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RESEARCH REPORT

# The accuracy of osteopathic manipulations of the lumbar Spine: A Pilot study

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**KEYWORDS**
Lumbar adjustments;
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**Abstract** *Objective:* To assess the segmental specificity, or accuracy, of osteopathic lumbar spinal manipulations.
*Background:* Prior studies of chiropractic technique of manual manipulations of the spine designed to target abnormal tissue have been shown to be inaccurate, resulting in adjustments of segments other than the targeted level. This can result in manipulations of areas other than the level of interest of a therapist.
*Methods:* Cross-sectional investigation of a convenience sample. Twenty subjects, 14 males and 6 females (mean age = 31.2 years), participated. Eighteen subjects received 2 manipulations and 2 subjects received 3 manipulations that were performed by an experienced osteopath, totalling 42 manipulations. If present, cavitations were recorded using accelerometers from which, quantifying the time to target, revealed the source location. The osteopath and subjects were also asked to report their perception regarding any "clicking" (signifying a cavitation) during manipulations.
*Results:* In 12 of the 20 subjects (60%) there was at least one cavitation recorded. Sixteen of the 38 recorded manipulations produced at least one cavitation. Eight (50%) of these were accurate to the intended target. The mean distance between the site of cavitation and the intended target (error) was 5.31 cm. Regression analysis revealed no statistically significant relationship between the site of cavitation and intended target ($p = 0.718$). There was an increased number of attempts to

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adjust upper lumbar segments (L1, L2) compared to lower segments (L3, L4); however, there was error inferior to the target segment for 18 of the 23 cavitations (78%).

*Conclusions:* These results suggest that osteopathic techniques employed in this study were no different in terms of accurately directing treatment to a specified spinal segment (the mean error was 1 segment away from the intended target segment) than those previously observed using chiropractic techniques.



Implications

- These data suggest that osteopathic techniques employed in this study were not accurate in terms of direct treatment to specific motion segments assessed to be pathologic.
- This work, combined with our similar work with other clinical professions, suggests that the influence on neural variables may not need segmental specificity to create a clinical effect.

## Introduction

Osteo-articular spinal manipulations are among the most important tools in osteopathy.[1] It is often assumed by those in the field of osteopathy that these techniques are both specific and accurate in their effect, yet no evidence exists to support this claim. In theory, the practitioner seeks out vertebral segments through mobility tests or palpatory techniques that are 'rigid' or lack mobility.[1,2] There are 4 primary types of dysfunctions that have been hypothesized to respond to spinal manipulation, these include: release of hypertonic muscles, release of entrapped synovial folds, disruption of articular adhesions and unbuckling of motion segments that have been disproportionately displaced.[3,4] Once diagnosed and a location determined, an appropriate manual manipulation technique intended to correct the dysfunction, or normalize the abnormal tissues, is applied to the target spinal level.[2,5] Often an audible cavitation or 'cracking' noise is heard.[5] This sound will be referred to as the cavitation, in this paper, without any further implication of the sound source. Various authors have suggested the cavitation is an indicator of the success of the adjustment,[6–9] while others have argued the audible release by itself does not evoke a tissue response.[10] It has been accepted that the cavitation location indicates the level reacting to the adjustment.[6] The question addressed here is whether or not a directed treatment has actually affected the desired vertebral level. Several studies have brought into question the actual mechanisms of the effects of spinal manipulation,[6,8,11] while others have implied that what a practitioner feels may not be as accurate as they suspect. Ross et al.[5] showed that the vibrations associated with a cavitation, may actually originate from a segment several levels away from the desired treatment target, at least with Chiropractic manipulation. In that study, twenty eight licensed chiropractors performed spinal manipulations on sixty-four volunteers. Thirty-six of 52 manipulations had at least 1 cavitation accurate to target (36/52 = 69%). But since most manipulative procedures resulted in multiple cavitations, the percentage of cavitations that were accurate to their intended segment was less (57 of 124 cavitations = 46%). The average distance of the cavitation from the desired location in the lumbar spine was found to be 5.29 cm (greater than one vertebral level away from the intended vertebra). The authors concluded that manipulation of the lumbar spine is not accurate to the intended target. Several osteopaths suggested that their techniques were different and more accurate, which motivated this study.

