THE PREVALENCE AND PREDISPOSING FACTORS OF INFANT GLENOHUMERAL JOINT DYSFUNCTION: A RETROSPECTIVE STUDY OF 178 CASES

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ABSTRACT

Objective: Shoulder obstruction occurs in 0.6-1.4% of deliveries and suggests a mechanism for the development of glenohumeral joint dysfunction. This study reviews 178 infants to determine prevalence of and predisposing factors to glenohumeral joint dysfunction.

Methods: Data from 178 consecutive infants examined at a paediatric only chiropractic clinic between January 1, 2010 to 31st December, 2010 were collated. Data on type of delivery, intervention during delivery, birth weight, sibling order, and infant shoulder examination findings from four paediatric-trained chiropractors were included.

Results: Glenohumeral joint dysfunction was apparent in 131 (73.6%). Prevalence was increased with Caesarean section (78.7%) compared to vaginal delivery (71.8%), in non-firstborns (77.7%) compared to firstborns (69.0%), in birth weight >3.5kg (76.8%) compared to <3.5kg (70.8%). Right shoulder (81.7%) was more frequently affected than left (18.3%).

Conclusion: Glenohumeral joint dysfunction is a common presentation to a paediatric chiropractic clinic. This study found Caesarean delivery, non-firstborn, female, and increased weight were associated with increased prevalence of glenohumeral dysfunction; however, statistical significance was not reached for these factors. Subcohort analysis found significant positive linear correlation of glenohumeral joint dysfunction with increasing weight in firstborns and longer gestation length in females.

Keywords: Glenohumeral joint; Shoulder; Dysfunction; Infant; Prevalence; Predisposing factors; Chiropractic

BACKGROUND

Glenohumeral joint dysfunction is commonly diagnosed and treated in infants, however predisposing factors have not previously been researched or published. One study recorded the prevalence of glenohumeral joint dysfunction in infants at 71.8% (1). The glenohumeral joint injury may occur either due to in-utero factors and/or as a result of the birth process. Possible factors impacting on the prevalence of glenohumeral dysfunction in infants include, but are not limited to, mode of delivery (Caesarean vs vaginal), presentation (occiput anterior vs occiput posterior vs breech), duration of labour, birth weight, gender, intervention during labour (manual vs forceps vs vacuum extraction), history of shoulder dystocia, number of siblings and gestational age.

In a study by Mehta *et al* in 2006, shoulder dystocia, a cause of obstructed labour in which the anterior shoulder is unable to pass the pubis symphysis, was found to occur in 0.6-1.4% of all deliveries (2). Of these deliveries, 21-42% of neonates experienced various morbidities ranging from non-permanent brachial plexus injury to fracture and sudden cardiac arrest (3-5).

The remaining 58-79% of shoulder dystocia cases in which morbidity was not recorded or identified may have less severe presentation leading to underdiagnosis of glenohumeral joint dysfunction. More subtle restrictions in glenohumeral joint range of motion may be easily overlooked due to ligamentous laxity and relative reduced tone of the infant. Our impression is that the majority of glenohumeral joint dysfunction apparent in infants after vaginal birthing occur as a result of trauma as the shoulder girdle crosses the symphysis pubis during birth.

At the commencement of labour, 15-20% of fetuses are in occiput posterior position (6, 7), with approximately 90% of vaginal deliveries occiput anterior and 10% occiput posterior (8, 9). In the case of the occiput anterior presentation, the right shoulder joint crosses the symphysis pubis with the left crossing with occiput posterior deliveries. If crossing the symphysis pubis is the site of injury, then clinically we would expect to find roughly 80-90% of cases with glenohumeral joint dysfunction to involve the right glenohumeral joint and about 10-20% to involve the left glenohumeral joint. The effect of Caesarean section delivery on glenohumeral joint function is unknown.

The presence of glenohumeral joint dysfunction in infants has been found to be associated with increased irritable behavior (10). Irritable behaviour in infants is important, as it has been found to be associated with decreased infant sleeping as well as a number of co-morbidities, such as lower IQ scores, poorer fine motor abilities, increased cognitive problems at 5 years of age, and hyperactivity (11). There is also an association with increased use of health services (12), increased maternal depression (13), increased paternal depression and anger (14), as well as increased child abuse (15). In light of these associations, further research into possible causes of irritable behaviour in infants becomes increasingly important.

