporary chiropractic and manual therapy spinal rehabilitation: radiography increases benefits and reduces risks. Dose Response. 2018;16:161559325818811521.

22. Jenkins HJ, Downie AS, Moore CS, French SD. Current evidence for spinal X-ray use in the chiropractic profession: a narrative review. Chiropr Man Ther. 2018;26:48.

23. Corso M, Cancelliere C, Mior S, Kumar V, Smith A, Côté P. The clinical utility of routine spinal radiographs by chiropractors: a rapid review of the literature. Chiropr Man Ther. 2020;28(1):33.

24. College of Chiropractors of British Columbia. Amendments to the PCH: routine and repeat imaging. 2021. https://www.chirobc.com/amendments-to-the-pch-routine-and-repeat-imaging/?fbclid=IwAR2gz8I4dbyzrMfvw30upHRexNXuIOolI.bdg3Vz3aOnS9NMS9szas54. Accessed February 13, 2021.

25. Oakley PA, Harrison DE. Radiophobic fear-mongering, misappropriation of medical references and dismissing relevant data forms the false stance for advocating against the use of routine and repeat radiography in chiropractic and manual therapy. Dose Response. 2021;19(1):1559325820984626.

26. Kauffman JM. Radiation hormesis: demonstrated, deconstructed, denied, dismissed, and some implications for public policy. J Sci Explor. 2003;17(3):389-407.

27. Baldwin J, Grantham V. Radiation Hormesis: Historical and Current Perspectives. J Nucl Med Technol. 2015;43(4):242-246.

28. Shibamoto Y, Nakamura H. Overview of biological, epidemiological, and clinical evidence of radiation hormesis. Int J Mol Sci. 2018;19(8):2387.

29. Schultz CH, Fairley R, Murphy LS-L, Doss M. The risk of cancer from ct scans and other sources of low-dose radiation: a critical appraisal of methodologic quality. Prehospital Disaster Med. 2020;35(1):3-16.

30. Vaiserman A, Koliada A, Zubaga O, Socol Y. Health impacts of low-dose ionizing radiation: current scientific debates and regulatory issues. Dose Response. 2018;16(3):1559325818796331.

31. Matanoski GM, Sternberg A, Elliott EA. Does radiation exposure produce a protective effect among radiologists? Health Phys. 1987;52(5):637-643.

32. Linet MS, Kitahara CM, Niwce E, et al. Multi-Specialty Occupational Health GroupMortality in U.S. physicians likely to perform fluoroscopy-guided interventional procedures compared with psychiatrists, 1979 to 2008. Radiology. 2017;284(2):482-494.

33. Cameron JR. Radiation increased the longevity of British radiologists. Br J Radiol. 2002;75(895):637-639.

34. Kitahara CM, Linet MS, Balter S, Miller DL, Rajaraman P, Cahoon NK, et al. Occupational radiation exposure and deaths from malignant intracranial neoplasms of the brain and CNS in U.S. radiologic technologists, 1983-2012. Am J Roentgenol. 2017;208(6):1278-1284.

35. Tubiana M. Computed tomography and radiation exposure. N Engl J Med. 2008;358(8):850-853.

36. Boice JD Jr, Cohen SS, Mumma MT, et al. Updated mortality analysis of radiation workers at rocketdyne (atoms international), 1948-2008. Radiat Res. 2011;176(2):244-258.

37. Muirhead CR, Goodill AA, Haylock RGE, et al. Occupational radiation exposure and mortality: second analysis of the National Registry for Radiation Workers. J Radiol Prot. 1999;19(1):3-26.

38. Muirhead CR, O’Hagan JA, Haylock RGE, et al. Mortality and cancer incidence following occupational radiation exposure: third analysis of the National Registry for Radiation Workers. Br J Canc. 2009;100(1):206-212.

39. Iwasaki T, Murata M, Ohshima S, et al. Second analysis of mortality of Nuclear industry workers in Japan, 1986-1997. Radiat Res. 2003;159(2):228-238.

40. Tubiana M, Aurengo A. Dose effect relationship and estimation of the carcinogenic effects of low doses of ionising radiation: The Joint Report of the Academie des Sciences (Paris) and of the Academie Nationale de Medecine. Int J Low Radiat. 2006;2:135-153.

41. National Research Council of the National Academies. Health Risks from Exposure to Low Levels of Ionizing Radiation: BEIRVII Phase 2. Washington, DC: The National Academies Press; 2006.

42. United Nations Scientific Committee on the Effects of Atomic Radiation. Sources, Effects and Risks of Ionizing Radiation: UNSCEAR 2016 Report to the General Assembly, with Scientific Annexes. United Nations Scientific Committee on the Effects of Atomic Radiation; 2017.
43. Oakley PA, Harrison DE. Death of the ALARA radiation protection principle as used in the medical sector. *Dose Response*. 2020;18(2):1559325820921641.

44. Image Gently Alliance. Alliance for radiation safety in pediatric imaging image gently. 2007. https://www.imagegently.org/About-Us/About-Us. Accessed March 6, 2021.

45. Joint Task Force on Adult Radiation Protection. The Imaging Wisely Campaign. 2009. https://www.imagewisely.org/About-Us. Accessed March 6, 2021.

46. Siegel JA, Pennington CW, Sacks B. Subjecting radiologic imaging to the linear no-threshold hypothesis: a non sequitur of non-trivial proportion. *J Nucl Med*. 2017;58(1):1-6.

47. Doss M. Disavowing the ALARA concept in pediatric imaging. *Pediatr Radiol*. 2017;47(1):118.

48. Siegel JA, Sacks B, Welsh JS. Time to terminate LNT: radiation regulators should adopt LT. *J Radiol Oncol*. 2017;1(5):49-53.

49. Siegel JA, Sacks B, Welsh JS. Time to eliminate LNT: The NRC needs to adopt LT and eliminate ALARA. *Nucl Med Biomed Imaging*. 2017;2(3):1-5.

50. Cohen MD. Reply to Dr. Andronikou: disavowing the ALARA concept in pediatric imaging. *Pediatr Radiol*. 2017;47(1):116-117.

51. Siegel JA, Sacks B, Pennington CW, Welsh JS. Dose optimization to minimize radiation risk for children undergoing CT and nuclear medicine imaging is misguided and detrimental. *J Nucl Med*. 2017;58(6):865-868.

52. Siegel JA, McCollough CH, Orton CG. Advocating for use of the ALARA principle in the context of medical imaging fails to recognize that the risk is hypothetical and so serves to reinforce patients’ fears of radiation. *Med Phys*. 2017;44(1):3-6.

53. Siegel JA, Welsh JS. Does imaging technology cause cancer? Debunking the linear no-threshold model of radiation carcinogenesis. *Technol Cancer Res Treat*. 2016;15(2):249-256.

54. Doss M. Should the ALARA Concept and the Image Gently Campaign be Terminated? Chicago, IL. 2016. http://www.pedrad.org/LinkClick.aspx?fileticket=3EHIVnxgKs%3d&portalid=5. Accessed March 25, 2020. Paper presented at the International Pediatric Radiology.

55. Cohen MD. Point: should the ALARA concept and image gently campaign be terminated?. *J Am Coll Radiol*. 2016;13(10):1195-1198.

56. Oakley PA, Harrison DE. Radiophobic fear-mongering, misappropriation of medical references and dismissing relevant data forms the false stance for advocating against the use of routine and repeat radiography in chiropractic and manual therapy. *Dose Response*. 2021;19(1):1-19.

57. Doss M. Evidence supporting radiation hormesis in atomic bomb survivor cancer mortality data. *Dose Response*. 2012;10:584-592.

58. Doss M. Linear no-threshold model vs. radiation hormesis. *Dose Response*. 2013;11(4):480-497.

59. Calabrese EJ, O’Connor MK. Estimating risk of low radiation doses - a critical review of the BEIR VII report and its use of the linear no-threshold (LNT) hypothesis. *Radiat Res*. 2014;182(5):463-474.

60. Doss M. The conclusion of the beir vii report endorsing the linear no-threshold model is no longer valid due to advancement of knowledge. *J Nucl Med*. 2018;59(11):1777.

61. Siegel JA, Greenspan BS, et al. The BEIR VII estimates of low-dose radiation health risks are based on faulty assumptions and data analyses: a call for reassessment. *J Nucl Med*. 2018;59(7):1017-1019.

62. Sutou S. Black rain in Hiroshima: a critique to the life span study of a-bomb survivors, basis of the linear no-threshold model. *Gene Environ*. 2020;42:1.

63. Calabrese EJ. The significance of the failed historical foundation of linear non-threshold model for cancer risk assessment. *Int J Low Radiat*. 2020;11(3/4):173-177.

64. Calabrese EJ. Was Muller’s 1946 Nobel Prize research for radiation-induced gene mutations peer-reviewed? *Philos Ethics Humit Med*. 2018;13(1):6.

65. Calabrese EJ. LNT and cancer risk assessment: its flawed foundations part 1: radiation and leukemia: where LNT began. *Environ Res*. 2021;197:111025.

66. Calabrese EJ. LNT and cancer risk assessment: Its flawed foundations part 2: How unsound LNT science became accepted. *Environ Res*. 2021;197:111041.

67. Calabrese EJ. On the origins of the linear no-threshold (LNT) dogma by means of untruths, artful dodges and blind faith. *Environ Res*. 2015;142:432-442.

68. Hecht MM, Calabrese EJ. How a ‘big lie’ launched the LNT myth and the great fear of radiation [Interview with Dr. Edward Calabrese]. 21st Century Science & Technology. 2011;Fall:20-27. https://21sci-tech.com/Articles_2011/Fall-2011/Interview_Calabrese.pdf.

69. Cuttler JM. The LNT issue is about politics and economics, not safety. *Dose Response*. 2020;18(3):1559325820940066.

70. Cuttler JM. Remedy for radiation fear - discard the politicized science. *Dose Response*. 2014;12(2):170-184.

71. Cuttler JM. Evidence of dose threshold for radiation-induced leukemia: absorbed dose and uncertainty. *Dose Response*. 2019;17(1):1559325818820973.

72. Feinendegen LE, Pollycove M, Neumann RD. Hormesis by low dose radiation effects: low-dose cancer risk modeling must recognize up-regulation of protection. In: Baum RP, ed. *Therapeutic Nuclear Medicine*. Springer; 2012:789-805.

73. Pollycove M. Radiobiological basis of low-dose irradiation in prevention and therapy of cancer. *Dose Response*. 2006;5(1):26-38.

74. Pollycove M, Feinendegen LE. Radiation-induced versus endogenous DNA damage: possible effect of inducible protective responses in mitigating endogenous damage. *Hum Exp Toxicol*. 2003;22(6):290-306.

75. Cuttler JM. Application of low doses of ionizing radiation in medical therapies. *Dose Response*. 2020;18(1):1559325819895739.

76. Calabrese E, Dhawan G, Kapoor R, Kozumbo W. Radiotherapy treatment of human inflammatory diseases and conditions: optimal dose. *Hum Exp Toxicol*. 2019;38(8):888-898.