The goal of this study was to determine the accuracy of osteopathic adjustments to the intended level in the lumbar spine.

## Methods

Volunteer subjects were a convenience sample, recruited from advertising posters in the office of the researcher and the Canadian College of Osteopathy. Those who met all the inclusion criteria, and were deemed suitable for the study following a physical examination completed and signed an informed consent form. The list of inclusion criteria follows:

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1. Between the ages of 18 and 40 years old (this is to minimize the risk of degenerative changes in the spine);
2. No history of disabling low back pain of greater than 3 weeks duration, or more than three episodes of low back pain in the last year;
3. A physical examination ensured that no contraindications to spinal manipulation were present;
4. Must have signed an informed consent form;
5. A lumbar osteo-articular restriction/lesion present upon examination.

The list of exclusion criteria follows:

1. Presence of disc degeneration, osteoarthritis, scoliosis, or other significant pathological condition;
2. Presence of any positive findings on the orthopaedic or neurological tests listed on the examination form for this study;
3. Pregnancy;
4. Exclusion at the discretion of the osteopath if they demonstrate resistance or hesitation in receiving the adjustment.

## Data collection

Subjects were screened with a questionnaire and underwent an orthopaedic assessment of the lumbar spine which included range of motion assessment as well as performance of standard tests including the quadrant, slump and straight leg raise. The osteopath then examined the subject's lumbar spine using inspection and palpation assessing for signs of somatic dysfunction, or "osteopathic lesions", which refers to impairment of elements of the somatic framework, not necessarily exclusive to the articular system (as noted in: www.aoa-net.org/publications/glossary202.pdf). On completion of his examination of the subjects the osteopath stated which level(s), if any, required manipulation in his opinion. The osteopath specifically named a single, particular segment which was to be targeted for each individual manipulation. Specifically the segment targeted is in reference to the named level and the one immediately below it, for instance L2 implies L2—L3. Following this assessment, accelerometers were attached to the skin overlying the spinous processes of T12, L3 and S1, which were used to triangulate the origin of the cavitation.

The determination of the location of cavitation was performed as follows: A spatial differentiation algorithm (which uses the speed of sound to measure distance similar to a fish-finding sonar, from three different accelerometer locations allows the distance from the source of the sound to be calculated — the interested reader is referred to the full details in Ross et al.[5]) computed the location of the origin of the cavitation resulting from SMT. Specifically, the instant in time in which each accelerometer first detected the cavitation was recorded, which is possible due to the distinct waveform which characterizes and distinguishes the cavitation versus a motion artifact due to the manipulation.[5] Assuming a constant speed of sound transmission, the time difference between all accelerometers was used to determine the location of the origin of the cavitation. The three accelerometer signals were sampled at 280,000 Hz to obtain sufficient spatial differentiation to distinguish between spinal levels (This method has been shown to be accurate to within 0.5 cm of the intended target by creating known cavitations in toe joints. In fact, the waveform of the cavitation is well within the Nyquist theorem given our very high sample rate. The very high sample rate was required to detect the onset of the waveform. The accuracy of this method has been established and published before. Again, the reader is referred to the Ross et al. paper[5]).

The manipulations were then performed. The osteopath was given the freedom to perform any preparatory work he desired. The osteopath then performed the manipulation, and again was free to utilize the technique of his choice.