This study aims to review 203 consecutive infant cases and retrospectively analyse prevalence and potential impact of birth type, weight, age, and sibling order as factors associated with the development of glenohumeral joint dysfunction.

METHODS

Participants were patients at a private practice in Melbourne, Australia. A retrospective, serial, single-centre analysis of clinical records of existing patient data from 1 January, 2010 until 31 December, 2010 was performed. 203 consecutive patients under 12 months of age (MOA) at the time of their initial consultation who had signed consent were included for record review. Five key data points were collated. These included birth method, weight, age, sibling order and gender. 25 cases with incomplete data recording were excluded, leaving 178 cases for data analysis (Table 1). This study was performed in accordance with the Australian National Statement of Ethical Conduct of Human Research (2007), and, as defined by section 5.1.8, carries only negligible risk. This study was performed in accordance with the Declaration of Helsinki 2013.

Data collection and analysis was performed by CF, who was not involved in any data recording or examination. Four chiropractors with post-registration training in chiropractic paediatrics with a minimum of 2-year or 1000-hour content performed examination and recorded findings. One chiropractor obtained case history and performed examination per case.

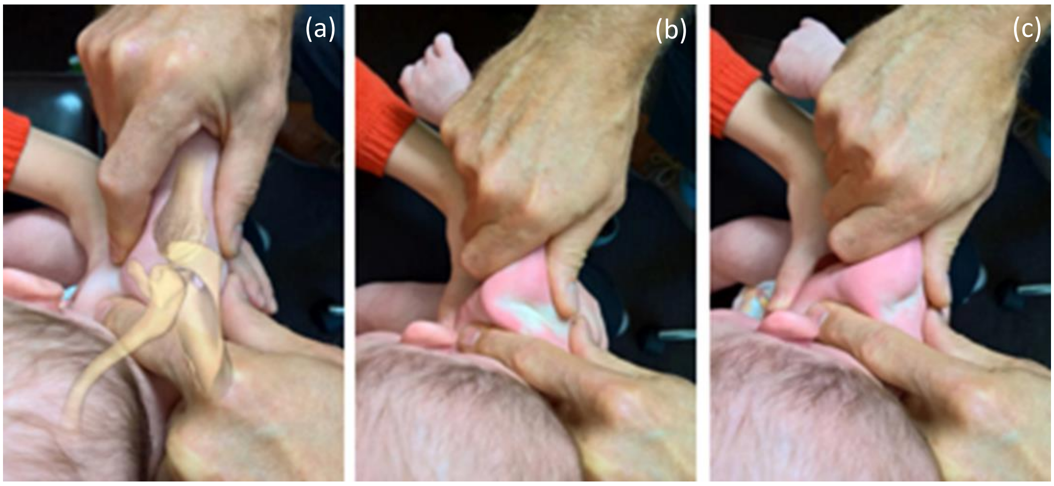


Figure 1 – Assessment of the Glenohumeral Joint
(a) Glenohumeral joint contact points, neutral position
(b) Anterior glenohumeral joint glide
(c) Posterior glenohumeral joint glide

Glenohumeral joint assessment was performed in accordance with standard post-graduate training in Australia. The glenohumeral joint was assessed with the arm held at 90° 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 (Fig. 1). Dysfunction was classified as a reduction in passive range of motion upon assessment of all ranges of motion, incorporating rotation, long-axis traction, and anteroposterior glide. Motion palpation findings were listed based on side and direction of restriction.

Data regarding delivery, birth weight, and sibling number was obtained from patient records. Further distribution of data based on mode of delivery incorporating age, weight, sibling order and birthing method was listed in Table 2.

Statistical analysis was performed by an external, independent statistician to determine the impact of weight, birth method, gender, sibling order and age on presence of glenohumeral joint dysfunction. Raw, tabulated data was provided in a Microsoft Excel spreadsheet for this purpose (Appendix A).

RESULTS

One hundred and seventy-eight infants (109 male, 69 female) with a mean age of 87.1 days (Standard deviation = 63.3 days, range = 5-312 days), met the inclusion criteria. Baseline characteristics are recorded in Table 1.

