Reviewer's report

Title: Bilateral and multiple cavitation sounds during upper cervical thrust manipulation

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Reviewer: Stephen Perle

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First let me apologize for the fact that I am going to bring up issues I had not in my initial review. I am not sure why I did not notice these but nonetheless they need to be addressed.

Major Compulsory Revisions

1. Manipulative method

Regarding the response of Dr. Dunning et al to my major compulsory revisions regarding the use of the term lever instead of vector. It appears that they are trying to write a paper that is full of physical therapy jargon and not one that uses standard profession independent terminology. Their excuse for using physical therapy jargon is that I am a Doctor of Chiropractic and that they are physiotherapists. If they believe that profession specific jargon is the best way to describe what they have done in this study than they should have submitted this paper to a physiotherapy journal where the reviewers and the readers would understand what they have written as they would have all had ingrained in them the physiotherapy jargon. The lever references that Dr. Dunning et al provided in their response only reinforces my understanding that they fervently desire the retention of profession specific jargon.

The requested changes from lever to vector or directions of movement of the subjects’ neck is not something that is predicated on this reviewer being a Doctor of Chiropractic but instead is intended to ensure that someone who is not a physiotherapist and is a member of any profession can understand what was actually done in this study.

The term vector is not a term specific to Doctors of Chiropractic; the jargon used by Doctors of Chiropractic is line of drive. Vector is proper terminology from physics and biomechanics. One applies a force in a particular direction with a particular magnitude. Direction and magnitude of a force are conveyed by the use of the term vector. To have applied a lever to a human one would have had to have attached a lever to a bone to push on.

Ultimately, I still do not know what manipulative method was used. I do not understand what “primary thrusting levers of left rotation in an arc toward the underside eye and translation toward the table means.” I have read all the directions over and over, I have looked at the photograph and really cannot figure
out what is done. While Dr. Dunning et al believe that the photograph allows one to discern what movement was created during the manipulation that is easy for them to say, they know what they did. I do not. That photograph could have been used to show purely left lateral flexion or purely right rotation or even pure extension or any combination of those movements. All it really explains to me is what they mean by the jargon, “cradle hold,” which I had assumed but was not sure of without the photograph.

To rephrase what I wrote in my original review. Dr. Dunning et al should talk about vectors IF that matters. (I do not actually think that the vector matters that much based upon research Kawchuk and I(1) published and work done by Bereznick et al(2).) I think what would be best is a description using standard anatomical terminology that explains what motions were produced in the cervical spine. E.g. right rotation, right lateral flexion. We don’t actually know what motions were created at any of the joints as this study did not use any imaging of bones.

2. In limitations the use of levers needs to be changed to vectors or direction the patient’s neck is moved through. Again vector is not the mandated change it could be motion of the cervical spine.

New revisions needed

3. Use of the term cavitation.

Dr. Dunning et al note in the introduction that the source of the “cracking sound in the MCP joints has typically been associated with the cavitation phenomenon.” This is not accurate, to the best of my knowledge. Although people who perform manipulation often use the term cavitation as an alternative to popping or cracking or audible release (it sounds better, more technical) it is not known that this is what happens when noise emanates contemporaneous with a manipulation, as noted by the authors in the previous paragraph, it is only a theory proposed by Unsworth et al(3) of how the sound is produced. The authors note that cavitation cannot be ascertained without establishing that there is gas in the joint. If we accept this last assertion, which I do, then the entire manuscript needs to remove the term cavitation regarding the study itself as in this study only sound was measured not any change in any joint. E.g. in the results it says “Of the 132 total cavitations” this should be “Of the 132 total popping sounds” (or cracking or audible events or sound events or…

4. Duration of thrust. – It is a huge assumption to measure the duration of the thrust from the popping sounds. The previous studies measuring duration did so by either pressure or force measurement or from kinematics. These studies found a delay in time from the increasing forces applied to the skin or the acceleration of the body part and the popping sound. Thus, as best one can say that the duration of the popping sound(s) were measured. Also the use of Figure 6 in the methods under duration of thrust is improper as this is a result not a method.

5. Results – Why were there only 37 manipulations? With 19 subjects to be
manipulated bilaterally there should have been 38 manipulations. Figures 5 & 6 show that no attempt was made to manipulate the left joint in subject 8. Did I miss an explanation about why subject 8 was not manipulated on the left side? If I missed that I am sorry please let me know where that explanation is.

6. Figures 5 & 6. I do not understand the relation between these two figures. For example in Subject 9 in Figure 5 it appears that the duration of the pops on the left and right to the left joint were 25ms but in Figure 6 it appears that the duration is over 700 ms. How is this possible? These two figures should be explained better.

7. In the results the subsection “duration of the thrust procedure” This sub-section is problematic as noted above. It is also quite an overstatement to say: “However, to date, our study is the first to report a duration for the HVLA thrusting procedure targeting specifically the C1-2 upper cervical articulation” when in fact you never measured the duration of the thrust only the duration of the cracking before or after or during a thrust. (I say before because personal experience, as a patient, as a doctor and as an observer of learners has demonstrated to me that sometimes there is a crack that appears to emanate from the spine when the spine is pre-loaded and before the actual force for the manipulation is applied. You never measured the timing of the sounds with respect to the applied force or movements.