77. Oakley PA. Is use of radiation hormesis the missing link to a better cancer treatment? *J Can Therap*. 2015;64(4):601-605.
78. Journy N, Rehel J-L, Ducou Le Pointe H, et al. Are the studies on cancer risk from CT scans biased by induction? elements of answer from a large-scale cohort study in France. Br J Cancer. 2015;112(1):185-193.

79. Shibata S, Shihabmoto Y, Maehara M, Hobo A, Hotta N, Ozawa Y. Reasons for undergoing CT during childhood: can CT-exposed and CT-naive populations be compared? Dose Response. 2020;18(1):159325820907011.

80. Pennington CW. Dismantling.

81. Sakata R, Preston DL, Brenner AV, et al. Radiation-related risk.

82. Grant EJ, Brenner A, Sugiyama H, et al. Solid cancer incidence among the life span study of atomic bomb survivors: 1958-2009. Radiat Res. 2017;187(5):513-537.

83. Ricci PF, Tharmalingam S. Ionizing radiations epidemiology does not support the LNT model. Chem Biol Interact. 2019;301:128-140.

84. Siegel JA, Brooks AL, Fisher DR, et al. A Critical Assessment of the Linear No-Threshold Hypothesis. Clin Nucl Med. 2019;44(7):521-525.

85. Muller HI. Artificial transmutation of the gene. Science. 1927;66(1699):84-87.

86. https://en.wikipedia.org/wiki/Hermann_Joseph_Muller.

87. Caspari E, Stern C. The in narrative.

88. Lewis EB. Leukemia and ionizing radiation.

89. Berrington A, Darby SC, Weijs C, et al. 100 years of observation on British radiologists: mortality from cancer and other causes 1897-1997. Br J Radiol. 2001;74(882):507-519.

90. Cardarelli JJ, Ulsh BA. Is use of radiation hormesis the missing link to a better cancer treatment? J Cancer Ther. 2015;6(7):601-605.

91. Lloyd DC, Edwards AA, Leonard A, et al. Chromosomal aberrations in human lymphocytes induced in vitro by very low doses of X-rays. Int J Radiat Biol. 1992;61(3):335-343.

92. Ozaka K, Shimizu Y, Suyama A, et al. Studies of the mortality of atomic bomb survivors, report 14, 1950-2003: an overview of cancer and noncancer diseases. Radiat Res. 2012;177(3):229-243.

93. Duncan JR, Lieber MR, Adachi N, Wahl RL. Radiation dose does matter: mechanistic insights into DNA damage and repair support the linear no-threshold model of low-dose radiation health risks. J Nucl Med. 2018;59:1014-1016.

94. Osipov AN, Buleeva G, Arkhangelskaya E, Klokov D. In vivo γ-irradiation low dose threshold for suppression of DNA double strand breaks below the spontaneous level in mouse blood and spleen cells. Mutation Res. 2013;756(1-2):141-145.

95. Cardis E, Vrijheid M, Blettner M, et al. The 15-country collaborative study of cancer risk among radiation workers in the nuclear industry: estimates of radiation-related cancer risks. Radiat Res. 2007;167(4):396-416.

96. CNSC. Verifying Canadian Nuclear Energy Worker Radiation Risk: A Reanalysis of Cancer Mortality in Canadian Nuclear Energy Workers (1957–1994): Summary Report. Minister of Public Works and Government Services Canada. Catalogue number CC172-65/2011E-PDF. ISBN 978-1-100-17760-1. Canadian Nuclear Safety Commission; 2011.

97. Calabrese EJ, Dharwan G, Kapoor R. The use of X rays in the treatment of bronchial asthma: a historical assessment. Radiat Res. 2015;184(2):180-192.

98. Calabrese EJ. X-ray treatment of caruncles and furuncles (boils). Hum Exp Toxicol. 2013;32(8):817-827.

99. Callabrese E, Dharwan G. Historical use of x-rays. Hum Exp Toxicol. 2014;33(5):542-553.

100. Calabrese EJ, Dharwan G. The role of X-rays in the treatment of gas gangrene: a historical assessment. Dose Response. 2012;10(4):626-643.

101. Dharwan G, Kapoor R, Dhamija A, Singh R, Monga B, Callabrese EJ. Necrotizing fasciitis: low-dose radiotherapy as a potential adjunct treatment. Dose Response. 2019;17(3):1599325819871757.

102. Calabrese EJ, Dharwan G, Kapoor R. Radiotherapy for pertussis: an historical assessment. Dose Response. 2017;15(2):1599325817704760.

103. Calabrese EJ, Dharwan G. How radiotherapy was historically used to treat pneumonia: could it be useful today? Yale J Biol Med. 2013;86(4):555-570.

104. Calabrese EJ, Dharwan G. The historical use of radiotherapy in the treatment of sinuses infections. Dose Response. 2013;11(4):469-479.

105. Calabrese EJ, Dharwan G, Kapoor R. Use of X-rays to treat shoulder tendonitis/bursitis: a historical assessment. Arch Toxicol. 2014;88(8):1503-1517.

106. Oakley PA. Is use of radiation hormesis the missing link to a better cancer treatment? J Cancer Ther. 2015;6(7):601-605.

107. Sakamoto K. Radiobiological basis for cancer therapy by total or half-body irradiation. Nonlinearity Biol Toxicol Med. 2004;2(4):293-316.

108. Sakamoto K, Myogin M, Hosoi Y, et al. Fundamental and clinical studies on cancer control with total or upper half body irradiation. JASTRO 1997;9(3):161-175.

109. Richaud PM, Soubeiran P, Eghbali H, et al. Place of low-dose total body irradiation in the treatment of localized follicular non-Hodgkin’s lymphoma: results of a pilot study. Int J Radiat Oncol Biol Phys. 1998;40(2):387-390.

110. Choi NC, Timothy AR, Kaufman SD, Carey RW, Aisenberg AC. Low dose fractionated whole body irradiation in the treatment of advanced non-Hodgkin’s lymphoma. Cancer. 1979;43(5):1636-1642.

111. Chaffey JT, Rosenthal DS, Moloney WC, Hellman S. Total body irradiation as treatment for lymphosarcoma. Int J Radiat Oncol Biol Phys. 1976;1(5-6):399-405.

112. Callabrese EJ, Kozumbo WJ, Kapoor R, Dharwan G, Lara PC, Giordano J. Nrf2 activation putatively mediates clinical benefits
of low-dose radiotherapy in COVID-19 pneumonia and acute respiratory distress syndrome (ARDS): Novel mechanistic considerations. *Radiother Oncol*. 2021;160:125-131.

113. Hess CB, Nasti TH, Dhere VR, et al. Immunomodulatory low-dose whole-lung radiation for patients with coronavirus disease 2019-related pneumonia. *Int J Radiat Oncol Biol Phys*. 2021;109(4):867-879.

114. Kojima S, Tsukimoto M, Shimura N, Koga H, Murata A, Takara T. Treatment of cancer and inflammation with low-dose ionizing radiation: three case reports. *Dose Response*. 2017;15(1):1559325817697531.

115. Kojima S, Thukimoto M, Cuttler JM, et al. Recovery from rheumatoid arthritis following 15 months of therapy with low doses of ionizing radiation: a case report. *Dose Response*. 2018;16(3):1559325818784719.

116. Kojima S, Cuttler JM, Shimura N, Koga H, Murata A, Kawashima A. Radon therapy for autoimmune diseases pemphigus and diabetes: 2 case reports. *Dose Response*. 2019;17(2):1559325819850984.

117. Kojima S, Cuttler JM, Inoguchi K, et al. Radon therapy is very promising as a primary or an adjuvant treatment for different types of cancers: 4 case reports. *Dose Response*. 2019;17(2):1559325819853163.

118. Cuttler JM, Moore ER, Hosfeld VD, Nadolski DL. Second update on a patient with Alzheimer disease treated by CT scans. *Dose Response*. 2018;16(1):1559325818756461.

119. Cuttler JM, Abdellah E, Goldberg Y, et al. Low doses of ionizing radiation as a treatment for Alzheimer’s disease: a pilot study. *J Alzheim Dis*. 2021;80(3):1119-1128.

120. Mizrahi DJ, Parker L, Zoga AM, Levin DC. National trends in the utilization of skeletal radiography from 2003 to 2015. *J Am Coll Radiol*. 2018;15(10):1408-1414.

121. Côté P, Yu H, Shearer HM, et al. Non-pharmacological management of persistent headaches associated with neck pain: A clinical practice guideline from the Ontario protocol for traffic injury management (OPTIMa) collaboration. *Eur J Pain*. 2019;23(6):1051-1070.

122. Côté P, Wong JJ, Sutton D, et al. Management of neck pain and associated disorders: A clinical practice guideline from the Ontario Protocol for Traffic Injury Management (OPTIMa) Collaboration. *Eur Spine J*. 2016;25(7):2000-2022.

123. Patel ND, Broderick DF, Burns J, et al. ACR Appropriateness Criteria Low Back Pain. *J Am Coll Radiol*. 2016;13:1069-1078.

124. Bussières AE, Taylor JAM, Peterson C. Diagnostic imaging practice guidelines for musculoskeletal complaints in adults-an evidence-based approach-part 3: spinal disorders. *J Manipulative Physiol Therap*.*e*. 2008;31:33-88.

125. Stiell IG, Clement CM, McKnight RD, et al. The Canadian C-spine rule versus the NEXUS low-risk criteria in patients with trauma. *N Engl J Med*. 2003;349:2510-2518.

126. Plaugher G, Lin A. Letter to Michelle Da Roza, Registrar of the CCBC regarding ‘Public Consultation on the Use of Radiography. *Sept.* 2020;8.

127. European Commission. *Radiation Protection 118. Referral Guidelines for Imaging in Conjunction with the UK*. Royal College of Radiologists; 2001. https://deputyprimeminister.gov. mt/en/forms/documents/radiation_protection.pdf.

128. Celestre PC, Dimar JR, Glassman SD. Spinopelvic parameters: lumbar lordosis, pelvic incidence, pelvic tilt, and sacral slope. *Neurosurg Clin*. 2018;29(3):323-329.

129. Tan LA, Riew KD, Traynelis VC. Cervical spine deformity-part 1: biomechanics, radiographic parameters, and classification. *Neurosurgery*. 2017;81(2):197-203.

130. Bess S, Protospsaltis T, Lafage V, et al. International Spine Study Group. Clinical and radiographic evaluation of adult spinal deformity. *Clin Spine Surg*. 2016;29(1):6-16.

131. Ames CP, Scheer JK, Lafage V, Smith JS, Bess S, Berven SH, et al. Adult spinal deformity: epidemiology, health impact, evaluation, and management. *Spine Deformity*. 2016;4(4):310-322.

132. Smith JS, Shaffrey CI, Fu K-MG, et al. Clinical and radiographic evaluation of the adult spinal deformity patient. *Neurosurg Clin*. 2013;24(2):143-156.

133. Scheer JK, Tang JA, Smith JS, et al. Cervical spine alignment, sagittal deformity, and clinical implications. *J Neurosurg Spine*. 2013;19(2):141-159.

134. Vrtovec T, Janssen MMA, Likar B, Castelein RM, Viergever MA, Perluš F. Evaluation of pelvic morphology in the sagittal plane. *Spine J*. 2013;13(11):1500-1509.

