Getting Down to Brass Tacks: The Neurophysiology of Spinal Manipulation

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Starting the new academic year off on a bold note, I would have to stick my neck out and say, in the language of racing aficionados who follow the horses (whose horses usually follow others, quoting Frank Sinatra from one of his movies), the fix is in. Yes, folks, I would have to join a growing chorus to state that the effects of spinal manipulation are indeed systemic and bear further research on the varied responding organ systems extending well beyond the localized area of adjustment. Let’s consider data from just two organ systems to lend some heft to this assertion.

The Nervous System

A wide variety of neurophysiologic studies are simply not possible to perform in humans; thus, animal models once again come to the forefront for providing the necessary evidence for chiropractic in the basic sciences. Table 1 provides some of the earlier outcome effects achieved in a variety of animals as the result of different types of interventions, all involving noxious stimuli.1-11 Quite distinct from pain are effects which extend far from the area of stimulation.

Table 1: Neural Responses To External Forces In Animal Models
<table>
<thead>
<tr>
<th>Animal</th>
<th>Intervention</th>
<th>Effect Observed</th>
</tr>
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<tbody>
<tr>
<td>Mouse</td>
<td>Ligature implant around sciatic nerve</td>
<td>Inflammation, Reduced nerve conduction velocity, Facilitation, Motor disturbances in gait</td>
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<tr>
<td>Rat</td>
<td>External pressure on L6</td>
<td>Slower nerve conductivity</td>
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<tr>
<td>Rat</td>
<td>Surgical clamp insertion with bending at T10-T11</td>
<td>Decreased blood pressure, Decreased renal nerve activity</td>
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<tr>
<td>Rat</td>
<td>Ligature implant around sciatic nerve</td>
<td>Changes in gait, Changes in nerve conduction velocity, Enzymatic changes in denervated muscles</td>
</tr>
<tr>
<td>Rabbit</td>
<td>Manual manipulation</td>
<td>Gastric smooth muscle inhibition</td>
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<td>Dog</td>
<td>Surgery plus glue injection into bilateral apophyseal joints in upper lateral spine</td>
<td>Impairment of natural killer lymphocytes</td>
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<tr>
<td>Rabbit</td>
<td>Miniature compression cuff around 1 sciatic nerve</td>
<td>Decreased aldolase activity, Decreased lactic dehydrogenase activity</td>
</tr>
<tr>
<td>Cat</td>
<td>Surgical preparations, Percutaneous bradykinin injections into motion segment</td>
<td>Slowly increasing excitatory discharges, Expansion of receptive fields, Hyper-responsiveness to subsequent stimuli</td>
</tr>
<tr>
<td>Rat</td>
<td>Mustard oil injection into paraarticular space around C2-C3 joint</td>
<td>Excitatory effects in muscles that were not local, including biphasic response</td>
</tr>
<tr>
<td>Cat</td>
<td>T3 and T4 dorsal nerve stimulation</td>
<td>Activated cardiac somatosympathetic reflexes</td>
</tr>
<tr>
<td>Rat</td>
<td>Dorsal spinal afferent nerve stimulation</td>
<td>Specific somatosympathetic reflex activity</td>
</tr>
</tbody>
</table>

With several of the investigations showing nerve conductivity is specifically affected, it is clear the nervous system provides an essential link between the experimentally produced aberrations and the physiological changes observed.

Additional investigations using rats have been able to elicit decreases in both mean arterial pressure and nerve blood flow following saline injections into the ipsilateral L4/L5 facet joint. Further experiments by the same investigator (Sato) demonstrated decreased gastric motility in response to a somatic stimulation (skin pinch).
Thus, a wide range of stimuli are capable of producing physiological responses, providing a much broader canvas with which subluxations can be represented in experimental research – and again placing the nervous system at the center.

A complete description of the autonomic nervous system and its division into the sympathetic and parasympathetic branches is beyond the scope of this article, but is provided elsewhere. With regards to changes in neural function in response to either stress or manipulation, however, several observations can be brought to light:

1. Insertion of a small pin into the IVF of the L4 and L5 vertebral joints of the experimental rat, mimicking a space-reducing lesion, produced thermal and mechanical hyperalgesia in the hind limb and increased the excitability of dorsal root ganglion cells. The same responses were observed with the injection of an inflammatory cocktail into the same region.

