The specific chiropractic adjustment is conducted within an articulation's physiological range of motion:

Part 4 of a series.

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Abstract: This presentation aims to review the accuracy and appropriateness of the term *beyond the normal physiological limit* in relation to the chiropractic adjustment of vertebral subluxations. We question the assertion that chiropractic adjustments may conduct a spinal articulation beyond this normal physiological or functional limit. We contend that the chiropractic vertebral adjustment does not take an articulation beyond its normal range of movement primarily because dysfunctional fixations occur within a joints physiological range. A discussion is presented which calls for the removal of this unsuitable and inaccurate term.

Indexing terms: Vertebral adjustment, Range of movement, Manipulation, Technique.

Introduction

In relation to manipulation of spinal facets, the term beyond the normal physiological limit (BNPL) was a concept proposed by Sandoz in 1976 which seems to have been adopted without further consideration until 2005. The phrase implies a major disturbance and displacement of an articulation undergoing adjustment. It is a concept that was seriously questioned by Vernon and Mrozek in 2005 and again by Ebrall in 2020. (1, 2, 3)

... the skilfully delivered spinal adjustment by trained chiropractors does NOT take the joint beyond its normal physiological limits.'

The notion that spinal manipulation transfers vertebral joints beyond their physiological limits would be tantamount to a joint strain or even a sprain with resultant signs and symptoms. (4) It is apparent that this is not the case, and therefore is not applicable to controlled and specific chiropractic adjustments.

Despite impressions by some, we assert that such an extreme does not occur. Were it to be the case there would be the likelihood of soft tissue damage and there has been no evidence to support this taking place. Vernon and Mrozek point out that tissue injury would occur beyond the anatomical limit of a joint. They state clearly that '*Manipulation is performed within the clinical physiological range.*' (2, Fig 5.)

If taken beyond the normal ROM radiological evidence could be apparent, and this has not been demonstrated to our knowledge. In addition, as capsules are rich in nociceptive fibres and there would be apparent noxious symptoms noted by patients. (5,6) We know of none.

While various versions exist, there has been general acceptance that joint motion may be divided up into stages of motion. (Table 1) Up to the point of joint sprain, there are functional divisions, not anatomical differentiations. As Herda et al noted '*the limits are usually represented in an oversimplified manner that does not closely correspond to reality*.' (7)

These so-called intra-articular zones are flexible and may vary amongst patients as a normal range.

Table 1.

- Passive
- Voluntary/ Active range of motion. [Region of centrode and segmental fixation]
- Active/assisted range of motion. [*Chiropractic vertebral adjustments occur here as*
    - *Mobilisation) variable and may range from mobilisation*
    - *Manipulation) and through to manipulation to the elastic barrier.*]
- Paraphysiological space → Elastic Barrier
- Manipulation under anaesthetic
- Anatomical limit, ligamentous and capsular restraint
- Joint sprain

We define the functional or physiological range of motion to include the active and assisted range into and inclusive of the elastic range up to the barrier of ligamentous and capsular restraint.

A definition of spinal manipulation in the Queensland Schedule Health Practitioner Regulation Nation Law Part 7, S123, (as adopted by the Australian Health Practitioner Regulation Agency) has some ambiguity, one of which is defining '*manipulation of the cervical spine means moving the joints of the cervical spine beyond a person's usual physiological range of motion*'. The inference in the use of this phrase is that cervical manipulation may sprain cervical facets. An examination of the literature sees it applied to other spinal levels as well. As such, the term beyond a person's usual physiological range of motion is inappropriate and should be discarded. (8)

For a segment's physiological range of motion (PROM) to be breached there would have to be clinical evidence of ligamentous and/or tendinous tissue damage indicating soft tissue strain or even sprain. The authors are not aware of any evidence of such a side effect under normal clinical care.

Range of motion (ROM) may be defined as the type of motion available at a particular articulation, usually a synovial joint. It may be classified further as (9,10) Anatomical ROM, the range of a joint limited by osseous elements and holding structures, and Physiological ROM, the range of a joint in real life.

Physiological ROM is subdivided thus:

Active ROM. The range where a person can move a joint by their own effort.

Passive ROM. The range of a joint's motion with the support of external forces.