135. Lee S-H, Kim K-T, Seo E-M, Suk K-S, Kwack Y-H, Son E-S. The influence of thoracic inlet alignment on the cranio-cervical sagittal balance in asymptomatic adults. *J Spinal Disord Tech*. 2012;25(2):E41-E47.

136. Young KJ. Evaluation of publicly available documents to trace chiropractic technique systems that advocate radiography for subluxation analysis: a proposed genealogy. *J Chirp Humanit*. 2014;21(1):1-24.

137. Oakley PA, Ehsani NN, Moustafa IM, Harrison DE. Restoring lumbar lordosis: a systematic review of controlled trials utilizing chiropractic bio physics (CBP) non-surgical approach to increasing lumbar lordosis in the treatment of low back disorders. *J Phys Ther Sci*. 2020;32(9):601-610.

138. Oakley PA, Moustafa IM, Harrison DE. Restoration of cervical and lumbar lordosis: CBP® methods overview. *Bettany-Saltikov J. Spinal Deformities in Adolescents, Adults and Older Adults*. London, UK: IntechOpen Publishers; 2019;1-19.

139. Harrison D, Moustafa I, Oakley P. Systematic review of Chiropractic Biophysics® (CBP®) methods employed in the rehabilitation of cervical lordosis. *Proceedings from the 14th International Society on Scoliosis Orthopedic and Rehabilitation Treatment (SOSORT) meeting*; April 25-27; San Francisco; 2019:156.

140. Nuckols TK, Lim Y-W, Wynn BO, et al. Rigorous development does not ensure that guidelines are acceptable to a panel of knowledgeable providers. *J Gen Intern Med*. 2008;23(1):37-44.

141. Moustafa IM, Diab A, Shousha T, Harrison DE. Does restoration of sagittal cervical alignment improve cervicogenic headache pain and disability: A 2-year pilot randomized controlled trial. *Heliyon*. 2021;7(3):e06467.

142. Moustafa I, Youssef ASA, Abhouch A, Harrison DE. Demonstration of autonomic nervous function and cervical sensorimotor
control after cervical lordosis rehabilitation: A randomized controlled trial. *J Athletic Training*. 2021;56(3):10.

143. Moustafa IM, Diab AA, Hegazy F, Harrison DE. Does improvement towards a normal cervical sagittal configuration aid in the management of cervical myofascial pain syndrome: a 1-year randomized controlled trial. *BMC Musculoskelet Disord*. 2018;19(1):396.

144. Moustafa IM, Diab AA, Harrison DE. The effect of normalizing the sagittal cervical configuration on dizziness, neck pain, and cervicophepatic kinesthetic sensibility: a 1-year randomized controlled study. *Eur J Phys Rehabil Med*. 2017;53(1):57-71.

145. Moustafa IM, Diab AAM, Hegazy FA, Harrison DE. Does rehabilitation of cervical lordosis influence sagittal cervical spine flexion extension kinematics in cervical spondylotic radiculopathy subjects?. *J Back Musculoskelet Rehabil*. 2017;30(4):937-941.

146. Moustafa IM, Diab AAM, Taha S, Harrison DE. Demonstration of central conduction time and neuroplastic changes after cervical lordosis rehabilitation in asymptomatic subjects: a randomized, placebo-controlled trial In: Proceedings of the 14th Biennial Congress of the World Federation of Chiropractic; March 15-18, 2017.

147. Moustafa IM, Diab AA, Taha S, Harrison DE. Addition of a Sagittal Cervical Posture Corrective Orthotic Device to a Multimodal Rehabilitation Program Improves Short- and Long-Term Outcomes in Patients With Discogenic Cervical Radiculopathy. *Arch Phys Med Rehabil* 2016;97(12):2034-2044.

148. Moustafa IM, Diab AA, Harrison DE. Does Improvement towards A Normal Cervical Sagittal Configuration Aid in the Management of Lumbosacral Radiculopathy: A Randomized Controlled Trial in: Proceedings of the 13th World Federation of Chiropractic Biennial Congress/ECU Convention; 2015; Athens, Greece: Paper #184. [Mediterranean Region Award Winning Paper].

149. Moustafa IM. Does improvement towards a normal cervical configuration aid in the management of fibromyalgia. A randomized controlled trial. *Bull Fac Ph Th Cairo Univ*. 2013;18(2):29-41.

150. Moustafa IM, Diab AM, Ahmed A, Harrison DE. The efficacy of cervical lordosis rehabilitation for nerve root function, pain, and segmental motion in cervical spondylotic radiculopathy. *PhysioTherapy*. 2011;97(supplement):846-847.

151. Lee CH, Heo SJ, Park SH, Jeong HS, Kim SY. The functional and morphological changes of the cervical intervertebral disc after applying lordotic curve controlled traction: a double-blind randomized controlled study. *Int J Environ Res Publ Health*. 2019;16(12):2162.

152. Gladin A, Katzman WB, Fukuoka Y, Parimi N, Wong S, Lane NE. Secondary change of ankle joint function after exercise intervention in older adults with hyperkyphosis and low physical function. *BMC Geriatr*. 2021;21(1):133.

153. Moustafa IM, Walton LM, Raigangir V, Shousha TM, Harrison D. Reduction of posture hyperkyphosis improves short- and long-term outcomes in patients with neck pain. Abstract In. *J Orthop Sports Phys Ther*. 2020;50(1):CSM143.

154. Katzman WB, Parimi N, Gladin A, Wong S, Lane NE. Long-Term Efficacy of Treatment Effects After a Kyphosis Exercise and Posture Training Intervention in Older Community-Dwelling Adults: A Cohort Study. *J Geriatr Phys Ther*. 2020;44:127-138. doi:10.1519/JPT.0000000000000262.

155. Watson SL, Weeks BK, Weis LJ, Harding AT, Horan SA, Beck BR. High-intensity exercise did not cause vertebral fractures and improves thoracic kyphosis in postmenopausal women with low to very low bone mass: the LIFTMOR trial. *Osteoporos Int*. 2019;30(5):957-964.

156. Jang H-J, Hughes LC, Oh D-W, Kim S-Y. Effects of corrective exercise for thoracic hyperkyphosis on posture, balance, and well-being in older women: a double-blind, group-matched design. *J Geriatr Phys Ther*. 2019;42(3):E17-E27.

157. Bezalel T, Carmeli E, Levi D, Kalichman L. The effect of Schroth therapy on thoracic kyphotic curve and quality of life in Scheuermann’s patients: a randomized controlled trial. *Asian Spine J*. 2019;13(3):490-499.

158. Katzmann WB, Vittinghoff E, Lin F, et al. Targeted spine strengthening exercise and posture training program to reduce hyperkyphosis in older adults: results from the study of hyperkyphosis, exercise, and function (SHEAF) randomized controlled trial. *Osteoporos Int*. 2017;28(10):2831-2841.

159. Kamali F, Shirazi SA, Ebrahimi S, Mirshamsi M, Ghanbari A. Comparison of manual therapy and exercise therapy for postural hyperkyphosis: a randomized clinical trial. *Physiotherapy Theory Pract*. 2016;32:92-97.

160. Seifi F, Rajabi R, Ebrahimi I, Alizadeh MH, Minoonejad H. The efficacy of corrective exercise interventions on thoracic hyperkyphosis angle. *J Back Musculoskelet Rehabil*. 2014;27(1):7-16.

161. Diab AAM, Moustafa IM. The efficacy of lumbar extension traction for sagittal alignment in mechanical low back pain: a randomized trial. *J Back Musculoskelet Rehabil*. 2013;26(2):213-220.

162. Moustafa IM, Diab AA. Extension traction treatment for patients with discogenic lumbosacral radiculopathy: a randomized controlled trial. *Clin Rehabil*. 2012;27(1):51-62.

163. Diab AA, Moustafa IM. Lumbar Lordosis Rehabilitation for Pain and Lumbar Segmental Motion in Chronic Mechanical Low Back Pain: A Randomized Trial. *J Manipulative Physiol Therapeut*. 2012;35(4):246-253.

164. Schreiber S, Parent EC, Hill DL, Hedden DM, Moreau MJ, Southon SC. Schroth physiotherapeutic scoliosis-specific exercises for adolescent idiopathic scoliosis: how many patients require treatment to prevent one deterioration? - results from a randomized controlled trial - *“SOSORT 2017 Award Winner”. Scoliosis and Spinal Disorder*. 2017;12:26.

165. Kuru T, Yeldan I, Dereli EE, Özdiınçler AR, Dikici F, Colak I. The efficacy of three-dimensional Schroth exercises in adolescent idiopathic scoliosis: a randomised controlled clinical trial. *Clin Rehabil*. 2016;30(2):181-190.

166. Schreiber S, Parent EC, Moez EK, et al. The effect of Schroth exercises added to the standard of care on the quality of life and muscle endurance in adolescents with idiopathic scoliosis-an
167. Noh DK, You J-H, Koh J-H, et al. Effects of novel corrective spinal technique on adolescent idiopathic scoliosis as assessed by radiographic imaging. *J Back Musculoskelet Rehabil*. 2014; 27(3):331-338.

168. Ambrosini E, Cazzaniga D, Rocca B, Ferrante S. Active self-correction and task-oriented exercises reduce spinal deformity and improve quality of life in subjects with mild adolescent idiopathic scoliosis. Results of a randomised controlled trial. *Eur Spine J* 2014;23(6):1204-1214.

169. ICA Committee on Chiropractic Practice Guidelines and Protocols. *Recommended Clinical Protocols and Guidelines for the Practice of Chiropractic*. ICA: Arlington, VA, 2000:1-465. https://registerchiropractor.nl/ICA_guidlines.pdf. Accessed March 7, 2021.

170. Practicing Chiropractors Committee on Radiology Protocols (PCCRP). USA. 2009. http://www.chiropractic.org/wp-content/uploads/2018/01/PCCRP-Radiology-Guidelines.pdf. Accessed March 7, 2021.

171. Harrison DE, Oakley PA. Necessity for biomechanical evaluation of posture, alignment and subluxation. Part I: the 6 subluxation types that satisfy Nelson’s criteria for valid subluxation theory. *J Contemp Chiropr*. 2018;1(1):9-19. https://journal.parker.edu/index.php/jcc/article/view/16.

172. Harrison DD, Janik TJ, Harrison GR, Troyanovich S, Harrison DE, Harrison SO. Chiropractic biophysics technique: a linear algebra approach to posture in chiropractic. *J Manipulative Physiol Ther*. 1996;19(8):525-535.

173. Harrison DE, Harrison DD, Troyanovich SJ. Three-dimensional spinal coupling mechanics: Part II. Implications for chiropractic theories and practice. *J Manipulative Physiol Ther*. 1998;21(3): 177-186.

174. Bess S, Line B, Fu K-M, et al. International Spine Study Group. The health impact of symptomatic adult spinal deformity. *Spine*. 2016;41(3):224-233.

175. Pellissié F, Vila-Casademunt A, Vila-Casademunt A, et al. European Spine Study Group, ESSG. Impact on health related quality of life of adult spinal deformity (ASD) compared with other chronic conditions. *Eur Spine J*. 2015;24(1):3-11.