2. Reflex responses in paraspinal muscles were attenuated by activating Z-joint receptors in rats, regarding noxious stimulation of nerves in the intervertebral disc. Accordingly, there may be interaction between spinal joint receptors and the processing mechanisms for spinal reflexes.

3. Abnormal somatosensory evoked potentials from the paraspinal musculature were found to correlate with decreased pain responses after lumbar manipulation, possibly due to a central effect of sensory processing.

4. In a cohort of 12 subjects with a history of recurrent neck stiffness and/or neck pain, but no acute symptoms at the time of study, a single session of cervical spine manipulation revealed a significant decrease in the amplitude of two components of somatosensory evoked potentials, lasting 20 minutes following the intervention. The implication is cervical spine manipulation may alter cortical somatosensory processing and sensorimotor integration, shedding light upon the mechanisms for the relief of pain and restoration of functional ability, which are the most widely observed outcomes to treatment by spinal manipulation.

5. In subjects subjected to side-posture manipulation, both Hoffman reflex and M-wave responses displayed the greatest attenuation with actual manipulation, as opposed to a positioning maneuver.

6. Following SI joint manipulation, there was a decreased inhibitory effect of knee joint pathology on quadriceps muscle activity, suggesting an interaction between spinal manipulation and the inhibition of voluntary activities produced by pain.

7. Power spectrum analyses of patient electrocardiograms suggested alterations of sympathetic and
parasympathetic activity produced by spinal manipulation.\textsuperscript{23-25}

8. In the experimental cat, muscle spindles and Golgi tendon organs in paraspinal muscles responded to vertebral loads with force-time profiles resembling those in spinal manipulation.\textsuperscript{26} The proprioreceptors displayed a unique response to the thrusting portion of the applied load, suggesting these receptors might contribute to the therapeutic effects of spinal manipulation.

9. More recently, in 36 subjects with identifiable myofascial pain syndrome in the infraspinatus and gluteus medius muscles, spinal manipulation at the C5-C6 spinal segment significantly reduced the pressure-pain threshold in the infraspinatus muscle, but not the gluteus medius. There was no decrease in either muscle in the sham-treated group. The implication is that the primary physiological effect of spinal manipulation may be neurophysiological, rather than changed joint mechanics, in which spinal manipulation produces inhibitory mechanisms in the myofascial tissues.\textsuperscript{27}

**The Endocrine System**

The evidence that chiropractic is effective in relieving pain is mentioned here in its possibly being mediated by two hormonal metabolites found to respond to spinal manipulation. Beta-endorphins (enkephalins) have been proposed to display a gating, palliative effect at the first synaptic relay in the spinal cord, limiting the transmission of pain information from the peripheral pain receptor to the brain.\textsuperscript{28} Investigations by Vernon\textsuperscript{29} revealed an approximately 8 percent increase in the level of plasma endorphins 5 minutes after a single rotary manipulation in asymptomatic men. This effect was not repeated in other studies;\textsuperscript{30-31} however, only Vernon’s study employed measurements timed to more closely match the rapid postintervention physiologic events suggested by others\textsuperscript{32} and are more indicative of the short half-life of plasma beta-endorphin.\textsuperscript{33}

Two specific forms of the prostaglandins, the hormones responsible for uterine contraction and suspected to be the cause of menstrual pain in dysmenorrhea, were found in a pilot study by Brennan to be suppressed together with menstrual pain after side-posture manipulation, as opposed to patients who received a low-force sham procedure.\textsuperscript{34} Inconclusive results were obtained in a follow-up full-scale randomized clinical trial;\textsuperscript{35} however, design flaws in that particular investigation may have substantially compromised its results.\textsuperscript{36}

A 2014 trial addressing markers of pain perception adds further credibility to the significance of hormonal responses to spinal manipulation. Thirty asymptomatic subjects subjected to cervical, thoracic, or sham
manipulation had blood samples taken before, immediately after and 2 hours after each intervention. Results were as follows:37

- Neurotensin and oxytocin levels significantly increased after both cervical and thoracic manipulations.
- Cortisol levels increased only in the cervical manipulation group.
- No changes were found in orexin A [a neuropeptide] levels.
- Two hours after the intervention, no differences were observed between the groups.

This is but a mere sampling of the fortunately deeper probes into what appear to be broader consequences of spinal manipulation than what may be regarded by the public. Chiropractors should be taking several bows with this emerging information, as well as making every effort to assure research along these lines can be adequately supported and disseminated.

References

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