According to the Brain Model
How can chiropractic care alter Organ function

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VP Research, Dean Research
New Zealand College of Chiropractic

1

Key References for today's talk

Haavik H, Niazi IK, Amjad I, Kumari N, Ghani U, Ashfaque M, Rashid U, Navid MS, Kamavuako EN, Pujari AN, Holt K. Neuroplastic Responses to Chiropractic Care: Broad Impacts on Pain, Mood, Sleep, and Quality of Life. Brain Sciences. 2024 Nov 7;14(11):1124. https://www.mdpi.com/2076-3425/14/11/1124

Heidi Haavik, Nitika Kumari, Kelly Holt, Imran Khan Niazi, Imran Amjad, Amit N. Pujari, Kemal Sitki Türker, Bernadette Murphy. (2021a) The contemporary model of vertebral column joint dysfunction and impact of high-velocity, low-amplitude controlled vertebral thrusts on neuromuscular function. Invited Review. European Journal of Applied Physiology. https://doi.org/10.1007/s00421-021-04727-z

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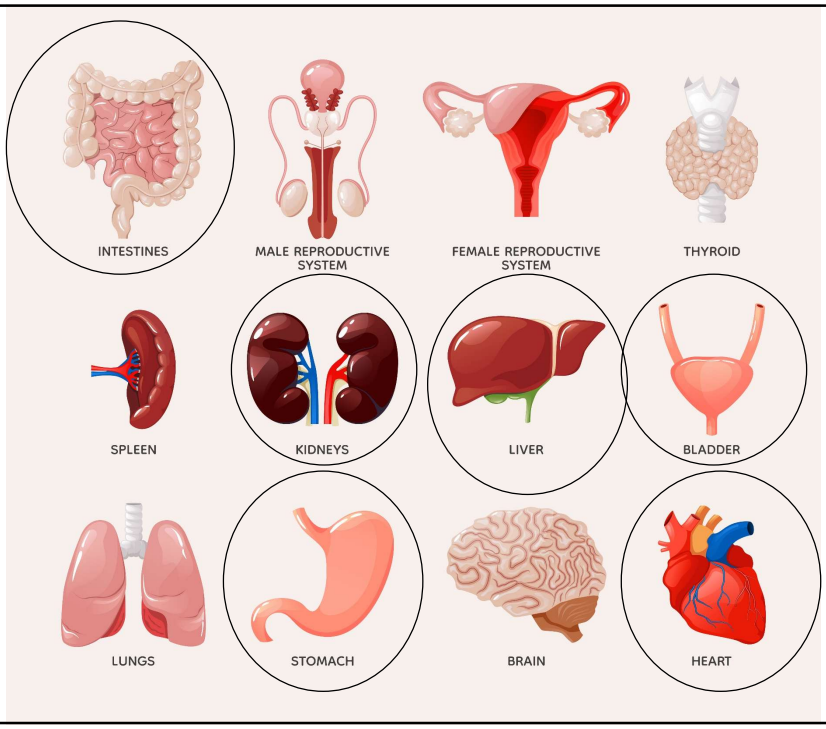

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HAAVIK RESEARCH

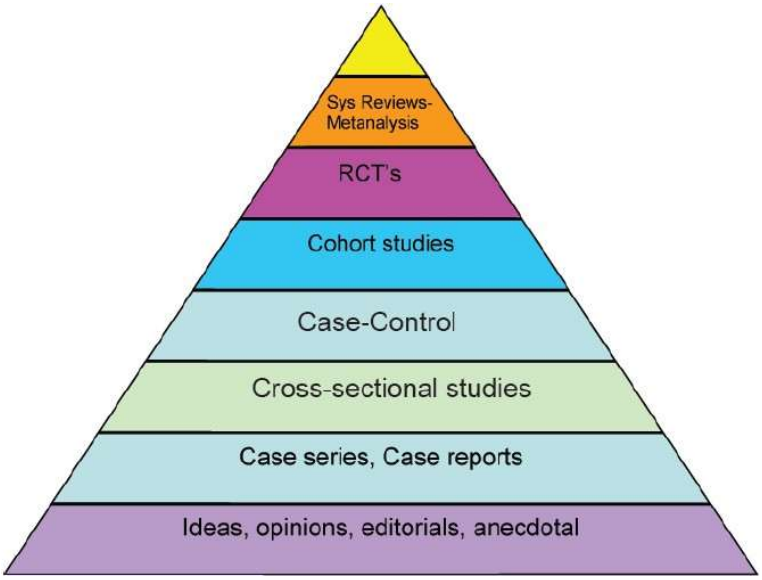
Basic Research
How does nature work? What causes disease?

Translational Research
How can biological knowledge be used to treat disease?

Clinical Research
Are these treatment strategies safe and effective in humans?

4

The Hierarchy of CLINICAL research evidence



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Lack of clinical trials about organ function

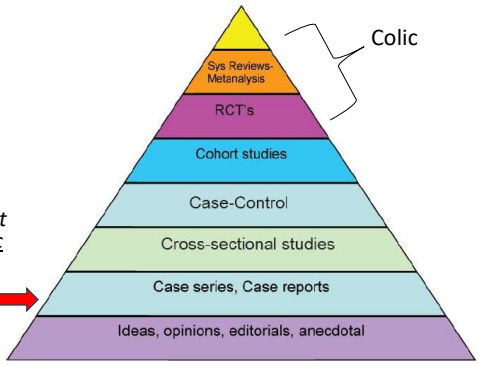
6

Chiropractic diagnosis and management of non-musculoskeletal conditions in children and adolescents

- "Most of the published literature centers around case reports or series. The more scientifically rigorous studies show conflicting results for colic and the crying infant, and there is little data to suggest improvement of otitis media, asthma, nocturnal enuresis or attention deficit hyperactivity disorder."

*Ferrance, R. J. and J. Miller (2010). "Chiropractic diagnosis and management of non-musculoskeletal conditions in children and adolescents." Chiropractic & Osteopathy **18**: 1-8.*

Most clinical research on kids and teenagers



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Reed et al, 1994

What they did

- Measured bed-wetting frequency of 46 children for 2 weeks
- Divided children into 2 groups
- One group received chiropractic care for 10 weeks
- The other group received a sham control intervention for 10 weeks
- Measured bedwetting frequency for another 2 weeks

What they found

- After 10 weeks chiropractic group dropped from 9.1 wet nights to 7.6
- 25% of the chiropractic group had a 50% or more reduction in wet night frequency over the course of the trial
- Control group saw minimal change and no such improvement

Key messages to share

What this means

- Study suggests chiropractic care can help some children suffering from bed-wetting
- Parents of suffering children should consider chiropractic care
- Reduction in bed-wetting can have a large impact on the child's life

Limitations

- Sample size was small
- Baseline bed-wetting frequencies differed between the 2 groups
- Chiropractic care was given by students

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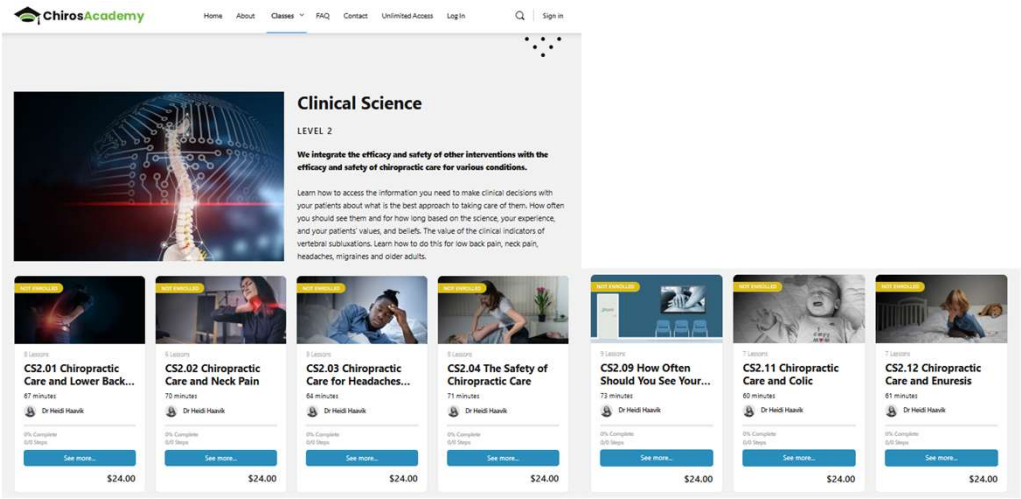

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HAAVIK RESEARCH

Colic and sleep outcomes of nonpharmacological intervention in infants with infantile colic: systematic review and meta-analysis

- OBJECTIVE: The aim of this study was to systematically review the colic and sleep outcomes of nonpharmacological intervention in infants with infantile colic and perform a meta-analysis of the available evidence.
- This meta-analysis included three studies involving a total of 386 infantile colic infants.
- CONCLUSION: According to the meta-analysis findings, it was determined that the risk of bias was low in the studies included and that nonpharmacological *chiropractic*, craniosacral, and acupuncture treatments applied to infantile colic infants in the three included studies *reduced crying time and intensity and increased sleep duration*.

Tanrıverdi, D. Ç., et al. (2023). "Colic and sleep outcomes of nonpharmacological intervention in infants with infantile colic: systematic review and metaanalysis." Revista da Associação Médica Brasileira **69**(5): e20230071.