176. Haas JW, Harrison DE, Oakley PA. Non-surgical reduction in anterior sagittal balance subluxation and improvement in overall posture in a geriatric suffering from low back pain and sciatica: A CBP® case report. *J Contemp Chiropr*. 2020;3(1):45-50. https://journal.parker.edu/index.php/jcc/article/view/101.

177. Anderson JM, Oakley PA, Harrison DE. Improving posture to reduce the symptoms of Parkinson’s: a CBP case report with a 21 month follow-up. *J Phys Ther Sci*. 2019;31(2):153-158.

178. Harrison DE, Cailliet R, Betz J, et al. Conservative methods for reducing lateral translation postures of the head: a non-randomized clinical control trial. *J Rehabil Res Dev*. 2004;41(4): 631-639.

179. Jaeger JO, Oakley PA, Moore RR, Ruggeroli EP, Harrison DE. Resolution of temporomandibular joint dysfunction (TMJD) by correcting a lateral head translation posture following previous failed traditional chiropractic therapy: a CBP case report. *J Phys Ther Sci*. 2018;30(1):103-107.

180. Haas JW, Oakley PA, Harrison DE. Cervical pseudo-scoliosis reduction and alleviation of dystonia symptoms using Chiropractic BioPhysics® (CBP®) technique: A case report with a 1.5-year follow-up. *J Contemp Chiropr*. 2019;2:131-137.

181. Harrison DE, Cailliet R, Betz JW, et al. A non-randomized clinical control trial of Harrison mirror image methods for correcting trunk list (lateral translations of the thoracic cage) in patients with chronic low back pain. *Eur Spine J*. 2005;14(2):155-162.

182. Henshaw M, Oakley PA, Harrison DE. Correction of pseudo-scoliosis (lateral thoracic translation posture) for the treatment of low back pain: a CBP case report. *J Phys Ther Sci*. 2018;30(9): 1202-1205.

183. Fortner MO, Oakley PA, Harrison DE. Chiropractic Biophysics management of straight back syndrome and exertional dyspnea: A case report with follow-up. *J Contemp Chiropr*. 2019;2:115-122. https://journal.parker.edu/index.php/jcc/issue/view/2.

184. Betz JW, Oakley PA, Harrison DE. Relief of exertional dyspnea and spinal pains by increasing the thoracic kyphosis in straight back syndrome (thoracic hypo-kyphosis) using CBP methods: a case report with long-term follow-up. *J Phys Ther Sci*. 2018;30(1):185-189.

185. Mitchell JR, Oakley PA, Harrison DE. Nonsurgical correction of straight back syndrome (thoracic hypokyphosis), increased lung capacity and resolution of exertional dyspnea by thoracic hyperkyphosis mirror image traction: a CBP case report. *J Phys Ther Sci*. 2017;29(11):2058-2061.

186. Gubbels CM, Werner JT, Oakley PA, Harrison DE. Reduction of thoraco-lumbar junctional kyphosis, posterior sagittal balance, and increase of lumbar lordosis and sacral inclination by Chiropractic BioPhysics methods in an adolescent with back pain: a case report. *J Phys Ther Sci*. 2019;31(10): 839-843.

187. Harrison DE, Oakley PA. Non-operative correction of flat back syndrome using lumbar extension traction: a CBP case series of two. *J Phys Ther Sci*. 2018;30(8):1131-1137.

188. Oakley PA, Ehsani NN, Harrison DE. Non-surgical reduction of lumbar hyperlordosis, forward sagittal balance and sacral tilt to relieve low back pain by Chiropractic BioPhysics methods: a case report. *J Phys Ther Sci*. 2019;31(10):860-864.

189. Fedorchuk C, Lightstone DF, Corner RD, Katz E, Wilcox J. Improvements in cervical spinal canal diameter and neck disability following correction of cervical lordosis and cervical spondylolisthesis using chiropractic biophysics technique: a case series. *J Radiol Case Rep*. 2020;14(4):21-37.

190. Fedorchuk C, Lightstone D. Reduction in cervical anterolisthesis & pain in a 52-year-old female using Chiropractic BioPhysics® Technique: A case study and selective review of literature. *Ann Vert Sublux Res*. 2016. https://www.chiroindex.org/?search_page=articles&action&articleId=24805. Online access only p 118-124.
utilizing Chiropractic BioPhysics technique: a case report with 1 year follow-up. J Phys Ther Sci. 2021;33(1):89-93.

192. Oakley PA, Harrison DE. Correction of multilevel lumbar retrolistheses by non-surgical extension traction procedures in a patient with congenital fusion of L5-S1: A CBP® case report with a 13-month follow-up. J Contemp Chiropr. 2020;3:137-142. https://journal.parker.edu/index.php/jcc/article/view/137.

193. Fedorchuk C, Lightstone DF, McRae C, Kaczor D. Correction of grade 2 spondylolisthesis following a non-surgical structural spinal rehabilitation protocol using lumbar traction: A case study and selective review of literature. J Radiol Case Rep. 2017;11(5):13-26.

194. Corso M, Côté P, Mior S, Cancelliere C, Taylor-Vaisey A, Kumar V. Clinical utility of routine spinal x-rays by chiropractors: a rapid review of the literature. https://www.crd.york.ac.uk/prospero/display_record.php?id=CRD42020158321. PROSPERO 2020 CRD42020158321 Available from.

195. Khangura S, Konnyu K, Cushman R, Grimshaw J, Moher D. Evidence summaries: the evolution of a rapid review approach. Syst Rev. 2012;1:10.

196. Tricco AC, Antony J, Zarin W, et al. A scoping review of rapid review methods. BMC Med. 2015;13:224.

197. College of Chiropractors of British Columbia. About CCBC. https://www.chirobc.com/about-ccbc/. Accessed March 10, 2021.

198. Ganann R, Ciliska D, Thomas H. Expediting systematic reviews: methods and implications of rapid reviews. Implement Sci. 2010;5:56.

199. Watt A, Cameron A, Sturm L, et al. Rapid versus full systematic reviews: validity in clinical practice?. ANZ J Surg. 2008;78(11):1037-1040.

200. Tricco AC, Langlois EV, Straus SE, eds Rapid Reviews to Strengthen Health Policy and Systems: A Practical Guide. World Health Organization; 2017.

201. Leboeuf-Yde C, Lanlo O, Walker BF. How to proceed when evidence-based practice is required but very little evidence available? Chiropr Man Ther. 2013;21(1):24.

202. Oakley PA, Moustafa IM, Harrison DE, The Influence of Sagittal Plane Spine Alignment on Neurophysiology and Sensormotor Control Measures: Optimization of Function through Structural Correction. 30th J. The Influence of Sagittal Plane Spine Alignment on Neurophysiology and Sensormotor Control Measures: Optimization of Function through Structural Correction; 2021. 10.5772/intechopen.95890. Available from: https://www.intechopen.com/online-first/the-influence-of-sagittal-plane-spine-alignment-on-neurophysiology-and-sensormotor-control-measures. Neurological Physical Therapy [Working Title] [Online First], IntechOpen.

203. Troyanovich SJ, Harrison D, Harrison DD, Harrison SO, Janik T, Holland B. Chiropractic biophysics digitized radiographic mensuration analysis of the anteroposterior cervicothoracic view: a reliability study. J Manipulative Physiol Therapeut. 2000;23:476-482.

204. Troyanovich SJ, Harrison DE, Harrison DD, Holland B, Janik TJ. Further analysis of the reliability of the posterior tangent lateral lumbar radiographic mensuration procedure: concurrent validity of computer-aided X-ray digitization. J Manipulative Physiol Therapeut. 1998;21:460-467.

205. Troyanovich SJ, Robertson GA, Harrison DD, Holland B. Intra- and interexaminer reliability of the chiropractic biophysics lateral lumbar radiographic mensuration procedure. J Manipulative Physiol Therapeut. 1995;18:519-524.

206. Harrison DE, Holland B, Harrison DD, Janik TJ. Further reliability analysis of the Harrison radiographic line-drawing methods: Crossed ICCs for lateral posterior tangents and modified Risser-Ferguson method on APViews. J Manipulative Physiol Therapeut. 2002:25:93-98.

207. Troyanovich SJ, Harrison SO, Harrison DD, et al. Chiropractic biophysics digitized radiographic mensuration analysis of the anteroposterior lumbo pelvic view: a reliability study. J Manipulative Physiol Therapeut. 1999:22:309-315.

208. Jackson BL, Harrison DE, Robertson GA, Barker WF. Chiropractic biophysics lateral cervical film analysis reliability. J Manipulative Physiol Therapeut. 1993;16:384-391.

209. Harrison DE, Harrison DD, Cailliet R, Troyanovich SJ, Janik TJ, Holland B. Cobb method or harrison posterior tangent method. Spine. 2000;25:2072-2078.

210. Harrison DE, Cailliet R, Harrison DD, Janik TJ, Holland B. Reliability of centroid, Cobb, and Harrison posterior tangent methods: which to choose for analysis of thoracic kyphosis. Spine. 2001;26(11):E227-E234.

211. Harrison DE, Harrison DD, Cailliet R, Janik TJ, Holland B. Radiographic analysis of lumbar lordosis: centroid, Cobb, TRALL, and Harrison posterior tangent methods. Spine. 2001;26(11):E235-E242.

212. Harrison DE, Harrison DD, Colloca CJ, Betz J, Janik TJ, Holland B. Repeatability over time of posture, radiograph positioning, and radiograph line drawing: an analysis of six control groups. J Manipulative Physiol Therapeut. 2003;26(2):87-98.

213. Harrison DE, Harrison DD, Troyanovich SJ. Reliability of spinal displacement analysis of plain X-rays: a review of commonly accepted facts and fallacies with implications for chiropractic education and technique. J Manipulative Physiol Therapeut. 1998;21(4):252-266.

214. Harrison DE, Holland B, Harrison DD, Janik TJ. Further reliability analysis of the Harrison radiographic line-drawing methods: Crossed ICCs for lateral posterior tangents and modified Risser-Ferguson method on APViews. J Manipulative Physiol Therapeut. 2002:25(2):93-98.

215. Jackson BL, Barker WF, Bentz J, Gambale AG. Reliability of the upper cervical x-ray marking system: a replication study. J Clin Invest Res. 1988;1:10-13.

216. Jackson BL, Barker W, Bentz J, Gambale AG. Inter- and intra-examiner reliability of the upper cervical X-ray marking system: a second look. J Manipulative Physiol Therapeut. 1987;10(4):157-163.

217. Plaugher G, Cremata EE, Phillips RB. A retrospective consecutive case analysis of pretreatment and comparative static radiological parameters following chiropractic adjustments. J Manipulative Physiol Therapeut. 1990;13:498-506.
218. Plaugher G, Hendricks AH. The inter- and intraexaminer reliability of the Gonstead pelvic marking system. *J Manipulative Physiol Therapeut.* 1991;14(9):503-508.

219. Burk JM, Thomas RR, Ratliff CR. Inter- and intra-examiner agreement of the Gonston line marking method. *Am J Chiro Med.* 1990;3:114-116.

220. Côté P, Cassidy JD, Yong-Hing K, Sibley J, Loewy J. Apophysial joint degeneration, disc degeneration, and sagittal curve of the cervical spine. *Spine.* 1997;22(8):859-864.