Assisted ROM/. The range of motion achieved with second party assistance or assistance - a combined effort.

We must also consider:

> Accessory Movements are those experienced as isolated translational movements which may be experienced with adjustments, manual therapy, manipulation and mobilisation; and
>
> Pathological ROM. The stage at which the holding elements limit the range of motion, beyond which become strain or sprain.

It is suggested that paraphysiological space comprising the area between the start of the elastic barrier and the anatomical limit is more of an elastic moderator rather than a barrier. Further, we would suggest that the pie chart depiction of the range of motion in a facet may be better depicted as a flexible zone of movement encompassing the centrode within the facet surface - a zone within a zone. (11)

In this proposal, a pathophysiological fixation would only occur in the vicinity of the anatomical limit of a joint's range of motion under severe trauma. It is suggested that the paraphysiological space is the region within a ROM where a joint may be moved with normal self-exertion or with assisted motion beyond, which the ligaments and capsular holding elements may be damaged as in cases of whiplash. Such tissue injury would not normally be associated with refined, calculated, chiropractic corrective adjustments.

It is suggested that the release of a fixated segmental facet by a vertebral adjustment takes place within this zone of axes of independent helical motion and well within a smaller area within the surface of the facet and not beyond functional limits. This zone would comprise a fraction of the surface area of the joint. Klein et al describe restricted joints as being '*trapped in the neutral zone.*' (12) Panjabi et al state that at the C1-C2 vertebral level the neutral zone is 70% of the facets' active range of motion, about 28° to 40°. (13)

Review

As noted by Ebrall, for a force propelling a vertebra into the extreme *elastic end zone* past the passive and active ranges is a contradiction of the *low* amplitude in the HVLA indicated by the terminology. In addition, at such an extreme limit the patient would most likely experience a degree of discomfort that is unnecessary and respond accordingly. (3)

There are some manual techniques which appear to take spinal joints beyond their normal range. Some decades ago, the techniques demonstrated by the medical physician Cyriax, appear to take segments to their extreme. These are not techniques employed by chiropractors. (14) Similarly, the methods used in a YouTube clip by a Russian paediatrician are not chiropractic techniques. It is felt that as extreme versions of manipulation they have been misinterpreted as applying to all such manipulative procedures including specific chiropractic adjustments. (15)

We submit that manual processes are a skill and an art based on anatomy, physiology, science, aptitude and understanding. Refined techniques cannot be mastered overnight. The rationale and subtleties of techniques take many hours of training.

Discussion

Initially there has to be a clinically identified reason to justify and to focus upon any of the manual manipulative procedures. This biomechanical lesion is identified in chiropractic and by the World Health Organisation as a vertebral subluxation. The lesion has also been labelled by other professions under a variety of names which include joint dysfunction, somatic dysfunction and many others. The chiropractic model takes into account the associated disturbance of physiological, anatomical, structural and functional ramifications to consider and recognise signs and symptoms of such an articular disturbance. After all, presenting symptoms and clinical signs are both indicators and confirmatory factors. (16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30)

The 1976 BNPL theory of vertebral manipulation was proposed by Sandoz who suggested that spinal manipulation took vertebral joints beyond their normal physiological range. This appears to have been based more on theoretical opinion and was subsequently adopted without challenge until 2005. Somehow, this theory had persisted without supporting evidence. The notion was dismissed by Vernon and Mrozek in 2005 when they stated clearly that '*it is wrong*.'(p69). That notion was questioned again by Ebrall in 2020 who concluded that '*the idea that a chiropractor takes the joint beyond its physiological range of movement is a confected nonsense*'. We could not locate any formal research to support the Sandoz hypothesis. (2,3)

By definition, for a joint to carry beyond the normal physiological limit would constitute at least a joint strain. Such an extreme may also result in a joint sprain with tearing soft tissue fibres. There are some general manipulative techniques movements which appear to take joints, even multiple joints to extremes. These are not chiropractic-specific adjustments. (14)

A range of chiropractic techniques which may appear to be quite physical are actually utilising adjunctive mechanical measures. These include the toggle drop piece, spring-loaded table sections, flexion distraction and pneumatic table sections. These facilitate the adjustive techniques and ameliorate forces in order to take advantage of the acceleration of velocity factor. These developments and considerations also mitigate a movement trend towards NPL and abate and absorb compressive forces on the patient while enhancing efficiency and efficacy.