On completion of the manipulation the osteopath was asked to state which level(s), if any, he felt produced a cavitation. The subject was asked if they heard a cavitation and, if so, how many. All recorded manipulations were performed with the patient in a side-lying position in order for the accelerometers to transmit the cavitation without any interference created by contact to them. Not all manipulations were recorded: the "Polyvalent" technique (nine trials in which the patient was taken from a long seated position and lowered onto the practitioner's hand contacting the involved segment) could not be recorded due to the sound distortion created by the accelerometers contacting the table; only manipulations producing a cavitation could be used in data compilation for this study. All the manipulations were performed by an expert osteopath with greater than 30 years' experience, recognized within the profession as a technique expert.

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**Table 1** The number of cavitations which occurred in each adjustment.

| Subject | First adjustment | | Second adjustment | |
|---|---|---|---|---|
| | Number of cavitations | Number of accurate cavitations | Number of cavitations | Number of accurate cavitations |
| 01 | 2 | 2 | 0 | 0 |
| 02 | 0 | 0 | 0 | 0 |
| 03 | 1 | 0 | 0 | 0 |
| 04 | 2 | 2 | 1 | 1 |
| 05 | 0 | 0 | 0 | 0 |
| 06 | 1 | 0 | 1 | 0 |
| 07 | 1 | 0 | 1 | 0 |
| 08 | 0 | 0 | 1 | 0 |
| 09 | 0 | 0 | 0 | 0 |
| 10 | 0 | 0 | 0 | 0 |
| 11 | 1 | 0 | 3 | 2 |
| 12 | 1 | 1 | 0 | 0 |
| 13 | 0 | 0 | 2 | 0 |
| 14 | 0 | 0 | 2 | 2 |
| 15 | 1 | 0 | 1 | 0 |
| 16 | 0 | 0 | 0 | 0 |
| 17 | 0 | 0 | 0 | 0 |
| 18 | 0 | 0 | 0 | 0 |
| 19 | 2 | 1 | 1 | 1 |
| 20 | 0 | 0 | 0 | 0 |

## Data analysis

The cavitations produced by the manipulations were recorded by the three accelerometers that were taped to the subjects' skin. The signal produced by a cavitation is seen as a unique waveform of high-frequency distinguishable from motion artifact.[5]

**Table 2** The distance (cm) from the intended target of each recorded cavitation for each adjustment attempt. A distance of up to 3.5 cm was considered to be accurate to the intended target.

| Subject | 1st Adjustment error Cav1 | 1st Adjustment error Cav 2 | 2nd Adjustment error Cav 1 | 2nd Adjustment error Cav 2 | 2nd \|Adjustment error Cav 3 |
|---|---|---|---|---|---|
| 01 | 0 | 2.5 | — | — | — |
| 02 | — | — | — | — | — |
| 03 | 8 | — | — | — | — |
| 04 | 10 | 10 | 3 | — | — |
| 05 | — | — | — | — | — |
| 06 | 11 | — | 8 | — | — |
| 07 | 8 | — | — | — | — |
| 08 | — | — | 7.5 | — | — |
| 09 | — | — | — | — | — |
| 10 | — | — | — | — | — |
| 11 | 8 | — | 4.5 | 2.5 | 0 |
| 12 | 1 | — | — | — | — |
| 13 | — | — | 8.5 | 6 | |
| 14 | — | — | 3.5 | 2.5 | — |
| 15 | 6 | — | 4.5 | — | — |
| 16 | — | — | — | — | — |
| 17 | — | — | — | — | — |
| 18 | — | — | — | — | — |
| 19 | 3.5 | 6 | 3 | — | — |
| 20 | — | — | — | — | — |

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**Table 3** A list of the number of times each level of the lumbar spine was targeted for adjustment.

| Lumbar spine segment | # of attempted adjustments |
|---|---|
| L1 | 10 |
| L2 | 11 |
| L3 | 8 |
| L4 | 7 |
| L5 | 4 |

To qualify as a cavitation 3 criteria must be met:

1. The cavitation must have been heard by the practitioner and the subject;
2. All three accelerometers must register the characteristic and distinguishing waveform in order to calculate the origin of the cavitation;
3. The time differential between the accelerometers must be consistent with the velocities determined for cavitation travel.

