Incidence of Somatic Dysfunction in Healthy Newborns

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Context: Recent evidence suggests that osteopathic manipulative treatment of somatic dysfunction in newborns may decrease complications and hospital length of stay. Such dysfunction may result from external forces related to the birth process, but its incidence is unknown.

Objective: To identify the incidence and patterns of somatic dysfunction in healthy newborns at least 6 hours after birth and to correlate those findings with maternal and labor history, gestational age, and findings of the initial newborn assessment performed immediately after birth.

Methods: Healthy newborns aged 6 to 72 hours were physically examined and assessed for somatic dysfunction, including asymmetry and motion restriction of the cranial, cervical, lumbar, and sacral regions. The total somatic dysfunction identified was summarized in a somatic dysfunction severity score (SDSS), calculated by assigning 1 point for each identified finding; the SDSS could range from 0 (no somatic dysfunction) to 34 (all somatic dysfunctions assessed present). Findings were correlated with maternal and newborn characteristics and labor history. Descriptive analyses were performed, and findings were compared between the initial newborn assessment and the research examination.

Results: One hundred newborns were examined (mean gestational age, 38.5 weeks). In 99 newborns (99%), at least 1 sphenobasilar synchondrosis strain pattern was present, with sidebending rotations being the most common (present in 63 newborns [63%]). Condylar compression was found in 95 newborns (95%), temporal bone restrictions in 85 (85%), motion restriction of at least 1 cervical vertebral segment in 91 (91%) and at least 1 lumbar vertebral segment in 94 (94%), and a posterior sacral base in 80 (80%). The SDSS was not associated with mode of delivery or labor augmentation (P=.49 and P=.54, respectively), but it was positively associated with the duration of labor; each 1-hour increase in labor increased the predicted SDSS by 0.12 points (P=.04).

Conclusion: Somatic dysfunction of the cranial, cervical, lumbar, and sacral regions was common in healthy newborns, and the total somatic dysfunction (SDSS) was related to the length of labor. (ClinicalTrials.gov number NCT01496872)

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Somatic dysfunction in newborns has been discussed in the osteopathic literature for decades[1-3] and may result from intrauterine factors (eg, fibroids, multiple fetuses, uterine shape) or strains during labor and delivery. Its presence has been theorized to predispose infants to musculoskeletal problems, such as deformational plagiocephaly, and to systemic problems, such as respiratory or nervous system symptoms.[1,4,5] Osteopathic manipulative treatment (OMT) of somatic dysfunction in preterm newborns has been associated with reduced gastrointestinal symptoms, decreased hospital length of stay, and reduced hospitalization costs.[5-7] Therefore, the identification and treatment of somatic dysfunction may lead to improved health in newborns.

To understand the effects of somatic dysfunction in newborns, its incidence in this population must be determined. Pizzolorusso et al[8] retrospectively evaluated 155 preterm and term newborns admitted to a neonatal intensive care unit. They found a high rate of cranial somatic dysfunction, including sphenobasilar synchondrosis (SBS) strain patterns, that was unrelated to gestational age or birth weight.[8] However, they did not compare their findings with those in healthy newborns. In another study,[9] clinical evaluation of cranial somatic dysfunction in 1600 newborns revealed no cranial strain patterns in the first 6 hours after birth, but a "process of (re)organization" was observed during the 15 to 20 minutes after birth in newborns of more than 26 weeks gestation. These clinical observations suggest that assessment for somatic dysfunction in newborns should be delayed until at least 6 hours after birth.

Multiple factors, such as maternal pelvic mobility during labor, duration of the first and second stages of labor, gravidity of the mother, labor augmentation, instrumental delivery, fetal head position, and cesarean delivery, may influence the development of cranial asymmetry and somatic dysfunction throughout the newborn's body.[9,10] The purpose of the current study was to identify the incidence and patterns of somatic dysfunction in healthy newborns at least 6 hours after birth and to correlate those findings with maternal and labor history, gestational age, and findings of the initial newborn assessment performed immediately after birth. Our hypothesis was that longer labor, vaginal delivery, and primiparity would be associated with a higher frequency of somatic dysfunction.

Methods

Recruitment

Newborn participants were recruited from the Northeast Regional Medical Center in Kirksville, Missouri, from December 2011 through December 2012. For inclusion in the study, participants had to be aged at least 6 but no more than 72 hours at the time of the research examination. The 72-hour maximum was chosen because most healthy newborns are discharged from the hospital by that time. Exclusion criteria included illness requiring intravenous lines or oxygen supplementation at the time of the research examination, open spina bifida occulta, or cleft lip or palate. Newborns who had received OMT, who were expected to receive OMT before the research examination, who were wards of the state, or who were born outside the hospital were excluded from the study.

Recruitment and enrollment were performed by the primary investigator (E.L.W.) on weekdays only. The medical records for all newborns under the care of participating attending physicians were screened for inclusion criteria. A parent or guardian of all eligible newborns was then approached about enrollment in the study; informed consent was obtained before study enrollment. The current study was reviewed and approved by the A.T. Still University–Kirksville Institutional Review Board and is registered with ClinicalTrials.gov (NCT01496872).

Medical History

The following information was collected from the maternal medical record: age, race, parity, mode of delivery, labor augmentation, type of anesthesia, duration of labor, duration of second stage (active pushing), and head presentation at delivery. The following information was collected from the initial newborn assessment performed immediately after birth by the newborn's attending physician and the nursing staff: sex; gestational age; weight; Apgar scores; occipitofrontal head circumference; degree of cranial molding (visual asymmetry: none, mild or moderate, or severe); and presence of caput succedaneum, cephalohematoma, or overriding sutures.