Appropriate technique set-ups coincide with particular spinal regions, but also with specific segments. The spinal laxity and joint play require recouping prior to an adjustment. Despite appearing to exaggerate the amplitude of the procedure, such measures actually reduce the final application awhile enhancing the efficacy of the technique. Other ameliorating factors include spring-loaded or pneumatic drop-sections on the adjusting table, or adequate cushioning which serve to attenuate the impulse. (31)

A subluxated vertebral segment could not be in displacement if it was not fixated ('locked'), Emphasis must then focus on a release of the fixation. This would take place in a predetermined vector such that it would normalise the segment's motion towards the joint's neutral position. That is the displacement must also be assessed when considering the release of fixation, but in a specific corrective direction - if repositioning is indicated. It would be a natural inclination for a vertebra to be prompted towards its neutral, resting position and more difficult and illogical to thrust it away from this natural neutral site. This consideration again repudiates the notion of taking a joint beyond its NPL.

It can be noted that a clinical finding of a hypermobile segment is a contradiction to direct manipulation. Such a clinical finding however may be addressed in other ways, particularly if compensatory fixations are located at other spinal levels. The release of these appears to help stabilise the hypermobile segment. (32, 33, 34, 35)

Range of motion along a centrode

Rousseau et al have determined that segmental kinematics demonstrate that vertebrae do not move around a fixed instantaneous axis of the facets, but through a moveable zone of axes referred to as the centrode. The centrode is the path of the instant axis of motion at a particular moment. The vertebral body provides a separate instantaneous axis of rotation but in conjunction with facet axes. (36, 37)

The notion of a single axis in vertebrae is not valid as the zygapophyseal axes are additional to the axis in the vertebral body, there are also axes of coupled motion for a loaded spine and we would assume altered axes with dysfunctional or subluxated vertebrae thereby making the topic of vertebral axes more complex. (36)

It is noted that as the path of the moveable instantaneous axes zone - the facet centrode is confined to a central region within the joint surface. The chiropractic adjustment is not intended and could not be taken beyond the joint's normal limits. This could not be accomplished without damage to the soft tissue holding elements as the adjustment is a release of the fixated joint within this central zone. As such, all adjustments are conducted well within a joint's physiological range as it is the fixation within the zone of axes that is being released. In relation to the Instantaneous Helical Axis, Wachowski et al also demonstrated '*that the joints are responsible for IHA-position, IHA-alignment and IHA-migration during axial rotations in all segments investigated*.' (36, 38, 39)

It would follow that facet fixation must take place within the physiological ROM within the joint itself along the centrode. Its release would then take place from within the centrode. A joint would then be adjusted with emphasis on the release of the joint with repositioning a secondary but integral consideration. A body centrode may be defined as being the path traced by the instantaneous centre of rotation (ICR) of a rigid plane figure moving in a plane. (40, 41)

Panjabi and colleagues calculated that in the upper cervical spine, the zone of neutral rotation for C1/C2 was approximately was 28° - 12°or 30% less than the normal full range. This would suggest that for a fixation to occur in the neutral zone as proposed here and its release would not approximate the limit of its physiological motion. (42)

In 2015, Buzzatti and colleagues using fresh specimens determined that a HVLA rotatory manipulation displaced the C1/C2 facet some 0 5mm (SD ± 0·5 mm) with a facet range of 6.0 mm (SD ± 3.4mm). (43)

Masharawa and colleagues found that the surface area of thoracic vertebral facets averaged approximately 11± mm X 10± mm and lumbar 13± mm X 14± mm, revealing surface areas of approximately 110 mm^2 and 182 mm^2 respectively. Noted factors considered in this study included facet tropism, differences in right to left facets, and of superior to inferior facet measurements. Given these dimensions it is suggested that displacement during vertebral adjustments is well within these parameters. In similar findings, Panjabi et al found that from C3 to L5 facet dimensions ranged from 9.6 -16.3 mm in width with heights ranging from 10.2 mm -18.4 mm. (44, 45)

