PRESENTATION OF NEONATES AND INFANTS WITH SPINAL VS EXTREMITY JOINT DYSFUNCTION

Christian J. Fludder, B.Chiro.Sc., M.Chiro., DACCP[1]
Braden G. Keil, B.App.Sc. (Chiropractic), M.C.Sc. (Paediatrics), FICC, FACCP[1]

[1]*Chiropractic Children's Healthcare, 9 Lower Plenty Road, Rosanna, VIC, 3084*

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ABSTRACT

Introduction: Behaviours and signs of infants presenting for assessment are varied and many. This study aims to determine if there is a difference in presentation based on the location of joint dysfunction.

Methods: Data were collated from 195 cases under 12 months of age attending a paediatric chiropractic clinic in 2010. Information included behavioural presentations and passive range of motion assessment of spine and extremity joints.

Results: 70.7% presented with unsettled behaviour, 48.7% with breastfeeding difficulty, 61.5% with Vagus nerve signs, 32.8% with positional preference, 26.1% with bowel signs and 5.1% with developmental delay. Four infants presented without any abnormal behaviour (2.0%).

Conclusion: There may be association of certain presentations with particular joint dysfunction locations, particularly unsettled behaviour, Vagus nerve dysfunction and breastfeeding difficulty. Further research is needed to further define the association between infant presentations and spinal and extremity joint dysfunction. (Chiropr J Australia 2018;46:79-91)

Key Indexing Terms: Behaviour; Infants; Joint Dysfunction; Chiropractic

INTRODUCTION

There are 3 categories that we can use to classify the presentation of infant behaviour. Firstly, infants may present with pain-based behaviours that stem from illness, procedure, or injury (1,2). Examples of behaviour observed when an infant is experiencing pain include facial grimacing, eye squeezing, or brow bulging, and these are frequently integrated within neonatal and infant pain assessing tools (3-8). The limitation of each of these tools is that they are designed to determine the degree of pain for a specific event or diagnosable condition, and are non-specific for localisation of pain epicentre. The challenge for the practitioner comes from the many potential causes of this form of behaviour, ranging from acute joint dysfunction (9,10), discomfort from cow's milk protein allergy (11), intussusception (12), or constipation (13).

A second category would incorporate behaviours that are currently not considered to be primarily pain driven such as head positional preference, fussiness with breastfeeding, breast attachment issues, arching, and vomiting. In 2012, Stewart conducted a survey of breastfeeding mothers regarding infant behaviours and found 14/19 respondents experienced difficulty with attaching, and 100% had "some arching or extension behaviour while breastfeeding" (14). The regions of dysfunction were noted as; occipitoatlantal (C0/1) joint dysfunction presenting in 70%, glenohumeral joint dysfunction in 70%, atlantoaxial (C1/2) joint dysfunction in 30%, and sacral dysfunction present in 30% (14). Joint dysfunction may be associated with varying degrees of pain ranging from acute intense pain to chronic low-level pain, intermittent pain, posture dependent pain and activity

dependent pain. This variability in pain experienced by the infant with joint dysfunction may explain many of the different behaviours found in infants and the results presented by Stewart. For example, in infants with positional preference the preferenced position can be explained as pain avoidance behaviour. In a recent analysis of 150 infants with plagiocephaly, Murgia *et al* listed “difficulty turning head, decreased cervical rotation, limited passive cervical rotation, and limited active cervical rotation” as risk factors for the development of positional plagiocephaly, with over 90% of the cases involved having restriction in active and passive cervical range of motion (15). This demonstrates a strong link between restricted passive cervical spine range of motion and the development of positional preference and subsequent plagiocephaly. While the restriction may or may not be painful in this scenario, the behaviour observed is that of positional preference.

The third category that may produce specific infant behaviours are non-painful conditions, such as tongue-tie. Tongue-tie is a condition in which the lingual frenulum is unusually short and may restrict tongue movement, and as such has been a cited reason for breastfeeding difficulty (16). This condition is a non-painful condition yet may promote the behaviour of breastfeeding difficulty.

Within each of these categories there are many case studies or case series that attribute particular areas of spinal or extremity dysfunction to infant behaviours such as unsettled behaviour (17-20), or breastfeeding difficulty (21-23). This then promotes the hypothesis that dysfunctions within different regions of the body may present with unique behaviours in infants.