Table 1. Baseline Characteristics

Number of patients	178
Age (days)	87.1 (SD=63.3, range=5-312)
Gender	109 male (61.2%), 69 female (38.8%)
Weight (Kg)	3.39 (SD=0.54, range=1.600-4.670)
Birthing Method	
Vaginal	131
Caesarean Section	47 (10 elective Caesarean, 24 emergency, 13 unspecified)

SD = Standard deviation

Of 178 cases of infants, there were 131 cases with glenohumeral dysfunction (73.6%). The percentage of infants with glenohumeral joint dysfunction in the Caesarean section cohort was 78.7% and 71.8% in those born vaginally. Of the 131 infants with glenohumeral joint dysfunction, right-sided dysfunction was recorded in 81.7%, and 18.3% on the left. Glenohumeral joint dysfunction present in 77.7% of non-firstborn children and 69.0% of firstborns. Further data regarding weight, age and gender are listed in Table 2.

Table 2. Prevalence of glenohumeral joint dysfunction by delivery type, weight, sibling order, age, and gender

	Total	GHJ		Right GHJ		Left GHJ	
Characteristic	n	n	%	n	%	n	%
Combined Data	**178**	**131**	**73.6**	**107**	**81.7**	**24**	**18.3**
Weight (kg)							
<2.499	13	6	46.2	4	66.7	2	33.3
2.5-2.999	23	18	78.3	17	94.4	1	5.6
3.0-3.499	60	44	73.3	37	84.1	7	15.9
3.5-3.999	59	48	81.4	40	83.3	8	16.7
>4.0	23	15	65.2	9	60.0	6	40.0
Sibling							
Firstborn	84	58	69.0	49	84.5	9	15.5
Non-firstborn	94	73	77.7	58	79.5	15	20.5
Age							
0-1 MOA	25	18	72.0	14	77.8	4	22.2
1-2 MOA	42	31	73.8	23	74.2	8	25.8
2-3 MOA	40	28	70.0	24	85.7	4	14.3
3-4 MOA	24	22	91.7	18	81.8	4	18.2
4-5 MOA	17	14	82.4	11	78.6	3	21.4

5-6 MOA	13	8	61.5	8	100.0	0	0.0
6+ MOA	17	10	58.8	9	90.0	1	10.0
Gender							
Male	109	77	70.6	63	81.8	14	18.2
Female	69	54	78.3	44	81.5	10	18.5
Vaginal Delivery	131	94	71.8	76	80.9	18	19.1
Weight (kg)							
<2.499	6	1	16.7	0	0.0	1	100.0
2.5-2.999	17	13	76.5	12	92.3	1	7.7
3.0-3.499	45	31	68.9	26	83.9	5	16.1
3.5-3.999	42	36	85.7	30	83.3	6	16.7
>4.0	21	13	61.9	8	61.5	5	38.5
Total	131	94	71.8	76	80.9	18	19.1
Sibling							
Firstborn	58	39	67.2	32	82.1	7	17.9
Non-firstborn	73	55	75.3	44	80.0	11	20.0
Age							
0-1 MOA	20	16	80.0	12	75.0	4	25.00
1-2 MOA	34	25	73.5	18	72.0	7	28.00
2-3 MOA	30	19	63.3	17	89.5	2	10.53
3-4 MOA	15	14	93.3	11	78.6	3	21.43
4-5 MOA	13	10	76.9	8	80.0	2	20.00
5-6 MOA	9	5	55.6	5	100.0	0	0.00
6+ MOA	10	5	50.0	5	100.0	0	0.00
Gender							
Male	83	59	71.08	48	81.4	11	18.6
Female	48	35	72.92	28	80.0	7	20.0
Caesarean Section	47	37	78.7	31	83.8	6	16.2
Weight (kg)							
<2.499	7	5	71.4	4	80.0	1	20.0
2.5-2.999	6	5	83.3	5	100.0	0	0.0
3.0-3.499	15	13	86.7	11	84.6	2	15.4
3.5-3.999	17	12	70.6	10	83.3	2	16.7
>4.0	2	2	100.0	1	50.0	1	50.0
Total	47	37	78.7	31	83.8	6	16.2
Sibling							
Firstborn	26	19	73.1	17	89.5	2	10.5
Non-firstborn	21	18	85.7	14	77.8	4	22.2
Age							
0-1 MOA	5	2	40.0	2	100.0	0	0.0
1-2 MOA	8	6	75.0	5	83.3	1	16.7
2-3 MOA	10	9	90.0	7	77.8	2	22.2
3-4 MOA	9	8	88.9	7	87.5	1	12.5
4-5 MOA	4	4	100.0	3	75.0	1	25.0
5-6 MOA	4	3	75.0	3	100.0	0	0.0
6+ MOA	7	5	71.4	4	80.0	1	20.0
Gender							
Male	26	18	69.2	15	83.3	3	16.7