In confirmation of a central or neutral zone as opposed to a fixed central axis with disturbed segmental mechanics, Klein and colleagues noted that the cervical spine of whiplash patients becomes '*trapped in the neutral zone*'. This scenario would suggest that fixation, even severe whiplash aetiology may fixate cervical segments well within their normal ROM. Such a notion would support the concept of cervical syndromes. (46, 47, 48)

A normal lumbar segment has an axial migratory range of motion of 10 – 60 mm of instantaneous helical axis - essentially its centrode. That would seem considerable travel in such a small segmental structure, but direction, migration, and screw-pitch of the vertebral body were tracked. (38, 39)

Ogston et al also found that in physiological movements the lumbar segments (L4/L5 and L5/S1) the centrode may travel some from 43.7mm to 55.9mm in normal postural movements. (49)

Byrne in 2018 and Ianuzzi in 2004 measured lumbar facet single plane translations in postural movements. While these varied movements of 5-6 mm were noted. We suggest that this is far more than that needed to conduct a manual adjustment of a vertebra in the lumbar spine. (50, 51)

In our review, we could find no firm determinant as to a single position within a lumbar segment's 10-60 mm (38) physiological migratory range ROM along which it may become functionally fixated. However, it would seem paradoxical to assume a fixated vertebral segment would have the same ROM as its physiological state, or that manipulation of a fixated segmental joint would conduct the joint through its assisted physiological range to the same degree. These are distinct variations of functions. The fixated joint would not approximate the anatomical limit if it is fixated within the neutral zone as we propose.

We therefore suggest that a fixation occurs at a point along the centrode within its neutral zone. As the centrode is within the zone of instantaneous helical axes, it is not at all likely to broach the physiological limit while being released. Whereas an assisted motion of a physiologically normal joint may approximate the anatomical limit and not have the restriction of a fixation imposed. It is noted that cavitation of a physiological joint (as in a phalangeal or metacarpophalangeal joint) does not approximate that joint's usual physiological limits. (52)

Nägerl et al state that the centrode of '*IHA-migration in spinal segments is determined by the curvature morphology and by the alignment of joint facets*.' This would suggest that a subluxation (fixation) or alteration in the alignment of joint facets has the potential to disrupt the joint's mechanoreceptors such as proprioceptors, nociceptors. (19, 53, 54)

Some techniques are distractive gapping techniques of the articulation while others have a line of drive parallel with the facet surface. It is suggested that both these vectors release the articulation before the thrust reaches the endpoint of physiological motion as the fixation sits within its axes zone and within the physiological range. (55)

Among slight variables, the surface area of lumbar facets increases with age particularly with the lower segments. They also differ in symptomatic patients from asymptomatic patients. These may range from an average of 126 mm^2 at the L3/L4 level in 20-year olds, up to 267 mm^2 at the L5/S1 level in 50-year-olds. With one exception, the symptomatic candidates have a greater surface area than the asymptomatic volunteers. It would then seem optimal for vertebral segments to maintain uninhibited facet motion which would also result in minimal noxious somatosensory activation. (56)

To clarify, the normal range of motion of a vertebral facet is centred on a mutable instantaneous axis of motion (centrode), not a fixed axis. We estimate that this zone resides well within the overall facet surface comprising approximately 60% of the total facet surface. Generally, the centres of rotation fall within a small centrode area meaning that flexion/extension is accompanied by only a small amount of shear translation. (57)

Wachowski and colleague demonstrated that via 3-D monitoring at least in the lumbar spine, that the facets were responsible for independent helical axis (IHA) in position, alignment and in rotation. They found that in postural movements '*In intact segments IHA-migration reached from one zygapophysial joint to the other IHA-paths came up to 10–60 mm within small angular intervals (±1 deg)*.' While this would not reflect the overall segmental movement, it indicates the dynamic adaptability of the role played by the axial foci of the facets as distinct form a separate IHA centred on the vertebral body. (38)

In relation to displacement of an articulation, there appears to be no definitive criteria to define the stage at which subluxated joint is clinically significant under the conservative medical definition relating just to displacement. We offer the clarification that it should be related to signs, symptoms, displacement and dysfunction. These are critical elements as the degree of displacement is not necessarily an indication as to its effect on the degree of sensory activation.