The primary aim of this retrospective case series, therefore, is to look beyond currently accepted infant pain indicators, using signs and behaviour presentations, and determine if there is a difference in presentation in neonates and infants experiencing spinal joint dysfunction when compared to extremity joint dysfunction. A secondary aim is to determine whether different regions of the spine associate with different presentations of behaviour.

METHODS

Participants
All infants under 12 months of age attending a private, children's only chiropractic clinic from 1st of January, 2010, until the 31st of December, 2010, were reviewed (n=202). 7 cases were excluded due to the presence of either medical conditions or not having musculoskeletal dysfunction present upon initial examination. Data were collated from 195 cases.

Presentations
As a part of a standard history, parents were questioned regarding their infants' presentation. These questions covered the standard history recommendations set out by Hawk *et al* (24).

Infant presentations were allocated into 6 categories; "Unsettled", "Breastfeeding Difficulty", "Vagal Nerve Dysfunction", "Developmental Delay", "Bowel Dysfunction", and "Positional Preference". If the infant did not have any indicators of these behaviours as a part of initial consultation, they were listed under "no abnormal behaviour". Each case could only be allocated to 1 category once; but in the presence of multiple presentations,

they could allocate to multiple categories each only once. Examples of presentations are included in Table 1.

Table 1. Examples of presentations

Presentation	Examples	Presentation	Examples
Unsettled	Unsettled Poor sleeping Poor day sleep Dislikes getting dressed Dislikes nappy change Dislikes tummy time "Colicky" Shaking head Difficult to settle Irritable Increased crying	**Developmental Delay**	"Delayed" Immature Delayed rolling Delayed crawling Delayed sitting Poor head control
Breastfeeding Difficulty	Poor feeding Difficulty latching Fussiness when feeding Breast preference Slow or prolonged feeding time Poor tongue use Side preference	**Bowel Dysfunction**	Straining Constipation Difficulty with bowel movements
Vagal Nerve Dysfunction	**Coughing** **Choking** **Gagging** **Vomiting** **Regurgitation** **Reflux** **Dribbling** **Difficulty swallowing**	**Positional Preference**	**Prefers left/right head rotation** **Prefers left/right position**

Assessment

On initial assessment, all infants underwent a complete physical examination. Articulations with reduced passive range of motion were listed based on side and direction of restriction. Passive joint range of motion assessment was performed as described in Chiropractic Pediatrics (25). The glenohumeral joint was additionally assessed with the infants' arm held at 90^{o} lateral abduction, the thumb and index finger of the hand holding the humerus contacting the proximal humerus as close as possible to the humeral head with the other hand stabilising the scapula and clavicle to prevent shoulder girdle movement. This, based on clinical experience, has been found to be a more age appropriate and accurate method for assessing shoulder joint function in infants.

Regions
Cases were divided based on area of determined dysfunction. All cases with dysfunction of the cervical, thoracic, lumbar and pelvic regions, or a combination thereof, were placed into the category "Spinal Dysfunctions". Cases of spinal dysfunction were further separated into lumbosacral dysfunction only and cervical dysfunction only, with involved joints listed in Table 2. Cases with Extremity Dysfunction only incorporated all joints of the upper and lower extremity, with joints involved displayed in Table 3. Cases that had combinations of both spinal and extremity dysfunctions were categorised "Spinal and Extremity Dysfunction". Data were included in Table 4.

RESULTS

TABLE 2. SPINAL DYSFUNCTION PATTERNS

Spinal Dysfunction	**Number of Cases** (n=49)
Cervical Spine Only	23
Right upper cervical	*14*
Left upper cervical	*7*
Bilateral upper cervical	*2*
Lumbosacral Spine Only	6
Left lumbosacral	*3*
Right lumbosacral	*1*
Bilateral lumbosacral	*2*
Multiple Regions	20
Right upper cervical with lumbar and/or sacral	*12*
Left upper cervical with lumbar and/or sacral	*7*
Bilateral upper cervical with lumbar and/or sacral	*1*