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Chiropractic care for hypertension: Review of the literature and study of biological and genetic bases

- "Results: We found 38 original studies that analyzed the effect of chiropractic therapy on hypertension. Of these studies, 10 were case reports and the statistical significance of the effects of chiropractic on blood pressure was not evaluated on these articles, so we focused on the remaining 28 articles."
- "Conclusions: The results of the review relative to chiropractic care were promising, but often contradictory, suggesting more research should be done. "

*Sullivan, S. G., et al. (2020). "Chiropractic care for hypertension: Review of the literature and study of biological and genetic bases." Acta Bio Medica: Atenei Parmensis **91**(Suppl 13): e2020017.*

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What effect does chiropractic treatment have on gastrointestinal (GI) disorders: a narrative review of the literature

- "Twenty-one articles were found that met our inclusion criteria. Retrievable articles varied from case reports to clinical trials to review articles of management options."
- "The majority of articles chronicling patient experiences under chiropractic care reported they demonstrated mild to moderate improvements in presenting symptoms."
- "No adverse side effects were reported."

ISSN 0008-3194 (p)/ISSN 1715-6181 (e)/2015/122–133/$2.00/©JCCA 2015

What effect does chiropractic treatment have on gastrointestinal (GI) disorders: a narrative review of the literature

Katherine Angus, BSc(Kin), DC[1]
Sepideh Asghardin, BSc(Hons), DC[2]
Brian Gleberzon, DC, MHSc[3]

The purpose of this study was to provide a narrative review of the literature of studies describing the management of disorders of the gastro-intestinal (GI) tract using "chiropractic therapy" broadly defined here as spinal manipulation therapy, mobilizations, soft tissue therapy, modalities and stretches. Search limiters include access to full text studies published between 1900 and November 2012 in peer-reviewed journals, English language only involving human subjects. Twenty-one articles were found that met our inclusion criteria. Retrievable articles varied from case reports to clinical trials to review articles of management options. The majority of articles chronicling patient experiences under chiropractic care reported they demonstrated mild to moderate improvements in presenting symptoms. No adverse side effects were reported. This suggests chiropractic care can be considered as an adjunctive therapy for patients with various GI conditions providing there are no co-morbidities.

L'objectif de cette étude était d'offrir un examen narratif des documents d'études décrivant la gestion de troubles du tractus gastro-intestinal (GI) à l'aide d'un traitement chiropratique ici au sens large, comme la manipulation vertébrale, les mobilisations, le traitement des tissus mous, les modalités et les étirements. Les limites de la recherche comprennent l'accès aux textes d'étude complets entre 1900 et novembre 2012 dans les journaux révisés par des pairs en anglais concernant des sujets humains. Vingt et un articles correspondant à nos critères d'inclusion ont été trouvés. Les articles consultables vont des exposés de cas et essais cliniques aux articles de revues sur les options de gestion. La majorité des articles rapportant des expériences de patients de soins chiropratiques indiquent qu'ils ont connu une amélioration légère à moyenne des symptômes présentés. Aucune réaction indésirable n'a été signalée, ce qui laisse entendre qu'on peut considérer les soins chiropratiques comme un traitement auxiliaire pour plusieurs maladies gastro-intestinales en absence de comorbidité.

(JCCA 2015; 59(2):122-133)

(JCCA 2015; 59(2):122-133)

*Angus, K., et al. (2015). "What effect does chiropractic treatment have on gastrointestinal (GI) disorders: a narrative review of the literature." The Journal of the Canadian Chiropractic Association **59**(2): 122.*

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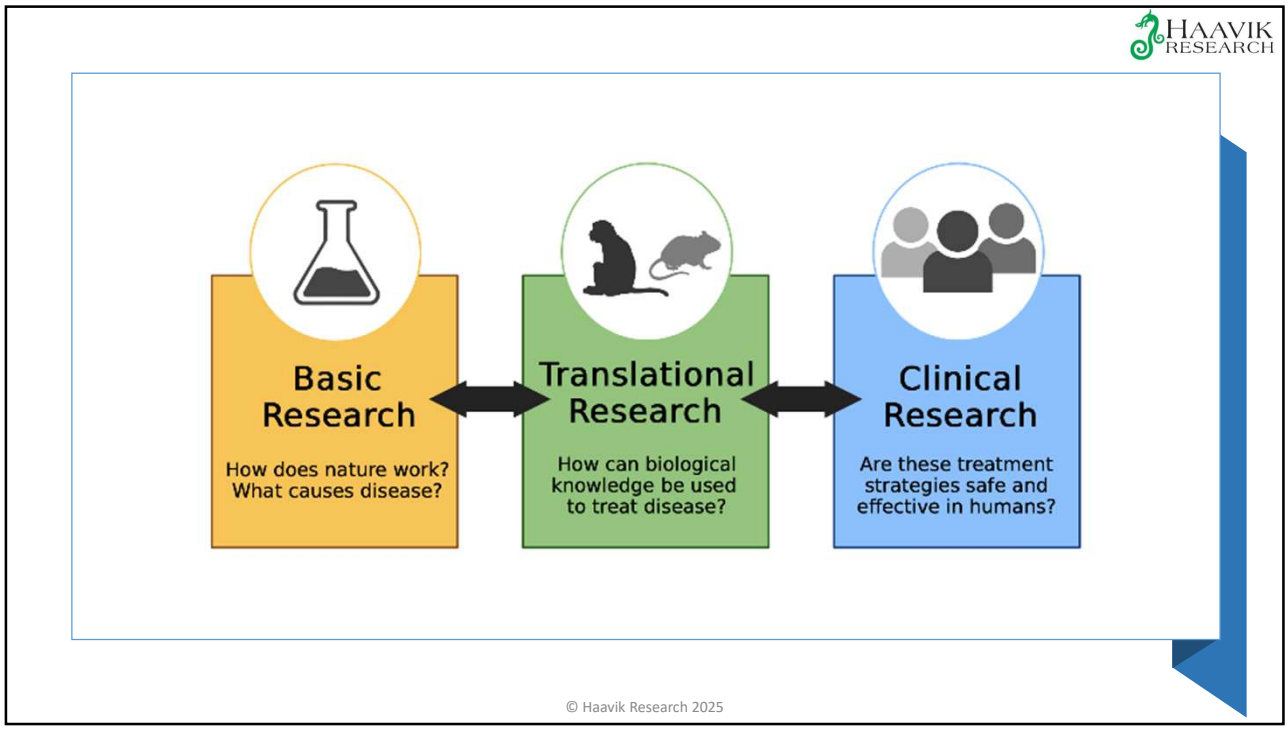
HAAVIK RESEARCH
Basic Research
How does nature work? What causes disease?
Translational Research
How can biological knowledge be used to treat disease?
Clinical Research
Are these treatment strategies safe and effective in humans?
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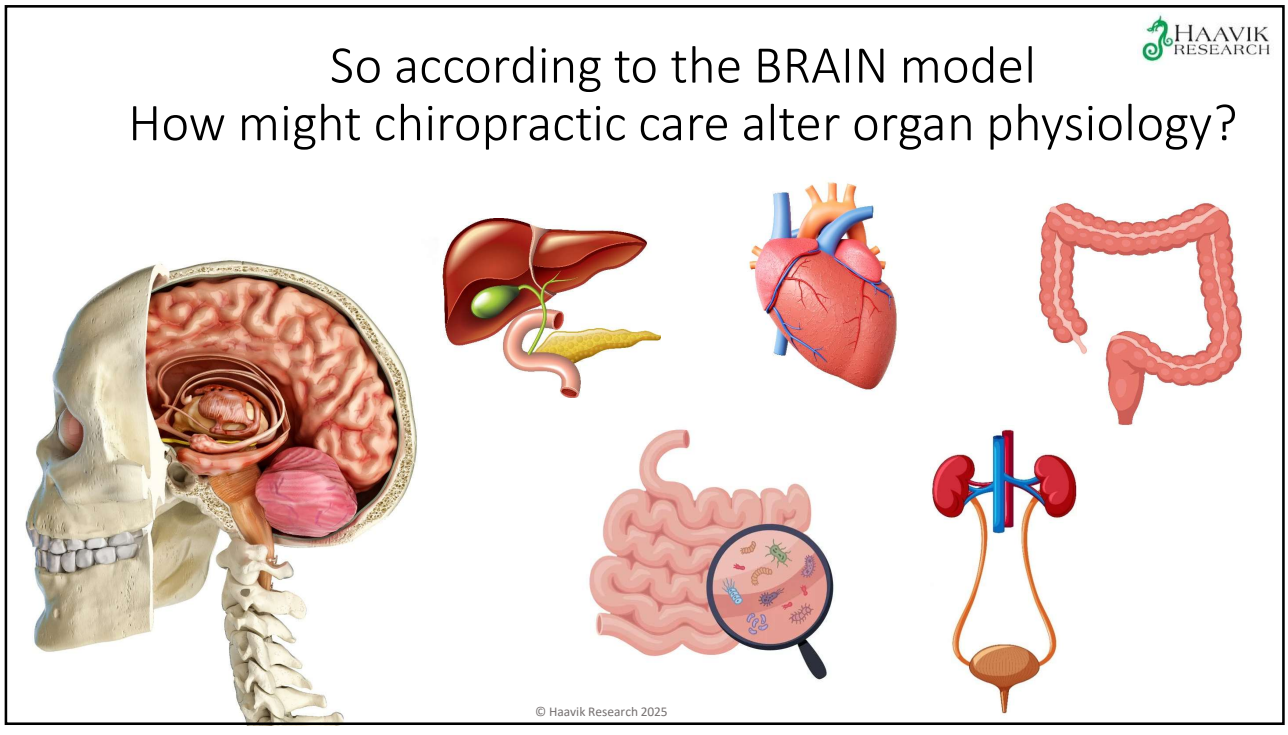
HAAVIK RESEARCH
So according to the BRAIN model
How might chiropractic care alter organ physiology?
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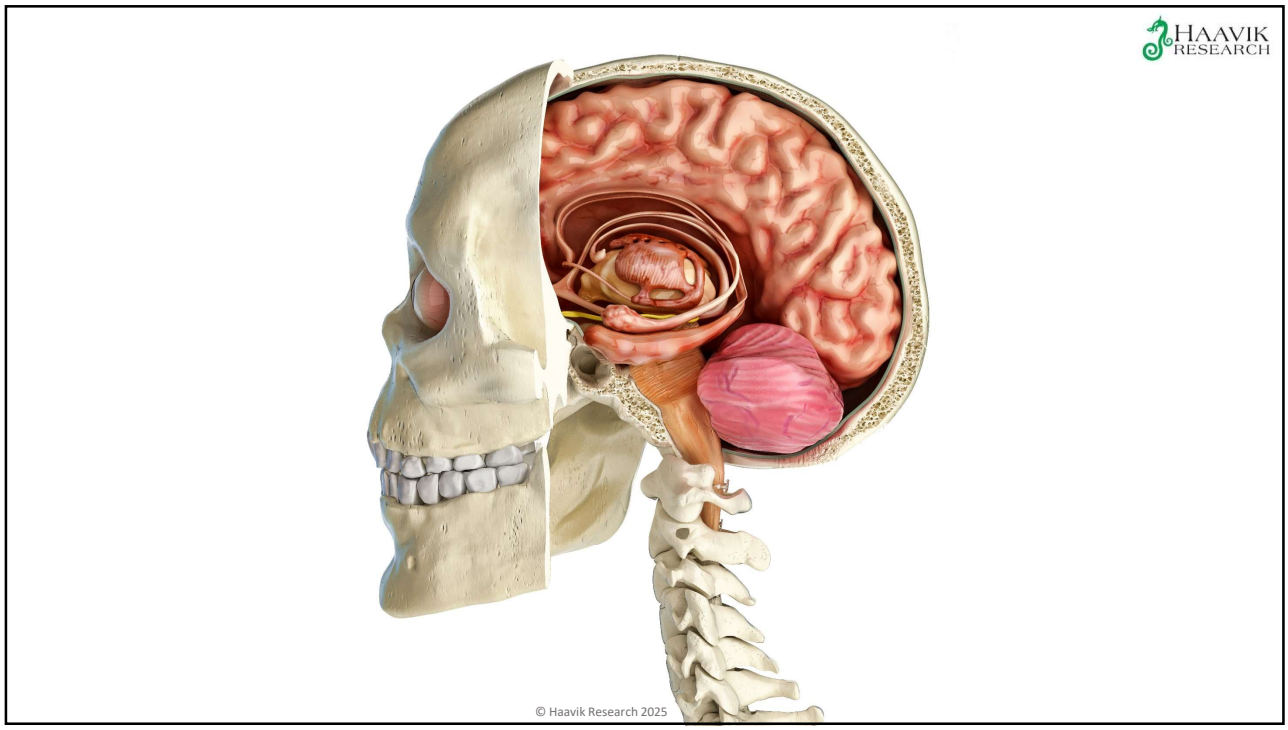