Female	21	19	90.5	16	84.2	3	15.8

MOA; Months of age, GHJ; Glenohumeral joint dysfunction, n; number

Odds ratios were determined based on frequency tables calculated by YN. Gender, weight, mode of delivery and sibling order were analysed and tabulated in Table 3. Subcohort analysis based on gender, sibling order, and birth method were included within Table 3.

Table 3. Predictors of glenohumeral joint dysfunction in infants

	Frequency Table			Odds Ratio		
	Characteristic	NIL	GHJ	OR	p-value	95% Confidence Interval
Total Population Analysis Gender	F	15	54	1.49	0.17	0.74-3.03
	M	32	77	0.67	0.17	0.33-1.35
Sibling Order	1st born	26	58	0.64	0.13	0.33-1.25
	2+	21	73	1.56	0.13	0.79-3.05
Weight (kg)	0-3.5	28	72	0.83	0.35	0.42-1.63
	3.5+	19	59	1.21	0.35	0.61-2.37
Birth Method	CS	10	37	1.45	0.23	0.65-3.22
	Vaginal	37	94	0.68	0.23	0.31-1.52
Male Cohort Analysis Sibling Order	1st born	15	32	0.81	0.38	0.35-1.85
	2+	17	45	1.24	0.38	0.54-2.84
Weight (kg)	0-3.5	17	41	1.01	0.58	0.44-2.29
	3.5+	15	36	0.99	0.58	0.43-2.27
Birth Method	CS	8	18	0.91	0.52	0.35-2.39
	Vaginal	24	59	1.09	0.52	0.42-2.85
Female Cohort Analysis Sibling Order	1st born	11	26	0.33	0.07	0.09-1.19
	2+	4	28	2.96	0.07	0.84-10.47
Weight (kg)	0-3.5	11	31	0.49	0.21	0.14-1.74
	3.5+	4	23	2.04	0.21	0.57-7.23
Birth Method	CS	2	19	3.53	0.09	0.72-17.30
	Vaginal	13	35	0.28	0.09	0.05-1.38
1st Born Cohort Analysis Gender	F	11	26	1.11	0.51	0.43-2.82
	M	15	32	0.90	0.51	0.35-2.29
Weight (kg)	0-3.5	18	32	0.54	0.16	0.20-1.46
	3.5+	8	26	1.83	0.16	0.68-4.87
Birth Method	CS	7	19	1.32	0.39	0.47-3.68
	Vaginal	19	39	0.75	0.39	0.27-2.11
Non-Firstborn Cohort Analysis Gender	F	4	28	2.64	0.08	0.80-8.66
	M	17	45	0.38	0.08	0.11-1.24
Weight (kg)	0-3.5	10	40	1.33	0.37	0.50-3.53
	3.5+	11	33	0.75	0.37	0.28-1.98
Vaginal vs CS	CS	3	18	1.96	0.24	0.52-7.45
	Vaginal	18	55	0.51	0.24	0.13-1.93

Caesarean Section Cohort Analysis						
Gender	F	2	19	4.22	0.07	0.79-22.61
	M	8	18	0.23	0.07	0.04-1.27
Weight (kg)	0-3.5	5	24	1.84	0.30	0.45-7.57
	3.5+	5	13	0.54	0.30	0.13-2.22
Sibling Order	1st born	7	19	0.45	0.24	0.10-2.02
	2+	3	18	2.21	0.24	0.49-9.89
Vaginal Cohort Analysis						
Gender	F	13	35	1.09	0.49	0.49-2.42
	M	24	59	0.91	0.49	0.41-2.02
Weight (kg)	0-3.5	23	48	0.63	0.17	0.29-1.38
	3.5+	14	46	1.57	0.17	0.72-3.43
Sibling Order	1st born	19	39	0.67	0.20	0.31-1.44
	2+	18	55	1.49	0.20	0.69-3.19