According to morphometric studies the distance between facet joints is 3—4.5 cm.[12—14] Therefore, any cavitation within 4.5 cm of the intended target was accepted as accurate.

## Results

Twenty volunteer subjects, fourteen males and six females, with an average age of 31.1 years participated in this study. A total of 42 manipulations were performed, with 18 subjects receiving two manipulations and two subjects receiving three. Note that no subjects met the exclusion criteria, thus none were excluded.

Of the 42 manipulations only 38 were successfully recorded: there were two instances of failure to record the cavitation because the osteopath failed to inform the data recorder that the manipulation was being performed, and two in one subject attributed to adipose interference. Of the 38 that were recorded, 18 (47.4%) resulted in at least one cavitation. On their first manipulation, nine of twenty subjects (45%) produced at least one cavitation while the other eleven of twenty subjects (55%) produced zero cavitations. On their second manipulation, eight (40%) of twenty subjects produced at least one cavitation and twelve (60%) produced zero cavitations. One patient who received a third manipulation produced zero cavitations, while the second patient who received a third manipulation did produce one cavitation but which was not recorded. Tables 1 and 2 lists the number of cavitations which occurred in each manipulation and the error from target of each cavitation measured in cm.

There seemed to be some preference for targeting the upper levels of the lumbar spine with a decreasing number of attempts at the lowest segments (listed in Table 3). The first lumbar was targeted 10 times, L2 was attempted 11 times, L3 was targeted 8 times, L4 was targeted 7 times and L5 received 4 attempts.

Of the 12 subjects (60%) producing at least one cavitation in at least one of the two manipulations, accuracy was observed in at least one of the two attempts in 7 of these 12 subjects (58.3%). While

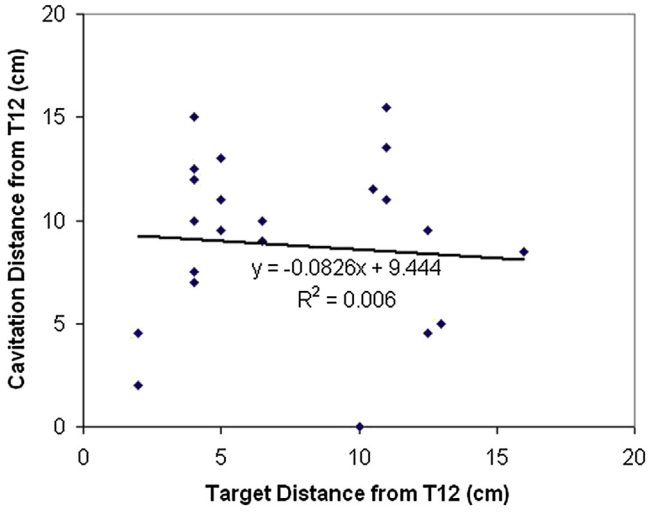


**Fig. 1** There was no association between target location and cavitation location as measured by the distance from the datum (the T12 vertebral segment). Regression analysis rendered a slope of best fit of 0.0826 ($p$ value = 0.073) meaning there was no relationship — a slope of 1 would have indicated a relationship between the intended and the actual target.

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the osteopath was allowed to disqualify subjects on a discretionary basis, this option was not exercised for any subjects.

The rate of accuracy of the first adjustments was three of nine (33%), and the accuracy rate in the second adjustment was five of seven (71.4%). Thus of the sixteen total adjustments, eight (50%) were measured to be accurate to the intended target. The mean error from target was 5.31 cm, or approximately one spinal segment. The error occurred inferior to the intended target in 18 of 23 (78%) adjustments. Given that there was a low rate of accurate manipulations, regression analysis was performed to determine if general accuracy (cavitations occurring in the general vicinity of the target vertebra) occurred. There was no relationship between target location and general cavitation location (Fig. 1).