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Mechanisms Brain - Body Communication

1. Autonomic Nervous System (ANS)

Sympathetic nervous system (SNS) – "fight or flight"
Parasympathetic nervous system (PNS) – "rest and digest"

These systems send and receive signals to and from organs using neurotransmitters like acetylcholine and norepinephrine.

2. Endocrine System Regulation

The brain (especially the **hypothalamus**) controls hormone release via the **pituitary gland**.
Hormones regulate various organs, such as the **adrenal glands**, which release cortisol during stress.
Hypothalamus Pituitary Thyroid; Hypothalamus Pituitary Gonads; Hypothalamus Pituitary Adrenals

3. Reflex Loops & Direct Neural Control

Spinal cord can mediate reflexes (e.g., pulling away from pain), bypassing the brain for quick reactions; some reflex loops go via the brain as well.
Voluntary neural control (e.g. muscles; bearing down; voiding bladder, etc)

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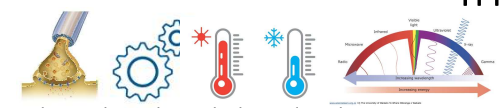
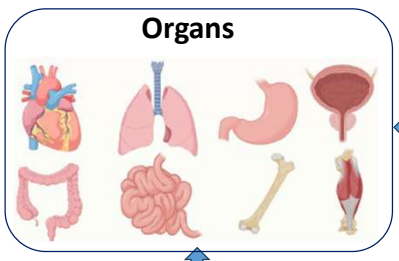
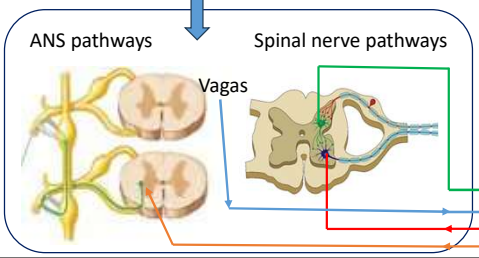
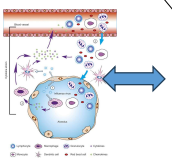
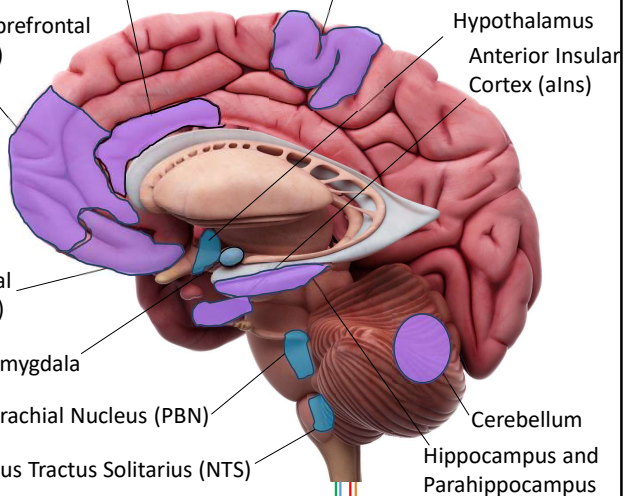
Interoception - Central Integration











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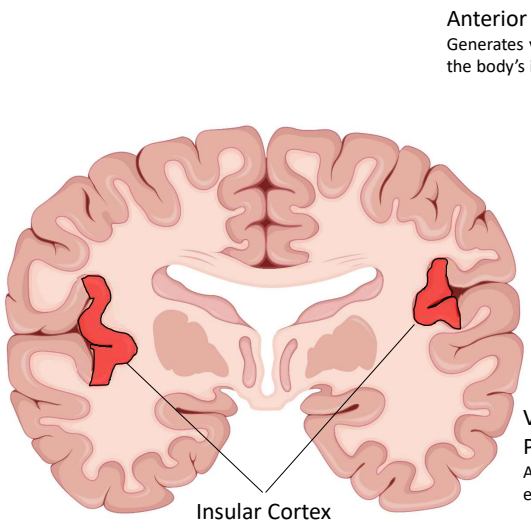
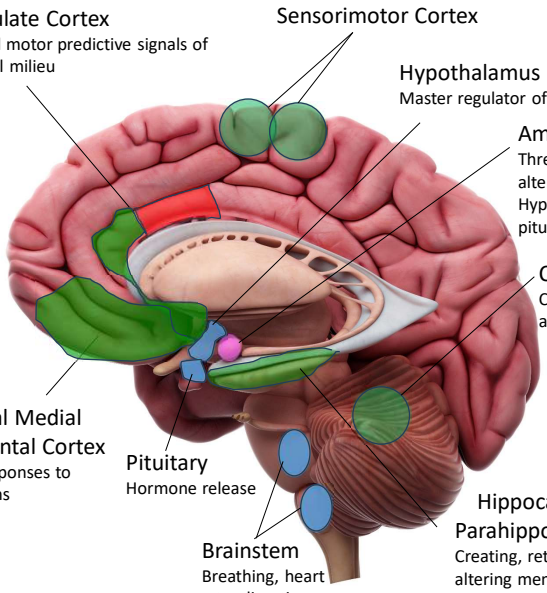
Some Brain Regions known to activate ANS & NeuroEndocrine Systems?