221. Wiegand R, Kettner NW, Brahme D, Marquina N. Cervical spine geometry correlated to cervical degenerative disease in a symptomatic group. *J Manipulative Physiol Therapeut.* 2003;26(6):341-346.

222. Wiegand RA, Pfefer MT, Hamilton KR. Inter- and Intra-examiner Reliability of Radiographic Computer-Aided Measurements. *J Chiropr Educ.* 2003;17(1):78.

223. Stupar M, Mauron D, Peterson CK. Inter-examiner reliability of the diagnosis of cervical pillar hyperplasia (CPH) and the correlation between CPH and spinal degenerative joint disease (DDJ). *BMC Muscoskel Disord.* 2003;4(1):28.

224. Brown SH, Hinson R, Owens EF. Comparison of Radiographic Analysis and Clinical Outcome for Two Upper Cervical Specific Techniques. *J Chiropr Educ.* 2000;14(1):28-29.

225. Jackson BL, Barker WF, Pettibon BR, et al. Reliability of the Petibon patient positioning system for radiographic production. *J Verteb Subluxat Res* 2000;4(1):3-11.

226. Tuck AM, Peterson CK. Accuracy and reliability of chiropractors and AECC students at visually estimating the lumbar lordosis from radiographs. *J Chiropract Tech.* 1997;10:19-26.

227. Rochester RP, Owens EF. Patient placement error in rotation and its affect on the upper cervical measuring system. *Chiropr Res J.* 1996;3:40-55.

228. Rochester RP. Inter and intra-examiner reliability of the upper cervical x-ray marking system: A third and expanded look. *Chiropr Res J.* 1994;3(1):23-31.

229. Thorkeldsen A, Breen AC. Gray scale range and the marking of vertebral coordinates on digitized radiographic images. *J Manipulative Physiol Therapeut.* 1994;17(6):359-363.

230. Seeman DC. A reliability study using a positive nasium to establish laterality. *Upper Cervical Monograph.* 1994;5(4):7-8.

231. Owens EF Jr. Line drawing analyses of static cervical X-ray used in chiropractic. *J Manipulative Physiol Therapeut.* 1992;15(7):442-449.

232. Sigler DC, Howe JW. Inter- and intra-examiner reliability of the upper cervical X-ray marking system. *J Manipulative Physiol Therapeut.* 1985;8(2):75-80.

233. Adam CJ, Askin GN. Automatic measurement of vertebral rotation in idiopathic scoliosis. *Spine.* 2006;31(3):E80-E83.

234. Almansour H, Pepke W, Rehm J, Bruckner T, Spira D, Akbar M. Interrater reliability of three-dimensional reconstruction of the spine. *Orthopädi* 2020;49(4):350-358.

235. Ames CP, Smith JS, Eastlack R, et al. International Spine Study Group. Reliability assessment of a novel cervical spine deformity classification system. *J Neurosurg Spine.* 2015;23(6):673-683.

236. Aubin C-E, Bellefleur C, Joncas J, et al. Reliability and accuracy analysis of a new semiautomatic radiographic measurement software in adult scoliosis. *Spine.* 2011;36(12):E780-E790.

237. Bagheri A, Liu X-C, Tassone C, Thometz J, Tarima S. Reliability of Three-Dimensional Spinal Modeling of Patients With Idiopathic Scoliosis Using EOS System. *Spine Deformity.* 2018;6(3):207-212.

238. Beekman CE, Hall V. Variability of scoliosis measurement from spinal roentgenograms. *Phys Ther.* 1979;59(6):764-765.

239. Berliner L, Kreang-Arekul S, Kaufman L. Scoliosis evaluation by direct digital radiography and computerized post-processing. *J Digit Imag.* 2002;15(suppl 1):270-274.

240. Bittersohl B, Freitas J, Zaps D, et al. EOS imaging of the human pelvis: reliability, validity, and controlled comparison with radiography. *J Bone Joint Surg.* 2013;95(9):e58.

241. Boniforti FG, Fujii G, Angliss RD, Benson MKD. The reliability of measurements of pelvic radiographs in infants. *J Bone Joint Surg.* 1997;79-B(4):570-575.

242. Boyer L, Shen J, Parent S, Kadoury S, Aubin C-E. Accuracy and precision of seven radiography-based measurement methods of vertebral axial rotation in adolescent idiopathic scoliosis. *Spine Deformity.* 2018;6(4):351-357.

243. Cannada LK, Scherping SC, Yoo JU, Jones PK, Emery SE. Pseudoarthrosis of the cervical spine. *Spine.* 2003;28(1):46-51.

244. Capaccioli L, Montigiani L, Donati P, Puglisi AT, Giurovich E, Puglisi F. Measurement reliability of dynamic x-rays of the cervical spine: an experimental model. *Ital J Anat Embryol.* 1998;103(1):13-25.

245. Capasso G, Maffulli N, Testa V. The validity and reliability of measurements in spinal deformities: a critical appraisal. *Acta Orthop Belg.* 1992;58(2):126-135.

246. Carmen DL, Browne RH, Birch JG. Measurement of scoliosis and kyphosis radiographs: intraobserver and interobserver variation. *J Bone Joint Surg Am.* 1990;72:228-333.

247. Chen Y-L. Vertebral Centroid Measurement of Lumbar Lordosis Ability of measurements of pelvic radiographs in infants. *J Bone Joint Surg.* 1997;79-B(4):570-575.

248. Chien C, Wang C, Wang Y, et al. Reliability analysis of spinopelvic parameters in adult spinal deformity. *Spine.* 2016;41(4):320-327.

249. Chemukha KV, Daffner RH, Reigel DH. Lumbar lordosis measurement. *Spine.* 1998;23(1):74-79.

250. Cheung J, Wever DJ, Veldhuizen AG, et al. The reliability of quantitative analysis on digital images of the scoliotic spine. *Eur Spine J.* 2002;11(6):535-542.

251. Chockalingam N, Dangerfield PH, Giakas G, Cochrane T, Dorgan JC. Computer-assisted Cobb measurement of scoliosis. *Eur Spine J.* 2002;11(4):353-357. Epub 2002 Mar 15.

252. Clarke GR. Unequal leg length: an accurate method of detection and some clinical results. *Rheumatology.* 1972;11:385-390.

253. Dang NR, Moreau MJ, Hill DL, Mahood JK, Raso J. Intra-observer Reproducibility and Interobserver Reliability of the Radiographic Parameters in the Spinal Deformity Study Group’s AIS Radiographic Measurement Manual. *Spine.* 2005;30(9):1064-1069.
254. Desmet AA, Goin JE, Asher MA, Scheuch HG. A clinical study between the scoliotic angles measured on posteroanterior and anteroposterior radiographs. J Bone Joint Surg. 1982;64:489-493.

255. Dimar JR 2nd, Carreon LY, Labelle H, Djurasovic M, Weidenbaum M, Brown C, et al. Intra- and inter-observer reliability of determining radiographic sagittal parameters of the spine and pelvis using a manual and a computer-assisted methods. Eur Spine J. 2008;17(10):1373-1379.

256. Duong L, Cheriet F, Labelle H, et al. Interobserver and intraobserver variability in the identification of the Lenke classification lumbar modifier in adolescent idiopathic scoliosis. J Spinal Disord Tech. 2009;22(6):448-455.

257. Dvorak J, Froehlich D, penning L, Baumgartner H, Panjabi MM. Functional radiographic diagnosis of the cervical spine: flexion/extension. Spine. 1988;13(7):748-755.

258. Dvorak J, Panjabi MM, Grob D, Novelty JE, Antinnes JA. Clinical validation of functional flexion/extension radiographs of the cervical spine. Spine. 1993;18(1):120-127.

259. Fann AV, Lee R, Verbois GM. The reliability of postural x-rays in measuring pelvic obliquity. Arch Phys Med Rehabil. 1999;80:458-461.

260. Faro FD, Marks MC, Pawelek J, Newton PO. Evaluation of a functional position for lateral segmental radiograph acquisition in adolescent idiopathic scoliosis. Spine. 2004;29(20):2284-2289.

261. Friberg O. Clinical symptoms and biomechanics of lumbar spine and hip joint in leg length inequality. Spine. 1983;8(6):643-651.

262. Friberg O, Koivisto E, Wegelius C. A radiographic method for measurement of leg length inequality. Diagn Imag Clin Med. 1985;54:78-81.

263. Fritz JM, Piva SR, Childs JD. Accuracy of the clinical examination to predict radiographic instability of the lumbar spine. Eur Spine J. 2005;14(8):743-750.

264. Frobin W, Brinckmann P, Biggemann M, Tillotson M, Burton K. Precision measurement of disc height, vertebral height and sagittal plane displacement from lateral radiographic views of the lumbar spine. Clin BioMech. 1997;12(suppl 1):S1-S63.

265. Frobin W, Brinckmann P, Leivseth G, Biggemann M, Reikerås O. Precision measurement of segmental motion acquisition from flexion-extension radiographs of the lumbar spine. Clin BioMech. 1996;11(8):457-465.

266. Frobin W, Leivseth G, Biggemann M, Brinckmann P. Sagittal segmental plane motion of the cervical spine. A new precision measurement protocol and normal motion data of healthy adults. Clin BioMech. 2002;17(1):21-31.

267. Frobin W, Leivseth G, Biggemann M, Brinckmann P. Vertebral height, disc height, posteroanterior displacement and dens-atlas gap in the cervical spine: precision measurement protocol and normal data. Clin BioMech. 2002;17(6):423-431.

268. George K, Rippstein J. A comparative study of the two popular methods of measuring scoliotic deformity of the spine. J Bone Joint Surg. 1961;43:809-818.

269. Giles LGF, Taylor JR. Low-Back Pain Associated With Leg Length Inequality. Spine. 1981;6:510-521.

270. Gilliam J, Brunt D, MacMillan M, Kinard RE, Montgomery WJ. Relationship of the pelvic angle to the sacral angle: measurement of clinical reliability and validity. J Orthop Sports Phys Ther. 1994;20(4):193-199.

271. Gliddon MJ, Xia JJ, Gatenjo J, et al. The accuracy of cephalometric tracing superimposition. J Oral Maxillofac Surg. 2006;64(2):194-202.

272. Golton JP, Trueman GE. Studies in osteoarthritis of the hip. Part II. Osteoarthritis of the hip and leg length inequality. Can Med Assoc J. 1971;104:791-799.

273. Goh S, Price RI, Leedman PJ, Singer KP. A comparison of three methods for measuring thoracic kyphosis: implications for clinical studies. Rheumatology. 2000;39:310-315.

274. Goldberg MS, Poitras B, mayo NE, Labelle H, Bourassa R, Cloutier R. Observer variation in assessing spinal curvature and skeletal development in adolescent idiopathic scoliosis. Spine. 1988;13(12):1371-1377.

275. Greenman PE. Lift therapy: Use and abuse. J Am Osteopath Assoc. 1979;79:238-250.

276. Gross C, Gross M, Kuschner S. Error analysis of scoliosis curvature measurement. Bull Hosp Joint Dis Orthop Inst. 1983;43:171-177.

277. Gupta M, Henry JK, Schwab Flnternational Spine Study Group, et al. Dedicated spine measurement software quantifies key spino-pelvic parameters more reliably than traditional picture archiving and communication systems tools. Spine. 2016;41(1):E22-E27.