TABLE 3. EXTREMITY DYSFUNCTION PATTERNS

Extremity Dysfunction	**Number of Cases** (n=12)
Right glenohumeral joint	9
Left glenohumeral joint	1
Right glenohumeral joint with concurrent right proximal radioulnar joint	1
Right glenohumeral joint with concurrent right wrist	1

TABLE 4. PRESENTATIONS BASED ON LOCATION OF JOINT DYSFUNCTION

Presentation	Spinal Dysfunction (%)	Extremity Dysfunction (%)	Lumbosacral Dysfunction (%)	Cervical Dysfunction (%)	Spinal and Extremity Dysfunction (%)
Number of Cases	49 (25.1)	12 (6.2)	6 (3.1)	23 (11.8)	134 (68.7)
Unsettled Behaviour	31 (63.3)	11 (91.7)	4 (66.7)	13 (56.5)	96 (71.6)
Breastfeeding Difficulty	21 (42.9)	6 (50.0)	1 (16.7)	13 (56.5)	68 (50.7)
Vagal Nerve Dysfunction Indicators	26 (53.1)	6 (50.0)	0 (0.0)	17 (73.9)	88 (65.7)
Developmental Delay	3 (6.1)	2 (16.7)	0 (0.0)	1 (4.3)	5 (3.7)
Bowel Dysfunction	7 (14.3)	2 (16.7)	2 (33.3)	2 (8.7)	42 (31.3)
Positional Preference	18 (36.7)	0 (0.0)	0 (0.0)	10 (43.5)	46 (34.3)
No abnormal behaviour	2 (4.1)	1 (8.3)	1 (16.7)	1 (4.3)	1 (0.7)

In 195 cases, unsettled behaviour was the most frequent presentation. Only 4 infants presented without any abnormal behaviours. Unsettled behaviour was the most frequently cited behaviour across extremity, lumbosacral and combined spinal and extremity presentations. This was not the case in cervical spine dysfunction cohort, where indicators of Vagal nerve dysfunction were the most common.

DISCUSSION

Regions Involved

When comparing the different presentations, there are noticeable differences in presentation based on location of joint dysfunction. Spinal joint dysfunctions were most frequently associated with unsettled behaviour, occurring in over 50% of cases. Cervical spine joint dysfunction was associated with unsettled behaviour (56.5%), breastfeeding difficulty (56.5%) and Vagal dysfunction (73.9%), whereas lumbosacral spinal joint dysfunction was more likely to be associated with unsettled behavior (66.7%), and noticeably less likely to be associated with breastfeeding difficulty (16.7%) and no apparent association with indications of Vagal nerve dysfunction. These findings may be explained by changes of mechanoreceptor density within the spine with the cervical spine having higher number and density of mechanoreceptors compared to the lumbosacral spine (26). This higher mechanoreceptor number and density could result in a greater neurological influence over particular presentations.

Unsettled Behaviour

Of the 195 cases, 138 (70.7%) presented with unsettled behaviour. In a recent retrospective analysis, extremity joint dysfunction, specifically that of the glenohumeral joint, was found to be a common occurrence in infants and neonates (27). In this study, unsettled behaviour was observed more frequently in cases with extremity joint dysfunction (91.7%) (Fig.1).