Insular Cortex
Processes Interoception
Controls ANS



Anterior Cingulate Cortex
Generates visceral motor predictive signals of the body's internal milieu

Sensorimotor Cortex

Hypothalamus
Master regulator of the ANS

Amygdala
Threat detector; alters ANS and Hypothalamus – pituitary gland

Cerebellum
Can alter ANS and pituitary

Ventral Medial Prefrontal Cortex
ANS responses to emotions

Pituitary
Hormone release

Brainstem
Breathing, heart rate, digestion

Hippocampus & Parahippocampus
Creating, retrieving and altering memory and, interoceptive learning

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The Contemporary Model of the Subluxation

Interoceptive input:
- Pain
- Temperature
- Chemoreception
- Emotions
- Proprioception

Exteroceptive input:
- Vision
- Olfaction
- Audition
- Gustation

Past experiences and expectations about the future

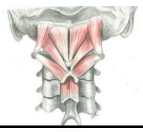
Spinal adjustment

Altered vertebral column afferent input

Abnormal multisensory processing and filtering of exteroceptive and interoceptive stimuli and abnormal sensorimotor integration

Impacting:
- Whole body proprioception
- Whole body motor control
- Whole body control, homeostasis, neuro- and bio-plasticity
- Resilience, adaptability, function, wellbeing

Vertebral subluxation



Altered vertebral column function

Altered vertebral column motor control

Haavik et al 2021 EJAP

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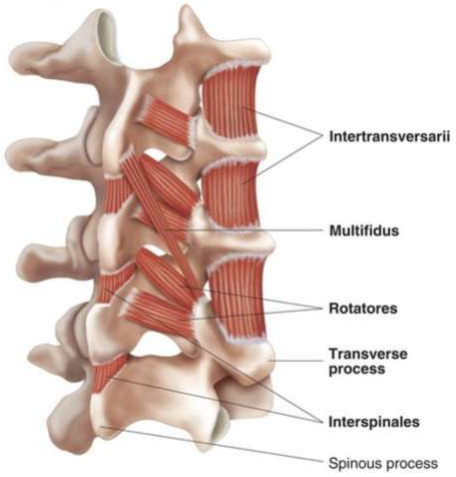
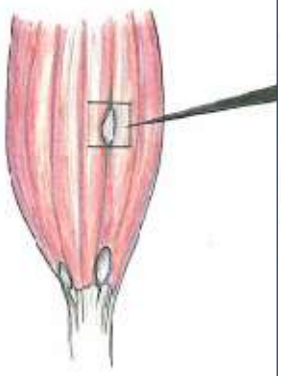
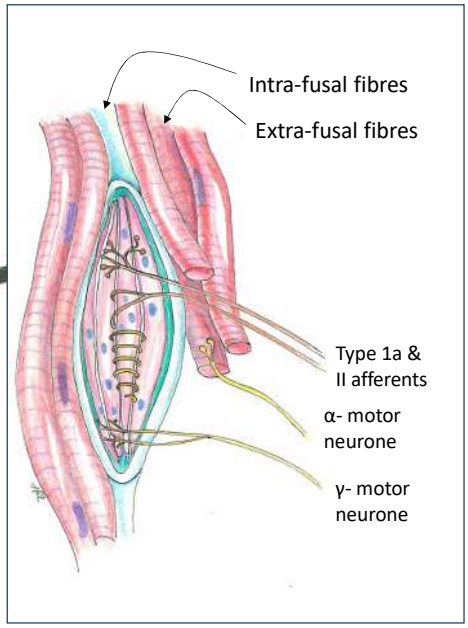
HAAVIK RESEARCH



MUSCLE SPINDLES





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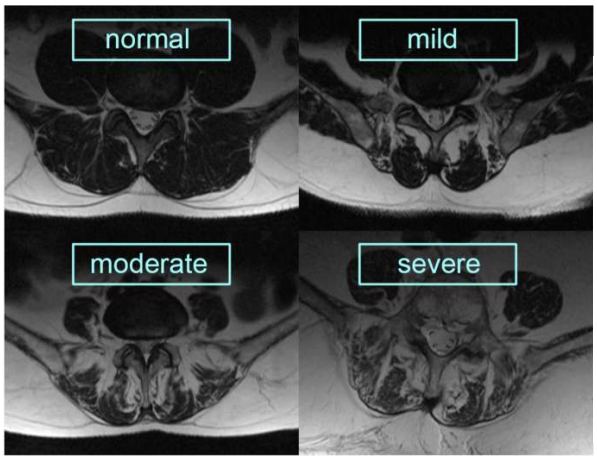
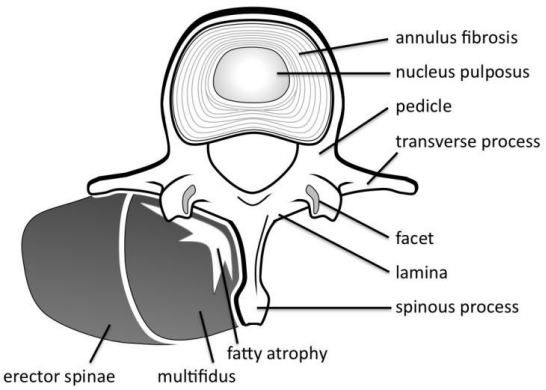
HAAVIK RESEARCH

NEW ZEALAND COLLEGE OF CHIROPRACTIC





Faur, C., Patrascu, J.M., Haragus, H. and Anglitoiu, B., 2019. Correlation between multifidus fatty atrophy and lumbar disc degeneration in low back pain. BMC musculoskeletal disorders, 20(1), pp.1-6.

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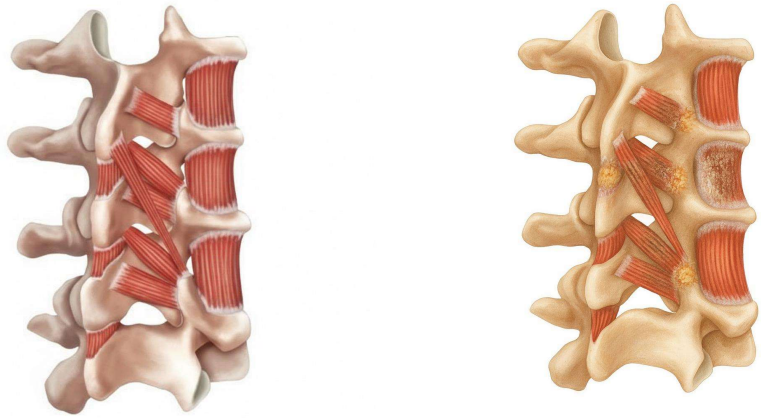

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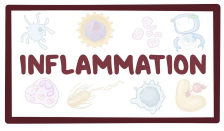
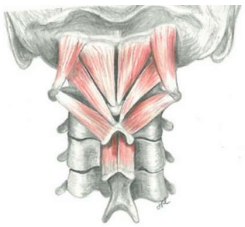


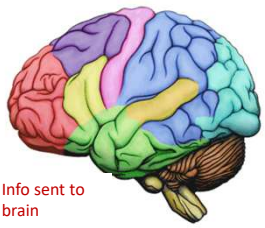
OR

Stress

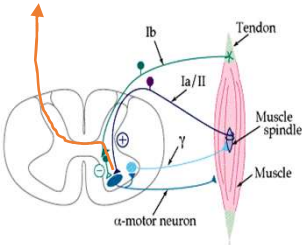
Injury

Small muscles closest to spine and skull go to sleep





Info sent to brain



Altered messages going to brain from spine

Poor body awareness
Poor body control
Poor function

So brain does NOT know accurately what is going on

Changes brains internal representations about what is going on inside and outside body

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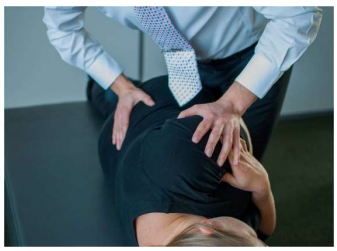
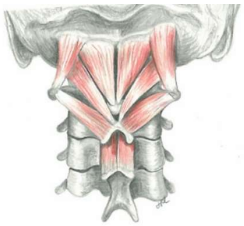
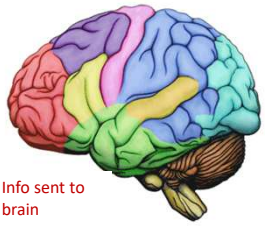


Adjustment

Stretches small muscles closest to spine and scull





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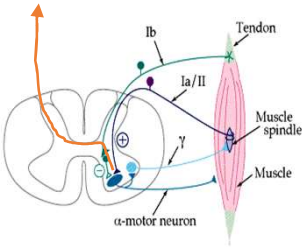
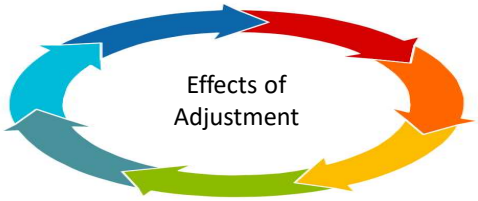


Bombards brain with mechanoreceptor input

Improved body awareness
Improved body control
Improved function



So brain knows MORE accurately what is going on

Changes brains internal representations about what is going on inside and outside body

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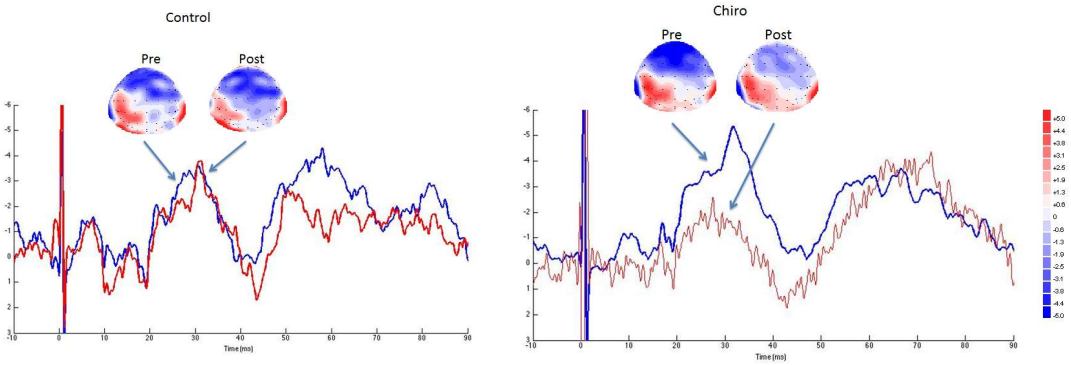
Chiropractic Adjustment brain changes were occurring in the Pre-Frontal Cortex



Lelic, D., Niazi, I.K., Holt, K., Jochumsen, M., Dremstrup, K., Yielder, P., Murphy, B., Drewe,s A. M., & Haavik, H. (2016). Manipulation of dysfunctional spinal joints affects sensorimotor integration in the prefrontal cortex: A brain source localization study. Neural Plasticity, 1.doi:10.1155/2016/3704964.