Citing other research, Ianuzzi and Khalsa summarise findings of segmental movement under manipulation with HVLA impulse. (58) They note that vertebral motions during spinal manipulation are relatively small (rotations: 1–2.5° (59); translations: .25–1.62 mm (60) as demonstrated by in vivo studies (59,60) and predictive modelling. (61) This displacement appears well within the physiological ROM although further studies would reveal displacement during a manipulative release in other spinal regions.

We note that the adjustive procedure is conducted well within the particular spinal segment regions range of motion and the leverage of the thrust moves the vertebra mere millimetres which is well within the facets' surface area and therefore segmental range of motion.

Relevant research by Ianuzzi and Khalsa found that in the process of lumbar spinal manipulation the magnitude of forces were within the physiological range indicating that spinal manipulation is biomechanically safe. (58)

A lumbar roll with a spinous contact could hardly be regarded as taking a joint beyond its physiological limits either. This type of adjustment releases the lumbar vertebra fixation in a rotary motion around the curved plane of its facet within its normal ROM.

We suggest further that the end range of movement of an articulation is not the peripheral edge of a joint but the edge of the region of instantaneous axes as a smaller zone within the joint.

As such, many chiropractic adjustments conduct release of a fixation with relatively little thrust or leverage and through an impulse at minimal amplitude. Manipulation on the other hand can be more general, physical and extreme. As Vaughan points out, manipulation has rather gross connotations as a purely physical manoeuvre.

However the concept of chiropractic vertebral adjustments creating cavitation into a joint's paraphysiological space or further is misleading. The adjustment is a release of a fixation within a joint's ROM and does not necessitate being taken to extremes, although consideration is given to restoration of normal positioning if it is indicated. We would suggest further that the nominal Sandoz zones within joint surfaces vary between joints and between individuals, as such they are not fixed zones but mutable.

The advent of adjusting instruments achieving positive outcomes on mechanical segmental fixations highlights the fact that a fixated joint does not need to be taken through its full range to be released, and that a limited amplitude will suffice. (63)

It is suggested that a fixation takes place within the physiological active range along the centrode, or even at times from the neutral position - the centrode being the path taken by dynamic instantaneous axes of motion. To release the fixation would be through a focussed impulse from within that zone and not a forced leverage that may take a joint past a paraphysiological 'zone' into the restraining elements.

In relation to those techniques that are considered to be HVLA, to be low amplitude suggests that the physiological limits of joints would not be breached and therefore could not be considered BNPL.

Conclusion

Given that a fixated articulation occurs within an articulations range of motion, this indicates that there is no need for a refined, calculated manipulative technique to take a subluxated vertebra beyond its physiological range of motion.

In contrast to some general manipulative techniques, the authors acknowledge that chiropractic techniques of all spinal regions as recommended and taught in chiropractic institutions do not exceed normal physiological limits of articular ranges of motion.

The calculated vertebral adjustment is conducted well within the physiological ROM of vertebral articulations. Beyond the normal physiological limit would be a joint strain if not a sprain. These terms are therefore not applicable to controlled chiropractic adjustments. The specific release of a fixation through an adjustment is a discrete, disciplined and accurate procedure.

Given that Diversified technique is a technique employed by 95.9% of chiropractors in the US, and has been classified here as Moderate Velocity with Low Amplitude (MVLA) to Moderate Velocity with Limited Amplitude (MVLA), it is highly improbable that advanced chiropractic adjustments would coerce a vertebral articulation to be moved beyond its normal range of motion during a controlled adjustment. (21)

We could find no evidence to support such a contention that a vertebra's physiological range of motion is breached during an adjustment other than unsubstantiated opinion. It is suggested that vertebral segmental displacement could not occur without fixation as the segment would simply retain its motion.

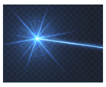
We contend that it is important to differentiate the controlled chiropractic adjustment with general generic manipulation.

We recommend discarding the term beyond the normal physiological limit as being redundant in relation to chiropractic adjustments.

We also recommend more judicious use of the HVLA terminology, with a greater understanding of the procedure and the depth of the amplitude.

The authors contend that the calculated vertebral adjustment is conducted well within the physiological range of articular motion. The specific release of an articulation is a more accurate description of an adjustment's function.

The specific release of a fixation through an adjustment is a more discrete disciplined and accurate procedure than the term beyond physiological limits would convey.



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