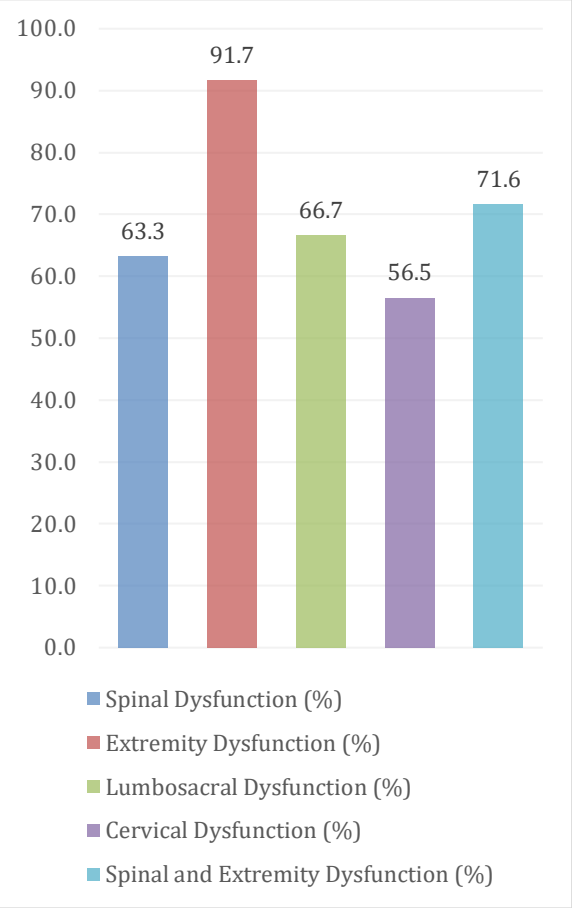

Figure 1 - Unsettled behaviour

The likely reason for unsettled behaviour is increased nociceptive input or pain responses. There is strong evidence supporting that infants do perceive pain (1,28-33). Afferent systems involved in pain perception are fully functional by 24 weeks gestation (34), but the cortical perception of pain cannot occur until thalamocortical pathways begin to function at around 30 weeks gestation (35). There have been multiple studies that have demonstrated a cortical response to pain generation in infants (36,37). This was further supported by Goksan *et al* who, using fMRI, demonstrated noxious stimulation to the extremity eliciting a cortical response with significant infant brain activity observed in 18 of the 20 active adult brain regions but not in the infant amygdala or orbitofrontal cortex (30). This contrasts previous beliefs of infants and neonates experiencing a reduced perception of pain (38). Joint dysfunction would therefore be a plausible mechanism behind the initiation of unsettled behavior due to activation of mechanical nociception (39).

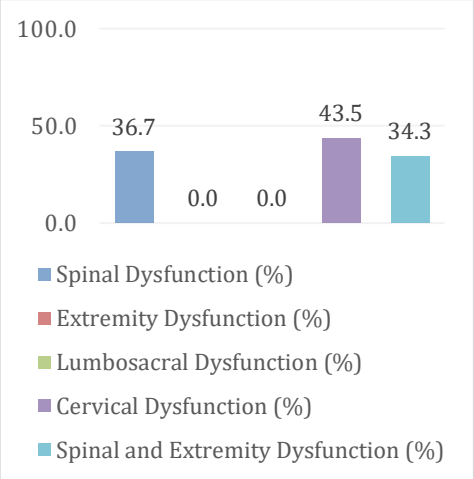

Figure 2 - Positional preference

Positional Preference

In this study, unsurprisingly, the Spinal Dysfunction (36.7%), Spinal and Extremity (34.3%) and Cervical Dysfunction (43.5%) groups demonstrated indications of positional preference, but neither of the Lumbosacral Dysfunction or Extremity Dysfunction group influenced position (Fig.2). This may suggest any dural membrane involvement or muscular tone changes secondary to spinal joint dysfunction in the lumbosacral region or extremity joint dysfunction was not of sufficient magnitude to create a positional preference of the head.

Vagal Nerve Dysfunction Indicators

Dysfunction of the Vagal nerve may result in uncoordinated breathing, suck and swallow with breastfeeding, which may present as coughing, choking, gagging or dribbling (40). Furthermore, dysfunctional Vagal nerve control of the lower oesophageal sphincter may present as reflux, regurgitation and/or vomiting (41).