## Discussion

The results of this study indicate that osteopathic adjustments were accurate 33% of the time (i.e. the target segmental level was the source of cavitation) with the first adjustment and 71% of the time with the second adjustment for a combined accuracy of approximately 50% of attempts. The mean error of 5.31 cm was nearly identical to the 5.29 cm reported by Ross et al.[5] who assessed chiropractic manipulative techniques. There appears to be no pattern in the types of somatic dysfunctions that were adjusted accurately compared to those that were not. Among the seven subjects who did receive accurate adjustments three were found to have dysfunction diagnosed between two vertebrae, L2 and L3 for example, and four were found to have greater than two vertebrae affected, or what was referred to as a "group lesion". Furthermore general accuracy of manipulation was not attained as there was no greater likelihood of cavitating an upper lumbar segment when targeting an upper lumbar segment than there was of cavitating a lower lumbar segment when targeting an upper lumbar segment and vice versa.

One interesting observation was those that did receive accurate adjustments, 6 of 7 (85.7%) of these subjects were treated with a "disco-corporeal" technique, which is intended to release local connective structures and re-enter the vertebra over its inferior segment, during the preparation to their adjustment. Of those that were not accurately adjusted only 1 of 5 (20%) received the disco-corporeal correction. The disco-corporeal correction is administered with the intent to remove tension from the intervertebral disc in relation to the two vertebral bodies to which it articulates. Given the high accuracy rate seen when performing this technique, versus the apparent randomness when it is not done, it may be wise to further study this correction as a preparation to all osteopathic adjustments of the lumbar spine.

There may be a few reasons why techniques which seem to emphasize such precision in diagnosis and execution could produce a relatively low level of accuracy to their intended target, even when administered by an expert. The hands of the osteopath are intended to be very soft and apply little force, acting almost exclusively in "listening" to tissue response, while the body of the practitioner does apply force at two sites; the thorax and the pelvis.[15,16] In typical osteopathy practice, and particularly in the adjustments performed in this study, it is generally thought that the forearm of the practitioner applies a distraction force to the pelvis, effectively using a force applied through the caudal forearm of the practitioner to create a force gapping the pelvis from the lumbar spine.[15,16] This will have a tendency to produce a preferential movement of the lower lumbar vertebrae. This may explain why, in this study, 18 of 23 cavitations (78%) showed an error inferior to the intended target. The study of chiropractic technique by Ross et al.[17] demonstrated that application of force mainly through the thorax of the subject could produce an increased tendency to cavitate the upper lumbar vertebrae, while force application to the pelvis would tend to produce cavitation in the lower lumbar segments. Further study using such precision measurement as utilized here may refine a method of more consistently producing accuracy in spinal adjustments.

There are several limitations for the interpretation of these results. Only one osteopath performed the intervention, however, he is recognized as an expert instructor and mentor in the profession. In addition, not all possible techniques were assessed. The choice of whether to select the disco-corporeal correction would benefit from more investigation. In addition, the approach to best address group lesions would benefit from more study and subsequently determine if it may be advantageous to remove these by first addressing the 'secondary' lesions, and following with an adjustment of the more 'primary' dysfunction. Finally, "accuracy", or the ability to direct treatment, was interpreted within the context of actual practice. Allowing a clinician to choose more than one segment to direct

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treatment alters the probability to achieve accuracy as do the occurrence of multiple cavitations.

In summary, the results suggest that the osteopathic techniques employed in this study achieved the same accuracy as previously reported chiropractic techniques. The results lie within the envelope of chance as to whether the target segment level experienced cavitation, or not.

## Author contribution statement

All authors were involved in the conception of the study, data collection and writing of the manuscript. Ross, McGill and Frantzis were involved in conducting the study, while funding came solely from McGill. Data analysis was performed by Ross and Frantzis.

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