F; Female, M; Male, CS; Caesarean Section, NIL; No abnormality detected, GHJ; Glenohumeral Joint Dysfunction present, OR; Odds Ratio

Point-Biserial correlations between linear variables of age at presentation, gestation length and weight were determined against the presence of glenohumeral joint dysfunction and listed within Table 4.

Table 4. Subcohort Analysis and Point Biserial Correlations

	Point-Biserial Correlation	***p*-value**	**Decision**
Total Cohort			
Age	-0.068797309	0.36	No correlation
Gestation	0.079541397	0.29	No correlation
Weight	0.074169132	0.33	No correlation
Male Subcohort			
Age	-0.119062145	0.22	No correlation
Gestation	-0.039746162	0.68	No correlation
Weight	0.035528178	0.71	No correlation
Female Subcohort			
Age	0.04575961	0.71	No correlation
Gestation	0.27565118	0.02	Positive linear correlation
Weight	0.16318781	0.18	No correlation
First-Born			
Age	-0.046917598	0.67	No correlation
Gestation	0.147122005	0.18	No correlation
Weight	0.229084705	0.04	Positive linear correlation
Non-Firstborn			
Age	-0.062177378	0.55	No correlation
Gestation	0.030793683	0.77	No correlation
Weight	-0.06316867	0.55	No correlation
C-Section			

Age	0.073707868	0.62	No correlation
Gestation	0.057831879	0.69	No correlation
Weight	0.019390883	0.89	No correlation
Vaginal			
Age	-0.137097601	0.12	No Correlation
Gestation	0.1116192	0.20	No Correlation
Weight	0.116881075	0.18	No Correlation

DISCUSSION

The results of this study highlight the high prevalence of infants presenting with glenohumeral joint dysfunction. We found that of the 178 infants recruited, 131 (73.6%) presented with alterations to passive range of motion of the glenohumeral joint. There is a plausible mechanism by which the birthing process itself may be contributing to the high prevalence of glenohumeral dysfunction, with trauma to the glenohumeral joint occurring as the shoulder girdle crosses the pubic symphysis during vaginal delivery.

Approximately 80-85% of fetuses are in occiput anterior position at labour commencement and 90% of vaginal deliveries occur in an occiput anterior position which is associated with the right shoulder girdle having to pass across the mother's symphysis pubis (9). If the passing of the right shoulder girdle across pubic symphysis was the mechanism of insult, we would expect to see a higher occurrence of right glenohumeral joint dysfunction in infants born vaginally. This is observed in this study; of vaginally delivered infants presenting with glenohumeral dysfunction, 80.9% presented with a right glenohumeral joint dysfunction, a finding very similar to the percentage of infants who commence labour in an occiput anterior position. A percentage of infants who commence delivery in an occiput posterior position, which is possibly associated with left glenohumeral joint injury, are eventually delivered occiput anterior which may explain the higher prevalence of left glenohumeral joint dysfunction identified when compared to occiput posterior deliveries.

The process of obstruction during delivery has been documented to occur more frequently in larger babies, particularly babies over 3.5kg birth weight, and is associated with increased shoulder girdle trauma (16–18). This is only partially consistent with our combined data, as 81.4% infants of 3.5-3.999kg presented with glenohumeral joint dysfunction, yet only 65.2% of infants greater than 4.0kg presented with glenohumeral joint dysfunction. There was a relative trend of increasing rate of dysfunction by weight; only 46.2% of infants under 2.5kg presented with glenohumeral joint dysfunction compared to 65.2% of those over 4kg, with the highest prevalence occurring at 3.5-3.999kg. When analysing OR for weight, weight below 3.5kg had a reduced likelihood of occurrence (OR=0.83, p=0.35, CI=0.42-1.63) compared to above 3.5kg which observed an OR of 1.21 (p=0.35, CI=0.65-3.22), however this was not statistically significant. A statistically significant positive linear correlation with increasing weight was observed in firstborns, but not subsequent deliveries, indicating increased frequency of glenohumeral dysfunction with increasing weight but this correlation was not observed with any other factor (Table 4). This may be due to low numbers in the cohorts involved.