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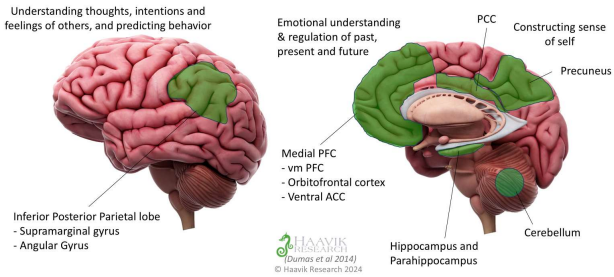
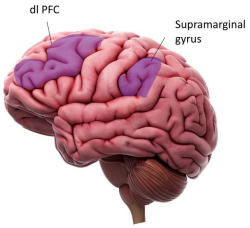
Default Mode Network

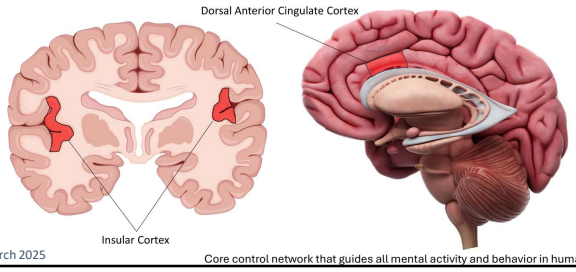


Fronto-parietal (Executive Control) Network

- It is Goal and Task oriented
- When you are actively engaged in a task
- Actively paying attention (and not judging)
- Capable of recruiting a wide variety of brain systems
- Multiple FP / EC networks
- Key Regions
  - Dorsolateral PFC
  - Posterior parietal cortex (supramarginal gyrus)



Salience Network



(Witt, van Ettinger-Veenstra et al. 2021; Menon and D'Esposito 2022; Menon and D'Esposito 2022)

Core control network that guides all mental activity and behavior in humans

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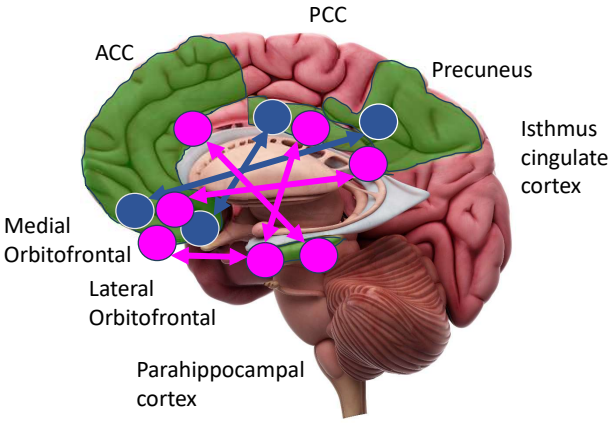
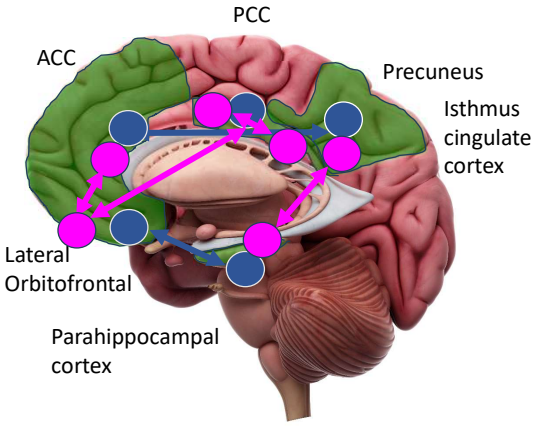
DMN changes after Chiro Care

Pre and Post Chiro



Pre and Post 4 weeks Chiro



(Haavik et al 2024, Brain Sciences)

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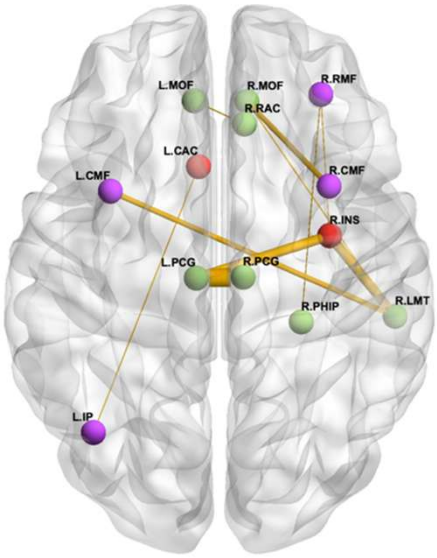
After first Adjustment session Chiro Group



Preliminary Results NOT published yet

Alpha

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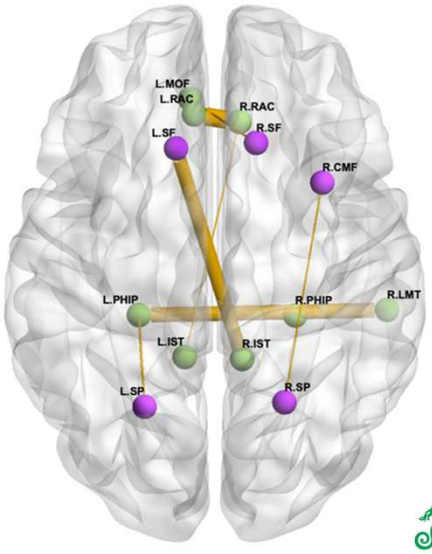
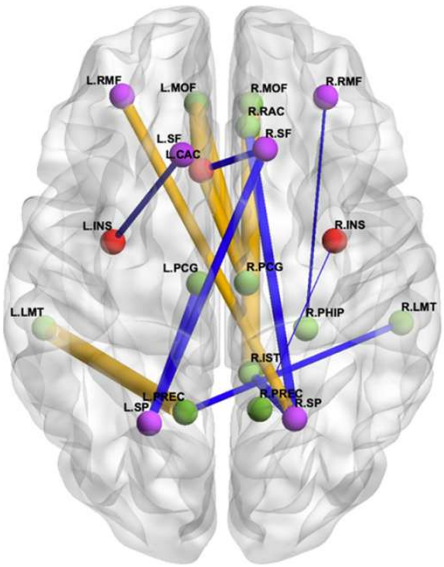
Preliminary Results NOT published yet

After 4 weeks Chiro Group Brain changes





Alpha

Beta

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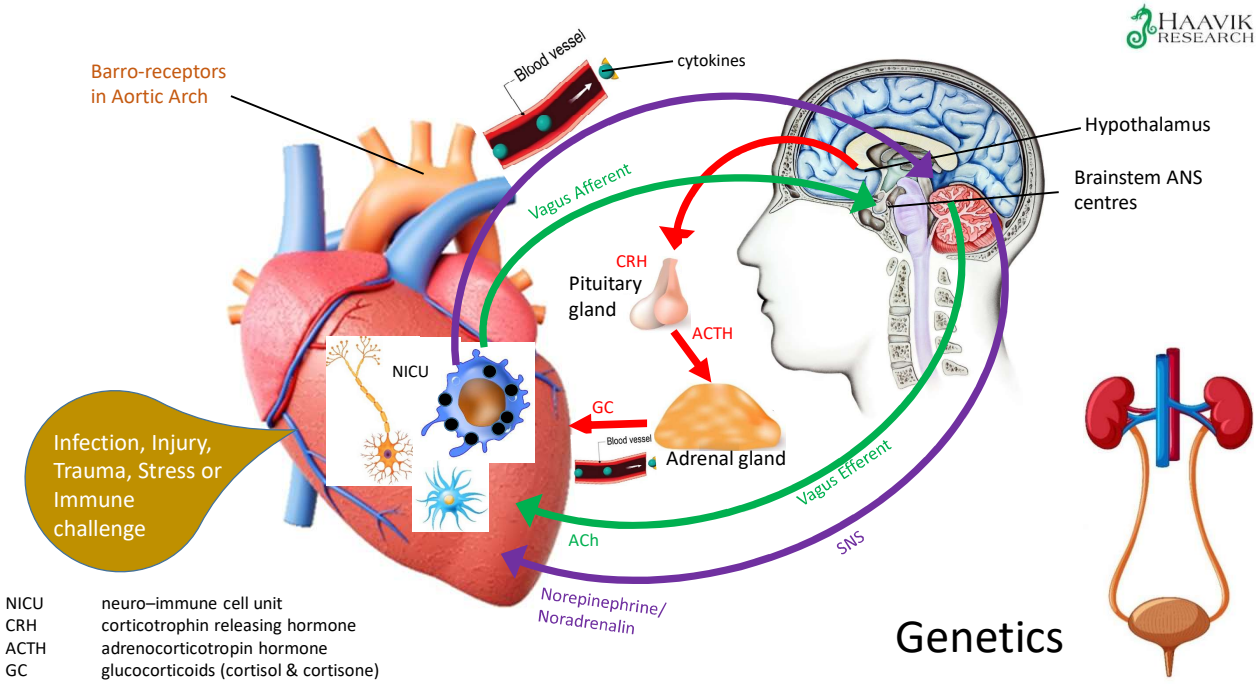

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Chiropractic care for hypertension: Review of the literature and study of biological and genetic bases

- "Hypertension is a multifactorial disease, strongly dependent on the responsiveness of the ANS (6,30). This responsiveness depends on the integrity of the afferent and efferent pathways, sensory end organ reactivity, and interactions with systems such as renal and cardiovascular (6,9-11). These interactions produce short- and long-term adaptations to changes in the internal and external environment, creating complex feedback loops such as the baroreceptor reflex and the RAAS (6,9-11,32,42,43,50). Further, individual genetic predisposition also provides a complicating layer to the control of hypertension (63)."