278. Ha K-Y, Jang W-H, Kim Y-H, Park D-C. Clinical Relevance of the SRS-Schwab Classification for Degenerative Lumbar Scoliosis. Spine. 2016;41(5):E282-E288.

279. Hamberg B, Björklund M, Nordgren B, Sahlsstedt B. Stretchability of the rectus femoris muscle: investigation of validity and intratester reliability of two methods including X-ray analysis of pelvic tilt. Arch Phys Med Rehabil. 1993;74(3):263-270.

280. Hamer OW, Strotzer M, Zorger N, et al. Amorphous silicon, flat-panel, X-ray detector. Invest Radiol. 2004;39(5):271-276.

281. Hardacker JW, Shuford RF, Capicotto PN, Pryor PW. Radiographic standing cervical segmental alignment in adult volunteers without neck symptoms. Spine. 1997;22(13):1472-1479.; discussion 1480.

282. Harvey SB, Hukins DWL. Measurement of lumbar spinal flexion-extension kinematics from lateral radiographs: simulation of the effects of out-of-plane movement and errors in reference point placement. Med Eng Phys. 1998;20(6):403-409.

283. Herickhoff PK, O’Brien MK, Dolan LA, Morcuende JA, Peterson JB, Weinstein SL. The gothic arch: a reliable measurement for developmental dysplasia of the hip. Iowa Orthop J. 2013;33:1-6.

284. Hermann NV, Jensen BL, Dahl E, Darvann TA, Kreiborg S. A method for three-projection infant cephalometry. Cleft Palate-Craniofacial J. 2001;38(4):299-316.

285. Hermann AM, Geisler FH. A new computer-aided technique for analysis of lateral cervical radiographs in postoperative patients with degenerative disease. Spine. 2004;29(16):1795-1803.
286. Illés T, Somoskeőy S. Comparison of scoliosis measurements based on three-dimensional vertebra vectors and conventional two-dimensional measurements: advantages in evaluation of prognosis and surgical results. *Eur Spine J.* 2013;22(6):1255-1263.

287. Jackson RP, Peterson MD, McManus AC, Hales C. Compensatory spinopelvic balance across the hip axis and better reliability in measuring lordosis to the pelvic radius on standing lateral radiographs of adult volunteers and patients. *Spine.* 1998;23:1750-1767.

288. Jackson RP, Kanemura T, Kawakami N, Hales C. Lumbar pelvic lordosis and pelvic balance on repeated standing lateral radiographs of adult volunteers and untreated patients with constant low back pain. *Spine.* 2000;25:575-586.

289. Jackson RP, Phipps T, Hales C, Surber J. Pelvic lordosis and alignment in spondylolisthesis. *Spine.* 2003;28(2):151-160.

290. Jeffries BF, Tarlton M, De Smet AA, Dwyer SJ, Brower AC. Computerized measurement and analysis of scoliosis: a more accurate representation of the shape of the curve. *Radiology.* 1980;134:381-385.

291. Kado DM, Christianson L, Palermo L, Smith-Bindman R, Jeffries BF, Tarlton M, De Smet AA, Dwyer SJ, Brower AC. Comparison of scoliosis measurements for digital adolescent idiopathic scoliosis measurements. *Spine Deformity Study Group.* Reliability analysis of manual and digital measurements in adolescent idiopathic scoliosis. *Spine.* 2006;31(11):1240-1246.

292. Kuklo TR, Potter BK, Schroeder TM, O’Brien MF. Comparison of manual and digital measurements in adolescent idiopathic scoliosis. *Spine.* 2005;14(2):200-205.

293. Leppilähti J, Koripelainen R, Karpakka J, Kvist M, Orava S. Ruptures of the Achilles tendon: relationship to inequality in length of legs and to patterns in the foot and ankle. *Foot Ankle Int.* 1998;19(10):683-687.

294. Liu Y, Liu Z, Zhu F, et al. Validation and reliability analysis of the new SRS-Schwab classification for adult spinal deformity. *Spine.* 2013;38(11):902-908.

295. Lucas B, Asher M, McIff T, Lark R, Burton D. Estimation of transverse plane pelvic rotation using a posterior-anterior radiograph. *Spine.* 2005;30(1):E20-E27.

296. Marawar SV, Ordway NR, Auston DA, et al. Assessment of inter- and intraobserver reliability and accuracy to evaluate apical vertebral rotation using four methods: an experimental study using a saw bone model. *Spine Deformity.* 2019;7(1):11-17.

297. Marshall DL, Tuchin PJ. Correlation of cervical lordosis measurement with incidence of motor vehicle accidents. *Australas Chiropr Osteopath.* 1996;5(3):79-85.

298. Mckinney R, Jefferies B, Tarlton M, De Smet AA, Dwyer SJ, Brower AC. Computerized measurement and analysis of scoliosis: a more accurate representation of the shape of the curve. *Radiology.* 1980;134:381-385.

299. Mok JM, Berven SH, Diab M, Hackbarth M, Hu SS, Deviren V. Comparison of observer variation in conventional and three-dimensional radiographic methods used in the evaluation of patients with adolescent idiopathic scoliosis. *Spine.* 2008;33(6):615-619.

300. Muggleton JM, Allen R. Insights into the measurement of vertebral translation in the sagittal plane. *Med Eng Phys.* 1998;20(1):21-32.

301. Oda M, Rauh S, Gregory PB, Silverman FN, Bleck EE. The significance of roentgenographic measurement in scoliosis. *J Pediatr Orthop.* 1982;2:378-382.

302. Omeroglu H, Ozekin O, Bicimagólo A. Measurement of vertebral rotation in idiopathic scoliosis using the Perdriolle torsionmeter: a clinical study on intraobserver and interobserver error. *Eur Spine J.* 1996;5(3):167-171.

303. Panjabi M, Chang D, Dvorak K. An analysis of errors in kinematic parameters associated with in vivo functional radiographs. *Spine.* 1992;17(2):200-205.

304. Penning L, Irwan R, Oudkerk M. Measurement of angular and linear segmental lumbar spine flexion-extension motion by means of image registration. *Eur Spine J.* 2005;14(2):163-170.
352. Takeshita K, Murakami M, Kobayashi A, Nakamura C. Relationship between cervical curvature index (Ishihara) and cervical spine angle (C2-7). J Orthop Sci. 2001;6(3):223-226.

353. Tallroth K, Ylikoski M, Landtmann M, Santavirta S. Reliability of radiographical measurements of spondylolisthesis and extension-flexion radiographs of the lumbar spine. Eur J Radiol. 1994;18(3):227-231.

354. Terry MA, Winell JJ, Green DW, et al. Measurement variance in limb length discrepancy. J Pediatr Orthop. 2005;25(2):197-201.

355. Teyhen DS, Flynn TW, Bovik AC, Abraham LD. A new technique for digital fluoroscopic video assessment of sagittal plane lumbar spine motion. Spine. 2005;30(14):E406-E413.

356. Thelen T, Thelen P, Demezon H, Aunoble S, Le Huec J-C. Normative 3D acetabular orientation measurements by the low-dose EOS imaging system in 102 asymptomatic subjects in standing position: Analyses by side, gender, pelvic incidence and reproducibility. J Orthop Traumat. 2017;103(2):209-215.

357. Tibrewal SB, Pearcy MJ. Lumbar intervertebral disc heights in normal subjects and patients with disc herniation. Spine. 1985;10(5):452-454.

358. Tilley P. Radiographic identification of the sacral base. J Am Osteo Soc. 1966;65:1177-1183.

359. Vedantam R, Lenke LG, Bridwell KH, Linville DL, Blanke K. The effect of variation in arm position on sagittal spinal alignment. Spine. 2000;25(17):2204-2209.

360. Vialle R, Lessor N, Rillardon L, Templier A, Skalli W, Guigui P. Radiographic analysis of the sagittal alignment and balance of the spine in asymptomatic subjects. J Bone Jt Surg Am Vol. 2005;87(2):260-267.

361. Vila-Casademunt A, Pellisé F, Acoroglou E, et al. ESSG, European Spine Study Group. The reliability of sagittal pelvic parameters. Spine. 2015;40(4):E253-E258.

362. Wah PL, Cooke MS, Hägg U. Comparative cephalometric errors for orthodontic and surgical patients. Int J Adult Orthodont Orthognath Surg. 1995;10(2):119-126.

363. Wang W, Wu M, Liu Z, et al. Sacrum pubic incidence and sacrum pubic posterior angle: two morphologic radiological parameters in assessing pelvic sagittal alignment in human adults. Eur Spine J. 2014;23(7):1427-1432.

364. Wellborn CC, Sturm PF, Hatch RS, Bomze SR, Jablonski K. Intraobserver reproducibility and interobserver reliability of cervical spine measurements. J Pediatr Orthop. 2000;20(1):66-70.

365. Wilson MS, Stockwell J, Leedy MG. Measurement of scoliosis by orthopedic surgeons and radiologists. Aviat Space Environ Med. 1983;54:69-71.

366. Wright J, Treble N, Feinstein A. Measurement of lower limb alignment using long radiographs. J Bone Joint Surg. 1991;73-B(5):721-723.

367. Wu W, Liang J, Du Y, et al. Reliability and reproducibility analysis of the Cobb angle and assessing sagittal plane by computer-assisted and manual measurement tools. BMC Muscoskel Disord. 2014;15:33.

368. Zhang R-F, Liu K, Wang X, et al. Reliability of a new method for measuring coronal trunk imbalance, the axis-line-angle technique. Spine J. 2015;15(12):2459-2465.

369. Ylikoski M, Tallroth K. Measurement variations in scoliotic angle, vertebral rotation, vertebral body height, and intervertebral disc space height. J Spinal Disord. 1990;3(4):387-391.

370. Zmurko MG, Mooney JF 3rd, Podeszwa DA, Minster GJ, Mendelow MJ, Guirgues A. Inter- and intraobserver variance of Cobb angle measurements with digital radiographs. J Surg Orthop Adv. 2003;12(4):208-213.

371. McAviney J, Schulz D, Bock R, Harrison DE, Holland B. Determining the relationship between cervical lordosis and neck complaints. J Manipulative Physiol Therapeut. 2005;28(3):187-193.

372. CBP NonProfit. Eagle, ID. www.cbnonprofit.com. Accessed March 7, 2021.

373. Harrison DD, Janik TJ, Troyanovich SJ, Holland B. Comparisons of Lordotic cervical spine curvatures to a theoretical ideal model of the static sagittal cervical spine. Spine. 1996;21(6):667-675.

374. Harrison DD, Janik TJ, Troyanovich SJ, Harrison DE, Colloca CJ. Evaluation of the assumptions used to derive an ideal normal cervical spine model. J Manipulative Physiol Therapeut. 1997;20(4):246-256.

375. Harrison DD, Harrison DE, Janik TJ, et al. Modeling of the sagittal cervical spine as a method to discriminate hypolordosis. Spine. 2004;29:2485-2492.

376. Harrison DE, Janik TJ, Harrison DD, Cailliet R, Harmon SF. Can the thoracic kyphosis be modeled with a simple geometric shape? J Spinal Disord Tech. 2002;15(3):213-220.