What is curious, however, is the higher prevalence of glenohumeral joint dysfunction in infants born via Caesarean section (78.7% vs 71.8%). While Caesarean section does reduce the relative risk of birth trauma, it does not prevent it from occurring (19, 20). Due to insufficient data, this study could not differentiate elective from emergency Caesarean section information. If shoulder dystocia had already occurred and was the instigator for emergency Caesarean section, we would then expect to see higher occurrence of glenohumeral joint dysfunction in higher birth weights. This is consistent with our data, but with only 2 cases of Caesarean-delivered infants over 4.0kg further research is required.

A 2009 study by Mehta *et al* identified that having a previous birth with shoulder dystocia is a risk factor for recurrence, with a 9.8 times higher rate of recurrence when compared to baseline rates of dystocia (21). In our data we compared prevalence of glenohumeral dysfunction between firstborns and non-firstborns, with increased occurrence of glenohumeral joint dysfunction present in non-firstborn children compared to firstborns in both vaginal (75.3% to 67.2%) and Caesarean section (85.7% to 73.1%) deliveries. The impact of greater infant size in infants who are not firstborn may be a contributing factor as in our data we did see a 187g increase in average weight in full-term non-firstborn infants compared to firstborn (firstborn average 3.43±0.39kg; non-firstborn average 3.61±0.46kg), however this was not the case in those born via Caesarean section (firstborn average 3.45±0.51kg; non-firstborn average 3.16±0.56kg). In this study we observed an increased frequency of glenohumeral joint dysfunction in non-firstborns in both vaginal and Caesarean section deliveries but this was not statistically significant (Table 2).

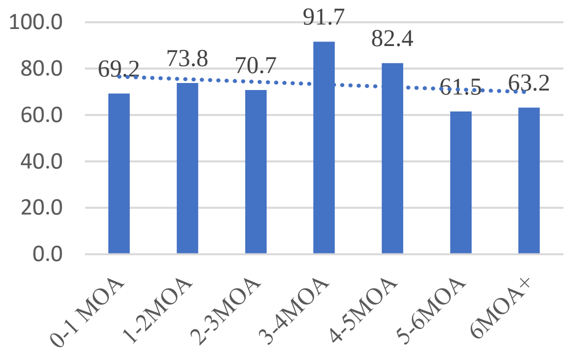
Infants under one month of age and over 5 MOA observed a relative lower rate of glenohumeral joint dysfunction when compared to 1-5 MOA. When separating based on birth method we observe a higher prevalence in the 0-1 MOA vaginal delivery cohort (80.0%) when compared to those born via Caesarean section (40.0%). Of infants born vaginally, the age with the highest prevalence of glenohumeral joint dysfunction present was 3-4 MOA (93.3%), and the lowest was the 6+ MOA bracket at 50.0%. In contrast, in infants born via Caesarean section the highest prevalence was observed in the 4-5 MOA cohort (100.0%) and the lowest in the 0-1 MOA (40.0%). All of the Caesarean age groups as well as the 5-6 MOA and the 6+ MOA vaginal delivery age groups contained 10 or fewer cases. Larger numbers in these age groups would provide more reliable data.

Interestingly, while the ratio of left:right dysfunction stayed similar in vaginal delivery between first- and non-firstborns, this changed in those born via Caesarean section, with a higher frequency of left glenohumeral joint dysfunction present in non-firstborns compared to firstborns.

When analysing female data, there was an increased risk of glenohumeral joint dysfunction being identified when birthed by Caesarean section (OR=3.53, p=0.09, CI=0.72-17.30) compared to vaginal delivery (OR=0.28, p=0.09, CI=0.05-1.38), and being a non-firstborn (OR=2.96, p=0.07, CI=0.84-10.47) compared to firstborn (OR=0.33, p=0.07, CI=0.09-1.19). In comparison, male data indicated Caesarean section (OR=0.91, p=0.52, CI= 0.35-2.39) and being non-firstborn (OR=1.24, p=0.38, CI=0.54-2.84) did not have the same impact on frequency of occurrence. This data, while not statistically significant, does hold clinical significance and it is important that future research address these relationships with larger data.