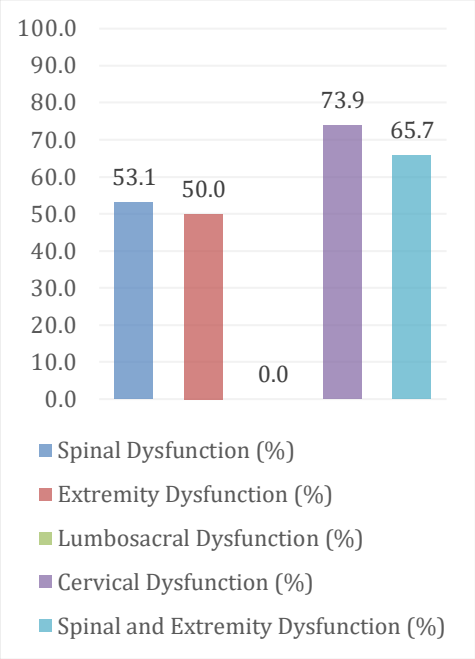

Figure 3 - Vagal nerve dysfunction

In this study, a very high number (73.9%) of infants with cervical spine dysfunction demonstrated Vagal nerve dysfunction indicators and was the most commonly associated area of joint dysfunction with Vagal nerve dysfunction indicators (Fig.3). The impact of altered cervical spine joint function on vagal activity, as reflected by its control over heart rate, or heart rate variability, has been demonstrated (42,43). Improvement in heart rate variability after correction of cervical spine joint dysfunction suggests changes to the function of the Vagus nerve, and a plausible mechanism for impact on other vagal nerve dysfunction signs listed in Table 1.

Interestingly, the involvement of extremity joint dysfunction was associated with a presentation of Vagal nerve dysfunction in 50% of cases (Fig.3). This is likely due to pain and its cortical influence over sympathetic activity (29,44).

Breastfeeding Difficulty

In this study, the definition of breastfeeding difficulty was the subjective experience of difficulty with latching, or difficulty with the process of feeding itself. Interestingly, all joint dysfunction locations were associated with presentations of breastfeeding difficulty, with lumbosacral joint dysfunction (16.7%) the least frequent and cervical joint dysfunction (56.5%) the most frequent (Fig.4). The cervical spine joint involvement likely incorporates a combination of mechanical dysfunction from restricted range of motion as well as pain, along with neurological involvement causing altered function of pathways associated with breastfeeding (45). Pain-avoidance behaviours triggering breastfeeding difficulties may also be a result of joint dysfunction, as demonstrated by Stewart in 2012, who upon treating 19 infants with breastfeeding difficulty observed significant improvements in breastfeeding behaviour (14).

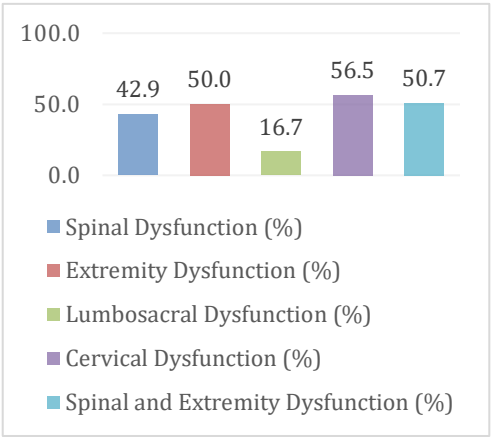

Figure 4 - Breastfeeding difficulty

Developmental Delay

In 2000, Anand and Scalzo discussed the impact of adverse experiences at perinatal stages and subsequent alterations to neurodevelopment and long-term behavioural outcomes (46). This supports our finding of extremity joint dysfunction being associated with a more frequent presentation of developmental delay indicators, when compared to a cervical spine dysfunction, as pain upon rolling or weight-bearing for crawling would be associated with an aversion to that activity (Fig.5).

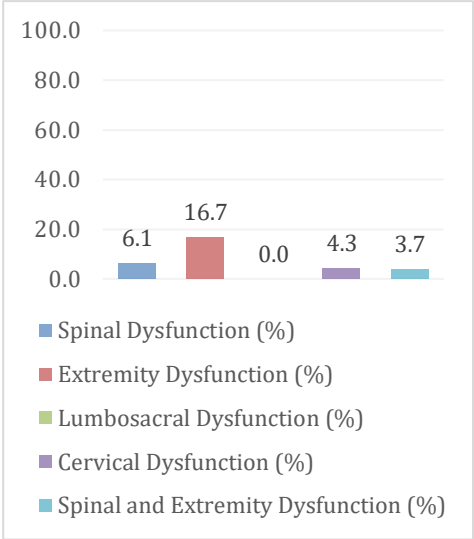

Figure 5 - Developmental delay

In cases of spinal joint dysfunction, a more complex mechanism may be involved. An insult to the developing neuroanatomy may result in changes to the development of the somatosensory cortex (47). This region of the brain is strongly involved in sensorimotor integration (48). This may have a two-fold effect on the developing infant; firstly the impact on the function of the somatosensory cortex itself may impede intra-cortical processing and subsequent development (47), and secondly altered afferent input may result in altered motor cortex function and muscle tone (49,50). Further evidence of the impact of cervical spine joint dysfunction on somatosensory integration was published in a 2016 study by Lelic *et al* whereby a correction of dysfunctional cervical spinal joints improved somatosensory integration of the upper limb (51).