377. Harrison DD, Harrison DE, Janik TJ, Cailliet R, Haas J. Do alterations in vertebral and disc dimensions affect an elliptical model of thoracic kyphosis? Spine. 2003;28(5):463-469.

378. Troyanovich SJ, Cailliet R, Janik TJ, Harrison DD, Harrison DE. Radiographic mensuration characteristics of the sagittal lumbar spine from a normal population with a method to synthesize prior studies of lordosis. J Spinal Disord Tech. 1997;10(5):380-386.

379. Janik TJ, Harrison DD, Cailliet R, Troyanovich SJ, Harrison DE. Can the sagittal lumbar curvature be closely approximated by an ellipse? J Orthop Res. 1998;16(6):766-770.

380. Harrison DD, Cailliet R, Janik TJ, Troyanovich SJ, Harrison DE, Holland C. Elliptical modeling of the sagittal lumbar lordosis and segmental rotation angles as a method to discriminate between normal and low back pain subjects. J Spinal Disord. 1998;11(5):430-439.

381. Chun S-W, Lim C-Y, Kim K, Hwang J, Chung SG. The relationships between low back pain and lumbar lordosis: a systematic review and meta-analysis. Spine J. 2017;17(8):1180-1191.

382. Guo G-M, Li J, Diao Q-X, et al. Cervical lordosis in asymptomatic individuals: a meta-analysis. J Orthop Surg Res. 2018;13(1):147.

383. Harrison DD, Jackson BL, Troyanovich S, Robertson G, de George D, Barker WF. The efficacy of cervical extension-
compression traction combined with diversified manipulation and drop table adjustments in the rehabilitation of cervical lordosis: a pilot study. *J Manipulative Physiol Theraput*. 1994;17(7):454-464.

384. Harrison DE, Cailliet R, Harrison DD, Janik TJ, Holland B. A new 3-point bending traction method for restoring cervical lordosis and cervical manipulation: A nonrandomized clinical controlled trial. *Arch Phys Med Rehabil*. 2002;83(4):447-453.

385. Morningstar MW. Outcomes for adult scoliosis patients receiving chiropractic rehabilitation: a 24-month retrospective analysis. *J Chiropr Med*. 2011;10(3):179-184.

386. Morningstar MW, Dvorany B, Stitzel CJ, Siddiqui A. Chiropractic Rehabilitation for Adolescent Idiopathic Scoliosis: End-of-Growth and Skeletal Maturity Results. *Clin Pract*. 2017;7(1):911.

387. Lantz CA, Chen J. Effect of chiropractic intervention on small scoliotic curves in younger subjects: A time-series cohort design. *J Manipulative Physiol Therapeut*. 2001;24(6):385-393.

388. Negrini S, Donzelli S, Negrini A, Parzini S, Romano M, Zaina F. Specific exercises reduce the need for bracing in adolescents with idiopathic scoliosis: A practical clinical trial. *Ann Phys Rehabil Med*. 2019;62(2):69-76.

389. Zaina F, Poggio M, Donzelli S, Negrini S. Can bracing help adults with chronic back pain and scoliosis? Short-term results from a pilot study. *Prosthet Orthot Int*. 2018;42(4):410-414.

390. Donzelli S, Zaina F, Minnella S, Lusini M, Negrini S. Consistent and regular daily wearing improve bracing results: a case-control study. *Scoliosis Spinal Disord*. 2018;13:16.

391. Negrini A, Negrini MG, Donzelli S, Romano M, Zaina F, Negrini S. Scoliosis-Specific exercises can reduce the progression of severe curves in adult idiopathic scoliosis: a long-term cohort study. *Scoliosis*. 2015;10:20.

392. Zaina F, de Mauroy JC, Donzelli S, Negrini S. SOSORT award winner 2015: a multicentres study comparing the Sforzesco and ART braces effectiveness according to the SOSORT-SRS recommendations. *Scoliosis*. 2015;10:23.

393. Negrini S, Donzelli S, Lusini M, Minnella S, Zaina F. The effectiveness of combined bracing and exercise in adolescent idiopathic scoliosis based on SRS and SOSORT criteria: a prospective study. *BMC Muscoskel Disord*. 2014;15:263.

394. Lusini M, Donzelli S, Minnella S, Zaina F, Negrini S. Brace treatment is effective in idiopathic scoliosis over 45°: an observational prospective cohort controlled study. *Spine J*. 2014;14(9):1951-1956.

395. Zaina F, Donzelli S, Negrini A, Romano M, Negrini S. SpineCor, exercise and Sforzesco rigid brace: what is the best for adolescent idiopathic scoliosis? Short term results from 2 retrospective studies. *Stud Health Technol Inf*. 2012;176:361-364.

396. Negrini S, Negrini F, Fusco C, Zaina F. Idiopathic scoliosis patients with curves more than 45 Cobb degrees refusing surgery can be effectively treated through bracing with curve improvements. *Spine J*. 2011;11(5):369-380.

397. Negrini S, Atanasio S, Fusco C, Zaina F. Effectiveness of complete conservative treatment for adolescent idiopathic scoliosis (bracing and exercises) based on SOSORT management criteria: results according to the SRS criteria for bracing studies - SOSORT award 2009 winner. *Scoliosis*. 2009;4:19.

398. Negrini S, Zaina F, Romano M, Negrini A, Parzini S. Specific exercises reduce brace prescription in adolescent idiopathic scoliosis: a prospective controlled cohort study with worst-case analysis. *J Rehabil Med*. 2008;40(6):451-455.

399. Negrini S, Atanasio S, Negrini F, Zaina F, Marchini G. The Sforzesco brace can replace cast in the correction of adolescent idiopathic scoliosis: A controlled prospective cohort study. *Scoliosis*. 2008;3:15.

400. Negrini S, Atanasio S, Zaina F, Romano M, Parzini S, Negrini A. End-growth results of bracing and exercises for adolescent idiopathic scoliosis. Prospective worst-case analysis. *Stud Health Technol Inf*. 2008;135:395-408.

401. Negrini S, Marchini G. Efficacy of the symmetric, patient-oriented, rigid, three-dimensional, active (SPoRT) concept of bracing for scoliosis: a prospective study of the Sforzesco versus Lyon brace. *Eur Mediphys*. 2007;43(2):171-174.

402. Negrini S, Negrini A, Romano M, Verzini N, Negrini A, Parzini S. A controlled prospective study on the efficacy of SEAS.02 exercises in preventing progression and bracing in mild idiopathic scoliosis. *Stud Health Technol Inf*. 2006;123:523-526.

403. Weiss H-R, Weiss G, Petermann F. Incidence of curvature progression in idiopathic scoliosis patients treated with scoliosis in-patient rehabilitation (SIR): an age- and sex-matched controlled study. *Pediatr Rehabil*. 2003;6(1):23-30.

404. Rigo M, Reiter C, Weiss HR. Effect of conservative management on the prevalence of surgery in patients with adolescent idiopathic scoliosis. *Pediatr Rehabil*. 2003;6(3-4):209-214.

405. de Mauroy JC, Journe A, Gagialiano F, Lecante C, Barral F, Fournet S. The new Lyon ARTbrace versus the historical Lyon brace: a prospective case series of 148 consecutive scoliosis with short time results after 1 year compared with a historical retrospective case series of 100 consecutive scoliosis; SOSORT award 2015 winner. *Scoliosis*. 2015;10:26.

406. McIntire KL, Asher MA, Burton DC, Liu W. Treatment of adolescent idiopathic scoliosis with quantified trunk rotational strength training. *J Spinal Disord Tech*. 2008;21(5):349-358.

407. Haefeli M, Elfering A, Kilian R, Min K, Boos N. Nonoperative treatment for adolescent idiopathic scoliosis. *Spine*. 2006;31(3):355-366.

408. Bialek M. Mild angle early onset idiopathic scoliosis children avoid progression under FITS method (functional individual therapy of scoliosis). *Medicine*. 2015;94(20):e863.

409. Weinstein SL, Dolan LA, Wright JG, Dobbs MB. Effects of bracing in adolescents with idiopathic scoliosis. *N Engl J Med*. 2013;369(16):1512-1521.

410. Gutowski WT, Renshaw TS. Orthotic results in adolescent kyphosis. *Spine*. 1988;13(5):485-489.

411. Riddle EC, Bowen JR, Shah SA, Moran EF, Lawall H Jr. The duPont kyphosis brace for the treatment of adolescent scoliosis.
Scheurmann kyphosis. J South Orthop Assoc. 2003;12(3):135-140.

412. Woodfield HC 3rd, York C, Rochester RP, et al. Cranio-cervical chiropractic procedures - a précis of upper cervical chiropractic. J Can Chiropr Assoc. 2015;59(2):173-192.

413. Woodfield HC 3rd, Hasick DG, Becker WJ, Rose MS, Scott JN. Effect of Atlas Vertebral realignment in subjects with migraine: an observational pilot study. BioMed Res Int. 2015;2015:630472.

414. Kessinger RC, Anderson MF, Adlington JW. Improvement in pattern analysis, heart rate variability and symptoms following upper cervical chiropractic care. J Uppr Cerv Chirop Res. 2013;3:32-42.

415. Torns S. Atlas vertebra realignment and arterial blood pressure regulation in 42 subjects. J Uppr Cerv Chirop Res. 2012(2):40-45. https://www.vertebralsubluxationresearch.com/2012/04/atlas-vertebra-realignment-and-arterial-blood-pressure-regulation-in-42-subjects/.

416. Eriksen K, Rochester RP, Hurwitz EL. Symptomatic reactions, clinical outcomes and patient satisfaction associated with upper cervical chiropractic care: a prospective, multicenter, cohort study. BMC Musculoskel Disord. 2011;12:219.

417. Rochester RP. Neck pain and disability outcomes following chiropractic upper cervical care: a retrospective case series. J Can Chiropr Assoc. 2009;53(3):173-185.

418. Bakris G, Dickholtz M, Meyer PM, et al. Atlas vertebra realignment and achievement of arterial pressure goal in hypertensive patients: a pilot study. J Hum Hypertens. 2007;21(5):347-352.

419. Khorshid KA, Sweat RW, Zemba DA, Zemba BN. Clinical efficacy of upper cervical versus full spine chiropractic care on children with Autism: A randomized clinical trial. J Vertebral Sublux ResMar. 2006;9:7p.

420. Owens EF, Eriksen K. Upper cervical post x-ray reduction and its relationship to symptomatic improvement and spinal stability. Chiropr Res J. 1997;4(2):10-17.

421. Eriksen K. Comparison between upper cervical X-ray listings and technique analyses utilizing a computerized database. Chiropr Res J. 1996;3(2):13-24.

422. Grostic JD, DeBoer KF. Roentgenographic measurement of atlas laterality and rotation: a retrospective pre- and post-manipulation study. J Manipulative Physiol Therapeut. 1982;5(2):63-71.

423. Anderson RRT. Anatomic rotation at the atlanto-occipital joint. Eleventh Annual Biomechanics Conference on the Spine. Boulder, CO: University of Colorado; 1980:Dec. 6-7, 113-140.

424. Aldis GK, Hill JM. Analysis of a chiropractor’s data. J Manip Physiol Ther. 1980;3:177-183.

425. Khamis S, Carmeli E. Relationship and significance of gait deviations associated with limb length discrepancy: A systematic review. Gait Posture. 2017;57:115-123.