One potential confounder in this study is the impact of post birth external factors occurring and influencing the presentation of glenohumeral joint dysfunction. In this study, we found a relatively consistent rate of glenohumeral joint dysfunction across age brackets, suggesting common aetiology likely to be the birthing process and demonstrating limited spontaneous resolution over the first 10 months of life (Fig. 2). There were spikes in the prevalence observed at the 3-4 and 4-5 month age brackets that may be the result of diminished effect of the relaxin hormone and increased perception of articular dysfunction in these age groups. In a previous study of infants found to have dysfunction of the glenohumeral joint, over 90% were demonstrating unsettled behaviour (10), which coupled with limited spontaneous resolution over the first 10 months suggests the need for clinical intervention.

Figure 2. Shoulder dysfunction by age (%)



There are three major concerns with glenohumeral joint dysfunction. Firstly, the potential long-term impact on glenohumeral joint growth, secondly, the impact on upper extremity motor function and finally, the impact of joint dysfunction associated pain. In a 2016 imaging study of 10 cases with brachial plexus birth palsy, all cases demonstrated alterations to the glenoid cavity and humeral head (22). This suggests that improper positioning, in this study the humeral head on the glenoid, may lead to alterations in bony structure due to abnormal mechanotransductive loading (23). Improper positioning of the glenohumeral joint resulting from joint dysfunction may not be of the same severity as a brachial plexus palsy, but alterations of mechanotransduction may still cause structural changes which may impact joint stability and may influence arm use. Further research identifying the potential impact to the glenohumeral joint of altered mechanotransduction is required.

The final major impact of a joint dysfunction is pain. Recent fMRI studies have shown that infants experience pain in a manner very similar to adults (24). While this study does not address pain or impact of glenohumeral joint dysfunction on infant behaviours, a previous article by the authors identified a high prevalence of glenohumeral joint dysfunction in infants presenting with pain associated behaviours such as unsettled behaviour (10).

These aspects of glenohumeral joint dysfunction highlight the importance of accurate assessment and appropriate management. Inadequate management may result in potential adverse long-term outcomes such as persistence of unfavourable behaviours. Accurate assessment of shoulder joint passive range of motion in the neonate and infant can be challenging. In cases of diagnostic uncertainty, it may be pertinent to refer to practitioners with additional levels of chiropractic paediatric training.

It is important to note that assessing active range of motion alone in this circumstance is inadequate, as changes in active and passive range of motion can occur independently of each other (25).

There are limitations involved in this study: as a retrospective analysis, we are unable to draw conclusions regarding causation; there are low numbers present within each cohort; there is practitioner bias as the findings are subjective motion assessments; and there are no current validity, inter- or intra-examiner reliability studies for assessment of the glenohumeral joint in the infant population. This study, however, is also strengthened by the use of four experienced, paediatric-trained chiropractors. There is need for future, prospective studies assessing the inter- and intra-practitioner reliability of the assessment of the glenohumeral joint in infants, as well as long-term outcomes of infants with glenohumeral joint dysfunction.

CONCLUSION

Glenohumeral joint dysfunction was a common presentation to a paediatric chiropractic clinic over the year of 2010. There was increased prevalence of glenohumeral joint dysfunction associated with Caesarean delivery, being a non-firstborn, female, and increasing weight; however, statistical significance was not reached for these factors. Subcohort analysis found significant positive linear correlation of glenohumeral joint dysfunction with increasing weight in firstborns and longer gestation length in females**.** Further prospective research with larger cohorts is needed.

Abbreviations

MOA; Months of age, GHJ; glenohumeral joint, V; Vaginal, CS; Caesarean Section, C-Section; Caesarean section

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 and as such does not require Ethics Approval. Furthermore, it 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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Authors' Contributions

BK developed the study concept and was a major contributor in writing the manuscript. CF collated, analysed and interpreted patient data, and was a major contributor in writing the manuscript.

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BK and CF 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 with an objective of health promotion and research in the field of chiropractic 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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