*Sullivan, S. G., et al. (2020). "Chiropractic care for hypertension: Review of the literature and study of biological and genetic bases." Acta Bio Medica: Atenei Parmensis **91**(Suppl 13): e2020017.*

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Lay person explanation for why we might improve hypertension

- High blood pressure is largely controlled by your nervous system – especially by how your brain and brainstem balance the "fight–flight" system (sympathetic) and the "rest–digest" system (parasympathetic).
- When the spine and its deep support muscles are not working well, the tiny sensors in those tissues send distorted information up to the brain.
- This "noisy" input can change how the brainstem and higher brain centers control your heart, blood vessels, and stress responses.
- Chiropractic adjustments help restore more normal movement and muscle activity in the spine.
- That appears to change the accuracy that the brain becomes aware of what is happening inside your body (improved function in key brain areas – like the prefrontal cortex and brainstem autonomic centers) – that can help your brain better regulate blood pressure.
- In simple terms: by helping your spine move and function better, chiropractic care may help your brain better balance your body's stress responses and blood vessel tone.
- For some people, this can contribute to healthier blood pressure – not as a replacement for medical care, but as a potential supportive approach that works via the nervous system.

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What NOT to say

- "Blood flow to the brain increases because C1 was out of place"
- "Adjustments directly affect blood vessels"
- "Realigns the atlas to fix BP"
- "Removes pressure on nerves"

- Why not?
  - too structural
  - not supported by modern neurophysiology
  - too simplistic and
  - not evidence-based

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Most Scientifically Plausible Mechanisms

1. Normalising dysafferentation from deep paraspinal muscles → ANS regulation
2. Improved Prefrontal Cortex (PFC) function → Inhibition of sympathetic overdrive
3. Improved baroreflex sensitivity (BRS) (better interoception)
4. Reduced stress-system reactivity (HPA axis)
5. Pain reduction → Reduced sympathetic arousal
6. Improved thoracic mobility & rib mechanics → Better respiratory autonomic coupling
7. Reduction in local inflammation → improved afferent signalling

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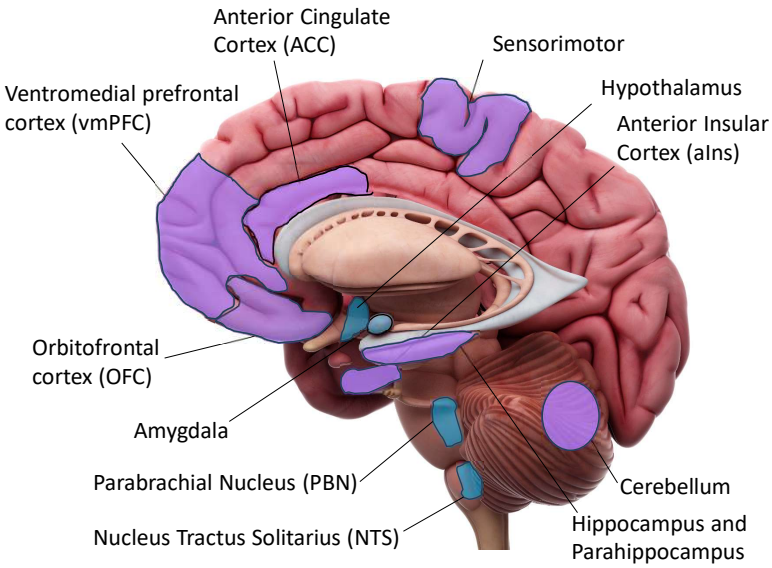
Interoception - Central Integration



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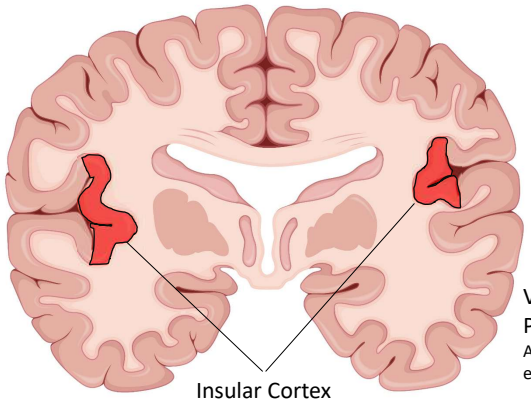
Brain Regions known to activate ANS & NeuroEndocrine Systems



Insular Cortex
Processes Interoception
Controls ANS

Anterior Cingulate Cortex
Generates visceral motor predictive signals of the body's internal milieu

Sensorimotor Cortex

Hypothalamus
Master regulator of the ANS

Amygdala
Threat detector; alters ANS and Hypothalamus – pituitary gland

Cerebellum
Can alter ANS and pituitary

Ventral Medial Prefrontal Cortex
ANS responses to emotions

Pituitary
Hormone release

Brainstem
Breathing, heart rate, digestion

Hippocampus & Parahippocampus
Creating, retrieving and altering memory and, interoceptive learning

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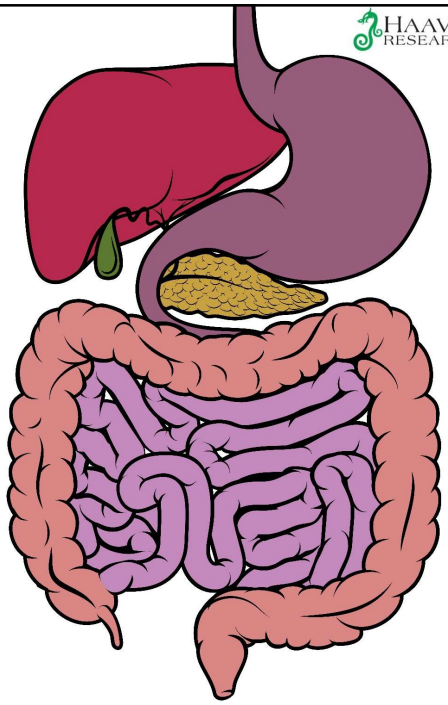
Brain – Gut Communication

- Spinal nerve pathway
- Sympathetic Nervous System
  - Parasympathetic
  - Sympathetic
- Hormonal pathway
- Enteric Nervous System
- GI lining
- Immune mechanisms
- Microbiome



Integration of mechanical, chemical, microbial, and hormonal signals maintains energy balance, digestion, immunity, and stress regulation.

Disruption contributes to obesity, IBS, metabolic disorders, anxiety, and depression.

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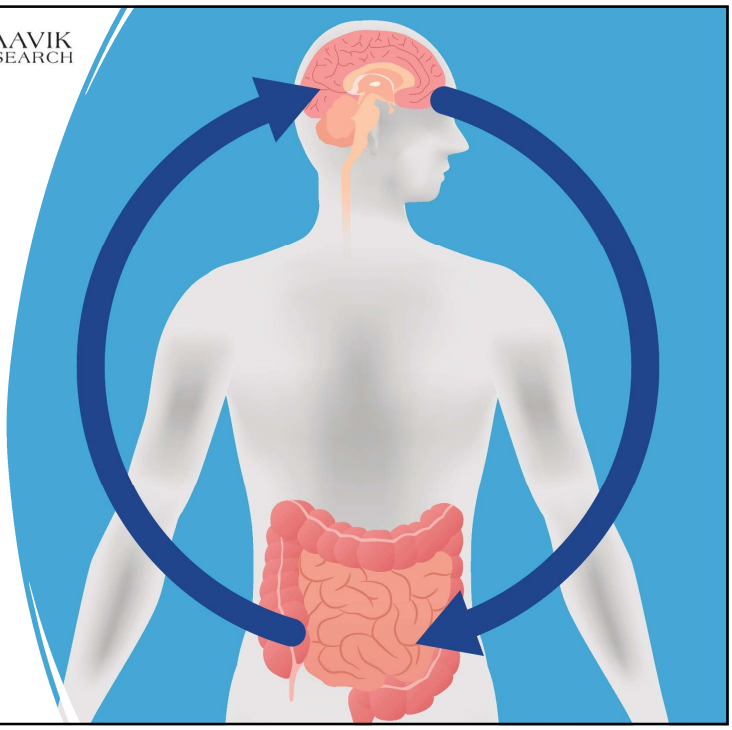
Gut to Brain Communication



- **Vagus nerve (primary route):** detects stretch, nutrients, toxins, inflammation, microbiota signals.
- **Spinal afferents:** essential for glucose sensing, nutrient-driven satiety.
- **Hormones:** CCK, GLP-1, ghrelin act on vagal/spinal neurons and directly on brain regions.
- **Enteric nervous system:** sense mechanical, chemical, and luminal signals and control smooth muscle, motility, and secretion
- **Microbiota metabolites:** modulate neural and immune signaling.
- **Immune mechanisms:** Toll-like receptors & macrophages - 'microbe sensors' that influence gut function and serotonin levels

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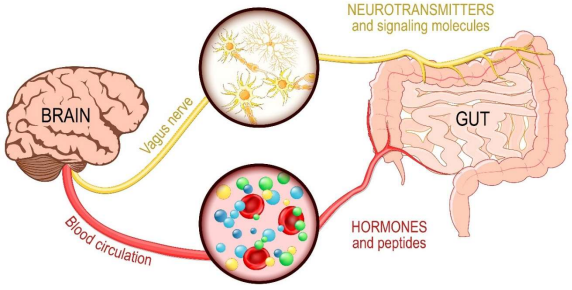
Brain to Gut Communication



Vagal motor (parasympathetic): controls digestive enzymes, acid secretion, motility, bile flow, nutrient absorption.