426. Betsch M, Rapp W, Przibylla A, et al. Determination of the amount of leg length inequality that alters spinal posture in healthy subjects using rasterstereography. Eur Spine J. 2013;22(6):1354-1361.

427. Beaudoin L, Zabjek KF, Leroux MA, Coillard C, Rivard CH. Acute systematic and variable postural adaptations induced by an orthopaedic shoe lift in control subjects. Eur Spine J. 1999;8(1):40-45.

428. Gordon JE, Davis LE. Leg length discrepancy: the natural history (and what do we really know). J Pediatr Ortho. 2019;39(Issue 6suppl 1):S10-S13.

429. Jenkins H, Zheng X, Bull PW. Prevalence of congenital anomalies contraindicating spinal manipulative therapy within a chiropractic patient population. Chiro J Australia. 2010;40(2):69-76.

430. Young KJ, Aziz A. An accounting of pathology visible on lumbar spine radiographs of patients attending private chiropractic clinics in the United Kingdom. Chiro J Australia. 2009;39(2):63-69.

431. Pryor M, McCoy M. Radiographic findings that may alter treatment identified on radiographs of patients receiving chiropractic care in a teaching clinic. J Chiropr Educ. 2006;20(1):93-94.

432. Beck RW, Holt KR, Fox MA, Hurtgen-Grace KL. Radiographic anomalies that may alter chiropractic intervention strategies found in a New Zealand population. J Manipulative Physiol Therapeut. 2004;27(9):554-559.

433. Bull PW. Relative and absolute contraindications to spinal manipulative therapy found on spinal X-rays. Proceedings of the World Federation of Chiropractic 7th Biennial Congress. WFC; 2003:376.

434. Hald HJ, Danz B, Schwab R, Burmeister K, Bühren W. [Radiographically demonstrable spinal changes in asymptomatic young men]. Röfo. 1995;163(1):4-8.

435. Andersen HT, Wågstaff AS, Sverdrup HU. Spinal X-ray screening of high performance fighter pilots. Aviat Space Environ Med. 1991;62(12):1171-1173.

436. Harrison DE, Cailliet R, Harrison DD, Janik TJ, Holland B. Changes in sagittal lumbar configuration with a new method of extension traction: nonrandomized clinical controlled trial. Arch Phys Med Rehabil. 2002;83(11):1585-1591.

437. Harrison DE, Harrison DD, Betz JJ, et al. Increasing the cervical lordosis with chiropractic biophysics seated combined extension-compression and transverse load cervical traction with cervical manipulation: nonrandomized clinical control trial. J Manipulative Physiol Therapeut. 2003;26(3):139-151.

438. Cocchiarella L, Andersson GBJ. AMA Guides® to the Evaluation of Permanent Impairment. 5th ed. AMA; 2001.

439. Rondinelli R. AMA Guides® to the Evaluation of Permanent Impairment. 6th ed. AMA; 2008.

440. White AA III, Panjabi MM. Clinical Biomechanics of the Spine. 2nd ed. Lippincott, Williams & Wilkins; 1990.

441. Harrison D, Betz J, Jaeger H, Hasa J, Colloca C. Do chronic neck pain subjects have an altered response of the cervical lordosis relative to thoracic inlet morphology? A comparison of a normal and chronic pain population. Proceedings of the 13th World Federation of Chiropractic Biennial Congress/ECU Convention. Athens, Greece. May 13-16, 2015:110-111.

442. Cóte P, Hartvigsen J, Axén I, Leboeuf-Yde C, et al. Correction to: The global summit on the efficacy and effectiveness of spinal manipulative therapy for the prevention and treatment of non-musculoskeletal disorders: a systematic review of the literature. Chiropr Man Ther. 2021;29(1):11. (Multiple
investigators refused to co-author in disagreement with conclusions).

443. Swain MS, Gliedt JA, de Luca K, Newell D, Holmes M. Chiropractic students’ cognitive dissonance to statements about professional identity, role, setting and future: international perspectives from a secondary analysis of pooled data. Chiropr Man Ther. 2021;29(1):5.

444. Simpson JK, Young KJ. Vitalism in contemporary chiropractic: a help or a hinderance?. Chiropr Man Ther. 2020;28(1):35.

445. Nim CG, Lauridsen HH, O’Neill S, Goncalves G, Jensen RK, Leboeuf-Yde C. Chiropractic conservatism among chiropractic students in Denmark: prevalence and consequences. Chiropr Man Ther. 2020;28(1):64.

446. Goncalves G, Demortier M, Leboeuf-Yde C, Wedderkopp N. Chiropractic conservatism and the ability to contra-indications, non-indications, and indications to chiropractic care: a cross-sectional survey of chiropractic students. Chiropr Man Ther. 2019;27:3.

447. Côté P, Bussières A, Cassidy JD, et al. More published full-time researchers, early career researchers, clinician-researchers and graduate students unite to call for actions against the pseudo-scientific claim that chiropractic care boosts immunity. Chiropr Man Ther. 2020;28(1):48.

448. Côté P, Bussières A, Bussières A, et al. A united statement of the global chiropractic research community against the pseudo-scientific claim that chiropractic care boosts immunity. Chiropr Man Ther. 2020;28(1):21.

449. Leboeuf-Yde C, Innes SI, Young KJ, Kawchuk GN, Hartvigsen J. Chiropractic, one big unhappy family: better together or apart?. Chiropr Man Ther. 2019;27:4.

450. Young K. Gimme that old time religion: the influence of the healthcare belief system of chiropractic’s early leaders on the development of x-ray imaging in the profession. Chiropr Man Ther. 2014;22(1):36.

451. Nelson CF, Lawrence DJ, Triano JJ, et al. Chiropractic as spine care: a model for the profession. Chiropr Osteopathy. 2005;13:9.(Precursor to Chiropr Man Therap).

452. Walker BF. The new chiropractic. Chiropr Man Ther. 2016;24:26.

453. Oakley PA, Harrison DE. Letter-to-the-editor regarding Taylor S, Bishop A. Patient and public beliefs about the role of imaging in the management of non-specific low back pain: a scoping review. Physiotherapy. 2020 Jun;107:224-233. Physiotherapy. 2020;107:224-233. Physiotherapy1109091.

454. Harrison DE, Harrison D. Letter to the editor: “The association between cervical spine curvature and neck pain (D. Grob et al.)”. Eur Spine J. 2007;16(10):1739-1740.; author reply 1741-3.

455. Oakley P. Influence of axial rotation on chiropractic pelvic analysis. J Manipulative Physiol Therapeaut. 2007;30(1):78-79.

456. Harrison DD, Harrison DE, Oakley PA. Evidence-based care, certainty, and the doctor’s duty of care. J Manipulative Physiol Therapeaut. 2005;28(9):732-733.; author reply 733-4.

457. Oakley PA, Harrison DE. Several pathways in the evolution of chiropractic manipulation. J Manipulative Physiol Therapeaut. 2004;27(1):72-74.; author reply 74-5.

458. Oakley PA, Harrison DE. Reply to “Lumbar lordosis: Study of patients with and without low back pain”. Clin Anat. 2004;17(4):367.

459. Harrison DE, Ferrantelli J, Oakley PA. Lateral cervical curve changes in patients receiving chiropractic care after a motor vehicle collision: a retrospective case series. J Manipulative Physiol Therapeut. 2004;27(2):133-134.; author reply 134-7.

460. Harrison DE. Letters to the editor. J Spinal Disord Tech. 2003;16(2):225.; author reply 225-6.

461. Harrison DE, Betz J. Effects of lifestyle and work-related physical activity on the degree of lumbar lordosis and chronic low back pain in a Middle East population. J Spinal Disord Tech. 2002;15(3):186.

462. Harrison DE, Bula JM, Gore DR. Letters. Spine. 2002;27(11):1249-1250.

463. Update CCBC. Public consultation on the review of clinical utility of routine spinal radiographs. 2020. https://www.chirobe.com/update-public-consultation-on-the-review-of-clinical-utility-of-routine-spinal-radiographs/. Accessed February 14-September 25, 2021.

464. Lesko LJ, Zineh I, Huang S-M. What is clinical utility and why should we care? Clin Pharmacol Ther. 2010;88(6):729-733.

465. Kuo Y-L, Chung C-H, Huang T-W, et al. Association between spinal curvature disorders and injury; a nationwide population-based retrospective cohort study. BMJ Open. 2019;9(1):e023604.

466. Rydman E, Elkan P, Eenqvist T, Ekman P, Järnbert-Pettersson H. The significance of cervical sagittal alignment for nonrecovery after whiplash injury. Spine J. 2020;20(8):1229-1238.

467. John JD, Yoganandan N, Arun MWJ, Saravana Kumar G. Influence of morphological variations on cervical spine segmental responses from inertial loading. Traffic Inj Prev. 2018;19(suppl 1):S29-S36.

468. Östh J, Mendoza-Vazquez M, Sato F, Svensson MY, Linder A, Brolin K. A female head-neck model for rear impact simulations. J Biomech. 2017;51:49-56.

469. Stenper BD, Yoganandan N, Pintar FA. Effects of abnormal posture on capsular ligament elongations in a computational model subjected to whiplash loading. J Biomech. 2005;38(6):1313-1323.

470. Sadler SG, Spink MJ, Ho A, De Jonge XJ, Chuter VH. Restriction in lateral bending range of motion, lumbar lordosis, and hamstring flexibility predicts the development of low back pain: a systematic review of prospective cohort studies. BMC Musculoskel Disord. 2017;18(1):179.

471. Goto NA, Koelle MC, van Loon IN, Boerboom FTJ, Verhaar MC, Emmelot-Vonk MH, et al. Thoracic vertebral fractures and hyperkyphosis in elderly patients with end-stage kidney disease; do these patients have different clinical outcomes? Bone. 2019;127:181-187.

472. Okura M, Ogita M, Yamamoto M, Nakai T, Numata T, Arai H. Self-assessed kyphosis and chewing disorders predict disability and mortality in community-dwelling older adults. J Am Med Dir Assoc. 2017;18(6):550-66.

473. Kado DM, Lui LY, Ensrud KE, et al. Hyperkyphosis predicts mortality independent of vertebral osteoporosis in older women. Ann Intern Med. 2009;150(10):681-687.
474. Kado DM, Huang M-H, Karlamangla AS, Barrett-Connor E, Greendale GA. Hyperkyphotic posture predicts mortality in older community-dwelling men and women: a prospective study. *J Am Geriatr Soc*. 2004;52:1662-1667.

475. Kado DM, Duong T, Nevitt MC, et al. Incident vertebral fractures and mortality in older women: a prospective study. *Osteoporos Int*. 2003;14:589-594.

476. Milne JS, Williamson J. A longitudinal study of kyphosis in older people. *Age Ageing*. 1983;12:225-233.

477. Anderson F, Cowan NR. Survival of healthy older people. *Br J Prev Soc Med*. 1976;30:231-232.

478. Sackett DL, Rosenberg WMC, Gray JAM, Haynes RB, Richardson WS. Evidence based medicine: what it is and what it isn’t. *BMJ*. 1996;312(7023):71-72.