Bowel Dysfunction

Autonomic control of the intestinal tract is derived from spinal fibres located from S2-S4 spinal segments and sympathetic fibres from T5-L2 spinal segments (52-56). It is unsurprising then to see a higher percentage (33.3%) of cases presenting bowel dysfunction being found to have lumbosacral dysfunction than all other regions (Fig.6). There have been numerous case studies have demonstrating improvement in bowel function upon correction of dysfunctional spinal joints (57-59).

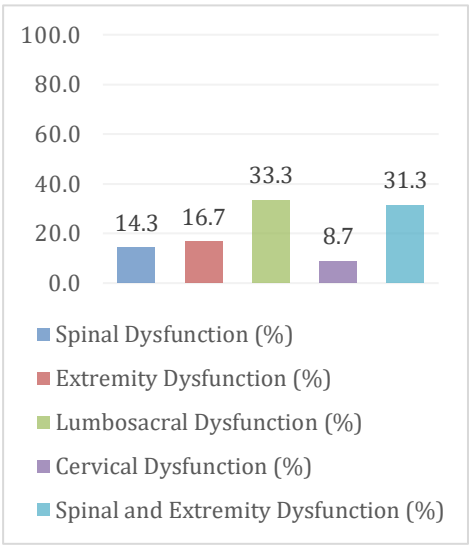

Figure 6 - Bowel dysfunction

Clinical Benefit

The benefit of understanding different behaviours, infant presentations and their relationship to location of joint dysfunction in infants may assist the practitioner in determining the primary source of the complaint. In the instance of Vagal nerve dysfunction presentations, none of the lumbosacral joint dysfunction only infants were in this category. This may suggest that in an infant presenting with Vagal nerve dysfunction, it would be less likely to be of lumbosacral joint dysfunction origin alone but more likely to be associated with cervical spine joint dysfunction and extremity joint dysfunction. Furthermore, it may also promote exploration of non-spinal causes for the presentation, such as cows' milk protein allergy (11). It is important, however, to appreciate that the presence of cervical spine joint dysfunction does not rule out underlying pathology which may co-exist with the same presentation, with prompt and appropriate referral as indicated.

There are limitations within this study; there was no blinding of the assessor to patient behavior increasing the risk of bias, behaviours are subjectively reported, and it is a

retrospective analysis of existing data. However, this study is strengthened by including data from four chiropractors with post-registration training in chiropractic paediatrics. Further research is needed, particularly well-designed, prospective studies, to further define the association between infant presentations and spinal and extremity joint dysfunction in infants.

CONCLUSION

There are many different presentations apparent in infants however there appear to be stronger associations of certain presentations with particular joint dysfunction locations. Being aware of this association may assist the practitioner in their examination, diagnosis and management. Further research is needed, particularly prospective studies, to further define the association between infant presentations and spinal and extremity joint dysfunction.

Declarations

Ethics Approval and Consent to Participate
This study, as defined by section 5.1.8 of the National Statement of Ethical Conduct of Human Research (2007), carries only negligible risk. Furthermore, it has been done in accordance with the Declaration of Helsinki (https://www.wma.net/policies-post/wma-declaration-of-helsinki-ethical-principles-for-medical-research-involving-human-subjects/).

Availability of data and material
All data generated or analysed during this study are included in this published article. Additional data are available from the corresponding author on reasonable request.

Competing Interests
The authors declare that they have no competing interests

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This study received no external funding, with the project done at the authors' expense.

Authors' Information
CF and BK are both paediatric-trained chiropractors working in a paediatric-only chiropractic clinic in Melbourne, Australia. They are both Foundation Members of the Australian College of Chiropractic Paediatrics, a College aimed at promoting higher standards of chiropractors in the field of paediatrics, with both BK and CF on the Board of Directors.
BK is also the author and principal lecturer of a 2-year, post-registration paediatric chiropractic program, with both BK and CF teaching this program across Australia.

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