Sympathetic pathways: activated by stress; slow digestion and alter immune responses.

HPA axis: CRH → ACTH → cortisol; affects motility, permeability, microbiota, and inflammation.

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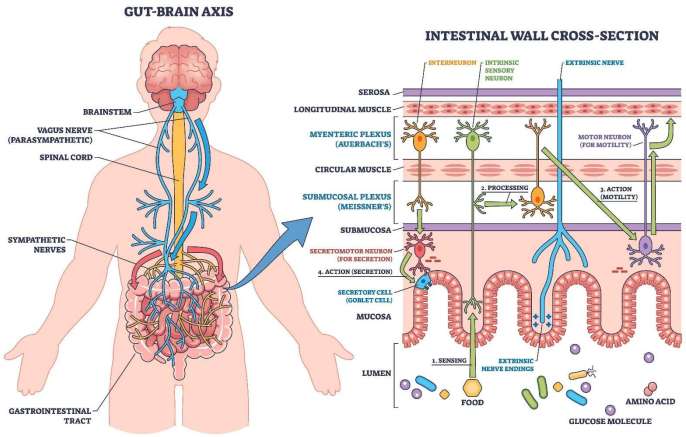
The Enteric Nervous System

- The ENS has **~200–600 million neurons**
- More neurons than the spinal cord
- Found throughout entire GI tract from mouth to anus
- It is modulated by:
  - vagal parasympathetics
  - sympathetic chain
  - hormones from the gut
  - immune signals
- ENS sends processed information back to the CNS, similar to a "local mini-brain" optimising digestion in real time.



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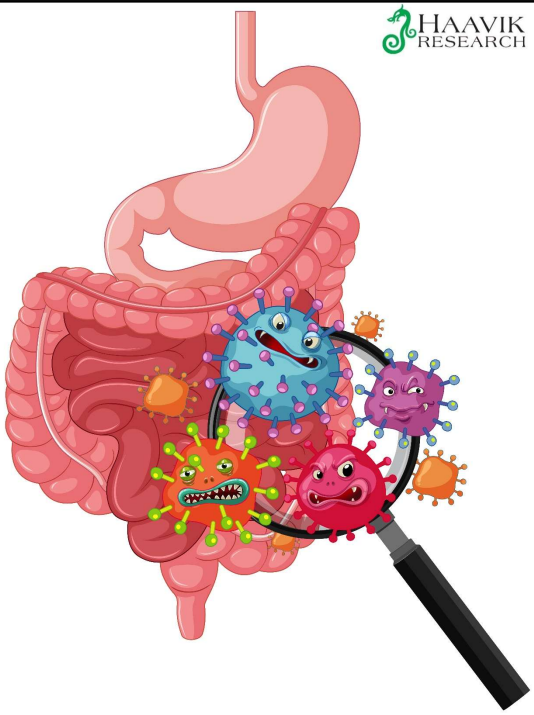
Microbiota Influence the gut–brain axis

The microbiota communicates with the brain through:

- **Vagal pathways** (via metabolites, 5-HT release, neuropod cells)
- **Immune pathways** (cytokines, TLR activation)
- **Endocrine pathways** (gut hormones)
- **Microbial metabolites** (SCFAs, tryptophan metabolites, indoles, bile acids)



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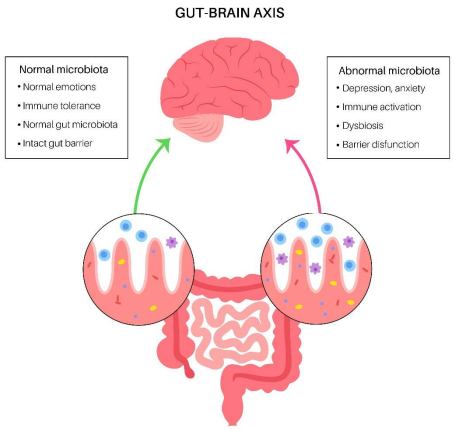
Immune Signaling in the Gut–Brain Axis

- Immune signaling is one of the **three major communication routes** between the gut and brain (the others are neural and endocrine).
- It means the gut and brain "talk" through **immune messengers**, including:
  - **Cytokines** (IL-6, IL-1β, TNF-α)
  - **Pattern-recognition pathways** (Toll-like receptors)
  - **Macrophage–neuron cross-talk**
  - **Inflammasomes** (NLRP6, caspase-11)
  - **Mast cells**
  - **Microglial activation** in the brain
- This pathway becomes especially important during:
  - Dysbiosis
  - Inflammation
  - Infection
  - Chronic stress
  - Increased intestinal permeability ("leaky gut")
- Because these conditions change the immune signals that reach the ENS, vagus, spinal afferents, and the brain.



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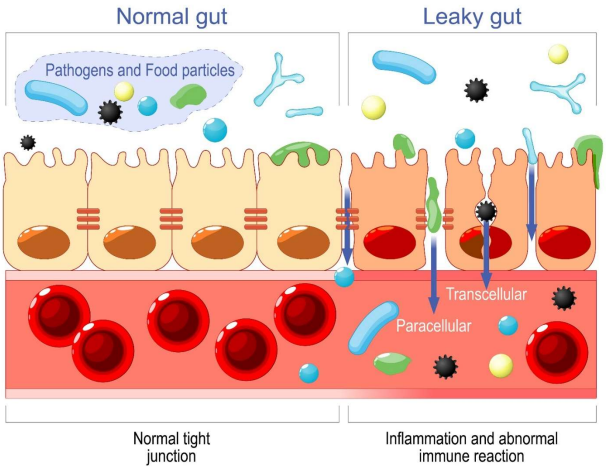
Leaky Gut

- Inflamed gut tissue releases:
  - Cytokines
  - Chemokines
  - Reactive metabolites
- These can:
  - Activate **vagal afferents**
  - Sensitise **spinal nociceptors (TRPV1, TRPA1)**
  - Increase visceral pain
  - Increase nausea/satiety signalling
  - Increase central inflammatory tone
- This is why GI inflammation is linked to:
  - Anxiety
  - Depression
  - Brain fog
  - Heightened pain sensitivity
  - Fatigue