Minor Compulsory Revisions

1. Regarding the use of the term “thrust manipulation” once again Dr. Dunning et al are using jargon and their excuse for doing so is that I am a Doctor of Chiropractic. Their evidence that this isn’t jargon used exclusively by physiotherapists is to note that physiotherapists and their journals use such terminology. The fact that a paper in Manual Therapies used thrust manipulation does not support their assertion, as my own paper published in Manual Therapies did not use the term thrust manipulation. (1) Never during peer review were we required to add this redundant adjective. As I noted in my initial review a multidisciplinary team that included Doctors of Chiropractic and physiotherapists agreed that if there is no thrust it is mobilization and if there is a thrust it is manipulation, seems to have gone unnoticed or rebutted. (4) Likewise, recent research conducted by both Doctors of Chiropractic and Doctors of Physical Therapy used manipulation without the adjective thrust. (5,6) So that usage seems to be the least profession specific jargon.

The authors are not consistent with their use of thrust manipulation. In many places they write spinal manipulative therapy or spinal manipulation – given their reply to my initial review shouldn’t this be spinal thrust manipulative therapy and spinal thrust manipulation?

Finally, if one must differentiate “thrust manipulation” from non-thrust manipulation what is mobilization or must one now say non-thrust mobilization in an effort to make our usage as redundant or repetitive or duplicative as possible? Parsimony ought to rule.

2. Pre-manipulative cervical artery testing. Most of the discussion about
pre-manipulative cervical artery testing was moved to the discussion – thank you. Although the authors do note that it wasn’t performed in their methods. Why didn’t they also note that imaging wasn’t performed, for example?

3. Dr. Dunning et al made a change here, which does not completely address the issue of whether or not cavitation as evidenced by change in joint spacing has been demonstrated in the spine. Dr. Dunning et al made this change:

“Therefore, it is still unknown if the cavitation phenomenon takes place in spinal facet joints, because to date, the cavitation or vacuum phenomenon has never actually been visualized or recorded in articulations of the cervical spine during or following thrust manipulation.” However, if the evidence as noted in the discussion of Cascioli et al for a lack of cavitation is that there was “no significant change in the width, area or density values of the cervical zygapophyseal joint spaces” and we know that Cramer et al (7) did find a change in the width of the lumbar zygapophyseal joint spaces then the authors cannot say: “it is still unknown if the cavitation phenomenon takes place in spinal facet joints”. This too needs the addition of the word cervical. Later the authors write that: “It is only theorized to be an intra-articular phase change of carbon dioxide and actual “cavities” in zygapophyseal joints have yet to be visualized during or immediately following HVLA thrust manipulation of any spinal region.” Visualization would not give evidence that there was a change in CO2 one would have had to aspirate the gas bubble as Unsworth et al(3) did but again Cramer et al did find a change in joint spacing after lumbar manipulation. (7)

New issues

4. In the methods when describing the manipulation the authors state: “This was repeated using the same procedure but directed to the left C1-2 articulation.” The procedure isn’t the same, it requires all the directions to be switched left for right and vice versa.

5. In Data Analysis the first line says: “Sound waves resulting from the upper cervical HVLA thrust manipulations were displayed in graphical format.” I believe that this references Figure 3A no? Then under Data Extraction it says: “A spectrogram is a 2-dimensional graphical representation with time on the x-axis, frequency on the y-axis, and color as a third dimension to express the amplitude, or power of the sound (Figure 3).” Shouldn’t this say Figure 3B?

6. Under the “Process for Calculating the duration of a single pop” is says that popping sounds that were detected during the 37 upper cervical thrust manipulation procedures Figure 5.” Aren’t the number of procedures, 37 and the results of those procedures show in Figure 5…results and therefore should be in the results section not the methods?

7. The manuscript says: “Notably, each cervical vertebra is involved in 4 facet joints, and each vertebra at C2 and below also has 4 uncovertebral joints; thus, it may be theoretically possible that anyone or combination of these joints may be cavitated during a thrust manipulation to the cervical spine” Anyone should be any one… and this is an example of where the authors should not use the term cavitated as they have never demonstrated cavitation (gas bubble, increased joint space etc.) and should instead say have cracked or popped or made a
sound. 

8. Clinical relevance of the cavitation sounds – again at best you can say sounds not cavitation sounds.

9. You write: “However, three studies[22, 23, 42, 43] (Flynn et al, 2003, 2006; Cleland et al., 2007, Bialosky et al, 2010) have suggested that the audible pop following thrust manipulation is not related to clinical outcomes.” There are four citations (as numbered references) then followed by what looks like APA style citation for four studies. I think you should say four not three studies and remove the APA style citations.

Discretionary Revisions

1. When writing about the exclusion criteria the authors write “…had evidence of central nervous system involvement (hyperreflexia, sensor…” I think involvement should be changed to disease. Involvement is a bit non-specific to the issue at hand, which is, was there nervous system disease.

2. In Figure 6 the authors use blue and red arrows to denote right and left. I think using orthogonal redundant coding by using up and down in addition to color would be helpful. That way if someone prints out the paper to read, they can still determine side where the pop event occurred.


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**Level of interest:** An article of outstanding merit and interest in its field

**Quality of written English:** Acceptable

**Statistical review:** Yes, and I have assessed the statistics in my report.

**Declaration of competing interests:**
I declare that I have no competing interests