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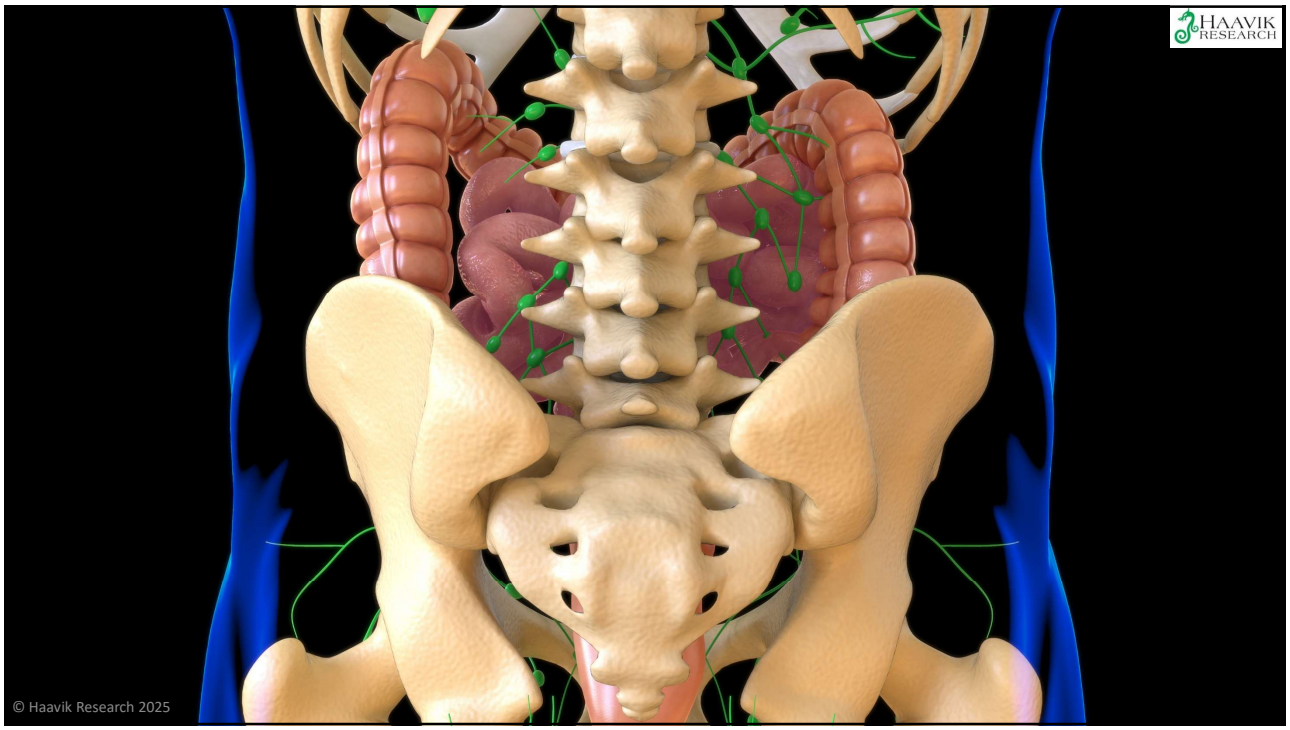
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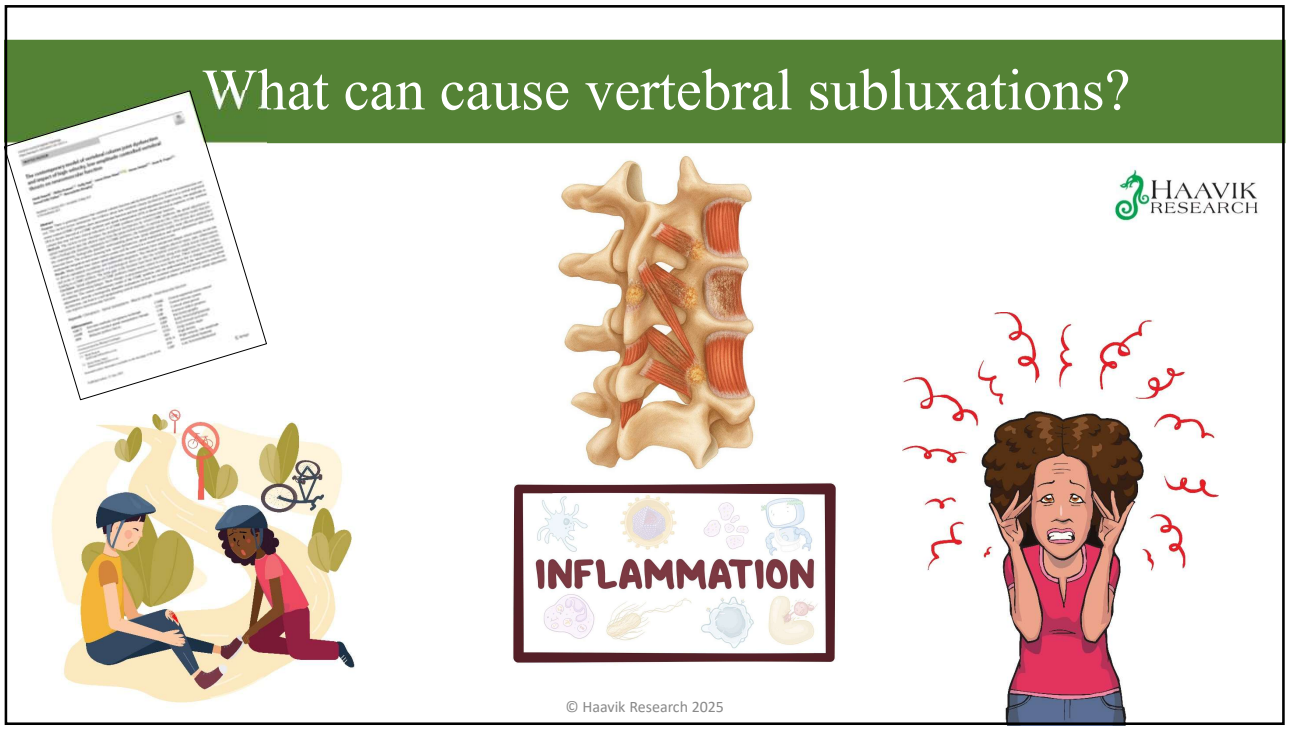
What can cause vertebral subluxations?
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Gut Function Likely affects Spinal Function & Chiropractic Care Likely Affects Gut Function

- Chiropractic care affects brain regions that control the gut
  - Prefrontal cortex function
  - Cerebellar processing
  - Sensorimotor integration
  - Default Mode Network stability
  - Proprioceptive and somatosensory processing
  - Central motor excitability
- These areas strongly regulate:
  - Vagal output (via PFC → brainstem pathways)
  - Autonomic balance (sympathetic vs parasympathetic)
  - HPA axis activity (stress → gut permeability & motility)
  - Interoception and visceral pain modulation
- If chiropractic care modulates these systems → gut function should change.

Local Inflammation affects proprioceptive signalling to the brain from paraspinal muscles, i.e. causes subluxations

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Inflammation Alters Proprioception

- The experimental muscle pain was induced by injecting hypertonic saline in right cervical multifidus
- The hypertonic solution triggers a local inflammatory cascade:
  - Release of inflammatory mediators (bradykinin, prostaglandins, substance P)
  - Sensitization of peripheral nociceptors
  - Activation of chemically-sensitive pain fibers (particularly C-fibers and A-delta fibers)
- This worsens cervical spine reposition errors

Wang et al. BMC Musculoskeletal Disorders (2022) 23:259
https://doi.org/10.1186/s12891-022-05170-7

BMC Musculoskeletal Disorders

RESEARCH Open Access

Effects of experimental pain on the cervical spine reposition errors

Xu Wang[1], Ning Qu[2], Yang Wang[1], Jian Dong[3], Jianhang Jiao[3] and Minfei Wu[1*]

Abstract

Background: Healthy subjects showed normal variance of cervical spine reposition errors of approximately 2 degrees. Effects of experimental pain on cervical spine reposition errors were unknown; thus, the purpose of this study was to investigate the effects of experimental pain on cervical spine reposition errors.

Methods: A repeated measured study design was applied. Thirty healthy subjects (12 males) were recruited. Reposition errors were extracted from upright cervical positions before and after cervical flexion movement in healthy subjects before and during experimental neck pain. Cervical spine reposition errors were calculated based on anatomical landmarks of each cervical joint. Reposition errors were extracted in degrees as constant errors and absolute errors for further statistical analysis. Repeated measures analysis of variance (RM-ANOVA) was applied to analyse experimental pain effects on either constant errors or absolute errors of different cervical joints.

Results: The cervical spine showed non-significant difference in reposition errors regarding the constant errors ($P>0.05$) while larger reposition errors regarding the absolute errors during experimental pain compared to before experimental pain ($P<0.001$). In addition, the pain level joint (C4/C5) and its adjacent joints (C3/C4 and C5/C6) indicated larger reposition errors regarding absolute errors ($P=0.035$, $P=0.329$ and $P=0.103$, respectively).

Conclusions: This study firstly investigated the cervical spine reposition errors in experimental neck pain and further found the joints adjacent to the pain level showed larger errors compared to the distant joints regarding absolute errors. It may imply that the larger reposition errors in specific cervical joint indicate probable injury or pain existed adjacent to the joints.

Keywords: Cervical spine, Experimental pain, Reposition errors, Cervical joint reposition, Spine

*Wang, X., et al. (2022). "Effects of experimental pain on the cervical spine reposition errors." BMC Musculoskeletal Disorders **23**(1): 259.*

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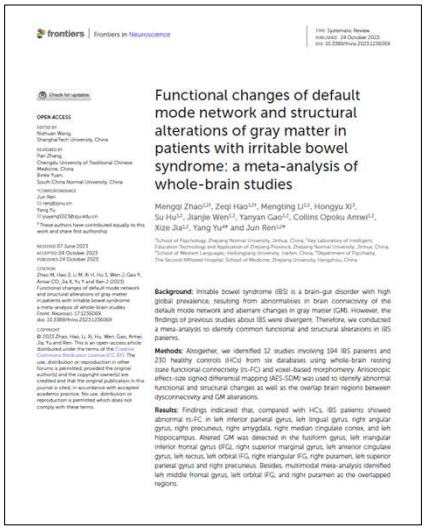
DMN changes in IBS patients

- Findings indicated that, compared with Healthy controls, IBS patients showed abnormal resting-state functional connectivity in left inferior parietal gyrus, left lingual gyrus, right angular gyrus, right precuneus, right amygdala, right median cingulate cortex, and left hippocampus.
- Altered gray matter was detected in the fusiform gyrus, left triangular inferior frontal gyrus (IFG), right superior marginal gyrus, left anterior cingulate gyrus, left rectus, left orbital IFG, right triangular IFG, right putamen, left superior parietal gyrus and right precuneus.
- Besides, multimodal meta-analysis identified left middle frontal gyrus, left orbital IFG, and right putamen as the overlapped regions.

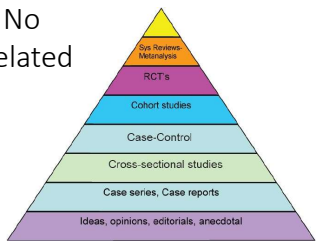


frontiers | Frontiers in Neuroscience

Functional changes of default mode network and structural alterations of gray matter in patients with irritable bowel syndrome: a meta-analysis of whole-brain studies

So what can we claim? CLINICAL

- Clinical research directly supporting organ function changes from chiropractic care is limited!
- Most published clinical literature for non-musculoskeletal organ claims consists of case reports or series rather than large, well-controlled trials.
- Research into conditions like colic, enuresis (bedwetting), hypertension, and gastrointestinal problems shows mixed or tentative results. No strong, consistent clinical trial evidence supports broad organ-related health claims.



So what can we claim? Mechanisms

- Current basic science evidence supports that spinal adjustments affect the nervous system—especially the autonomic nervous system (ANS), endocrine regulation, and reflex loops—all of which can theoretically influence organ function.
- Mechanisms include:
  - Modulation of ANS balance (sympathetic and parasympathetic outflow) through neural pathways, including the vagus nerve and spinal afferents.
  - Changes in how the brain processes signals from the body, especially via regions known to regulate organ systems such as the hypothalamus and prefrontal cortex.
  - Impact on sensorimotor integration and interoceptive awareness, which can affect homeostasis and whole-body regulation.
  - Theoretical influence on hormonal and immune signaling through neuroendocrine routes, as the central nervous system coordinates with organs using neurotransmitters and hormones.

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Questions?

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