Research Examination

Newborn participants underwent a research examination performed by the primary investigator (E.L.W.), a resident in a combined family medicine and neuromusculoskeletal medicine and osteopathic manipulative medicine program, and an A.T. Still University–Kirksville College of Osteopathic Medicine faculty physician (K.T.S. or M.D.L.), board certified in neuromusculoskeletal medicine and osteopathic manipulative medicine. Areas of somatic dysfunction assessed included the cranial, cervical, lumbar, and sacral body regions. The examination included measurement of occipitofrontal head circumference; degree of cranial molding (visual asymmetry: none, mild or moderate, or severe); presence of caput succedaneum, cephalohematoma, or overriding sutures; facial paralysis; facial asymmetry of orbits, mouth, and nose; presence of torticollis; quality of suckle on a gloved finger (strong with good coordination or weak with poor coordination); cranial rhythmic impulse (CRI) in cycles per minute[11]; and presence of cranial, cervical, lumbar, or sacral somatic dysfunction. Both examiners had to agree on findings for each examination, and findings were openly discussed. For disagreements on findings, the area was reexamined and a consensus was reached.

The assessment for somatic dysfunction included the presence of occipital condylar compression (right, left, or bilateral); cranial motion preference of 1 or more SBS strain patterns (flexion or extension, right or left torsion, right or left sidebending/rotation, inferior or superior vertical strain, right or left lateral strain, or SBS compression); temporal bone restriction (right, left, or bilateral); cranial quadrant motion restriction (right and left frontal or right and left occipital); presence of spinal segmental motion restriction of the cervical spine (C1-C7), lumbar spine (L1-L5), or sacrum (S1-S3); and positional finding of sacral base anterior (right or left) or sacral base posterior (right or left). The total amount of somatic dysfunction identified was summarized in a somatic dysfunction severity score (SDSS) that was calculated by assigning 1 point to each of the above somatic dysfunctions identified; the SDSS could range from 0 (no somatic dysfunction) to 34 (all assessed somatic dysfunctions present).

Data Analysis

Head circumference measurements obtained at the initial newborn assessment (at time of birth) and at the research examination (6-72 hours after birth) were compared using a paired *t* test; agreement between these 2 measurements was determined using the concordance correlation coefficient.[12,13] Linear regression analysis was used to determine whether the difference in these measurements was dependent on the newborn's age at research examination. For other comparisons of findings between the initial newborn assessment and the research examination, the Bowker test of symmetry[14] and weighted κ were used for the degree of molding and the McNemar test[15] and simple κ were used for the presence or absence of caput succedaneum, cephalohematoma, or overriding sutures. Newborn age at the research examination was correlated with the findings from that examination and agreement between the 2 measurements for head circumference; degree of molding; and presence of caput succedaneum, cephalohematoma, and overriding sutures. The κ values were interpreted as follows: 0.81 to 1.00 indicated almost perfect agreement; 0.61 to 0.80, substantial agreement; 0.41 to 0.60, moderate agreement; 0.21 to 0.40, fair agreement; 0 to 0.20, slight agreement;

and less than 0, poor agreement.[16] Independent-samples *t* tests and linear regression analyses were used to determine if there was a correlation between newborn age at research examination and asymmetry of the orbits, mouth, and nose; presence of torticollis; quality of suckle; and CRI. Independent-samples *t* test was used to determine if there was a correlation between gestational age and the quality of suckle.

The CRI was also compared with gestational age, quality of suckle, SBS strain pattern, and cranial quadrant motion restriction using linear regression. A χ^2 test or Fisher exact test was used to assess associations between specific SBS strain patterns and overriding sutures; asymmetry of the orbits, mouth, and nose; and cranial quadrant motion restriction. Odds ratios and asymptotic or exact point probability 95% CIs were reported.[17] Because exact inference for contingency tables is a discrete problem, the coverage was not exactly 95% but at least 95%.[18]

The SDSS was correlated with the following: examiner team, gestational age, newborn age at research examination, parity, mode of delivery, labor augmentation, type of anesthesia, duration of labor, duration of second stage of labor, Apgar score, head circumference, presence of caput succedaneum, presence of cephalohematoma, quality of suckle, and CRI. Because the onset of labor is often uncertain, the total duration of labor was recorded in 4-hour intervals, beginning with no labor (0, 4, 8, 12, 16, 20, or 24 hours). If applicable, the duration of the second stage was recorded in 15-minute intervals for the first hour and then in 1-hour intervals for the first 4 hours. Both durations were analyzed using the midpoint interval values. The χ^2 test was used to assess the association between sacral base position and restricted motion of sacral segment S1. Multiple comparison adjustments were not used in the current study because they were considered problematic owing to the potential low power as detailed by Perneger.[19] $P \leq .05$ was considered statistically significant. Analyses were conducted using SAS 9.3 software (SAS Institute Inc).

Results

One hundred newborns, 51 male (51%) and 49 female (49%), participated in the current study, with no dropouts. Demographic characteristics of the mothers and labor history details are summarized in *Table 1*. Characteristics of the newborns are summarized in *Table 2*. A significant difference was found between head circumferences documented at the initial newborn assessment and those measured at the research examination (concordance correlation coefficient, 0.69; $P<.001$); the mean head circumference measured at birth was 0.74 cm larger (95% CI, 0.52-0.96 cm). Cranial molding was documented significantly more often at the research examination than at the initial newborn assessment (weighted κ, 0.13; $P<.001$), as were overriding sutures (κ, –0.03; $P<.001$); the most common overriding sutures were lambdoidal (left, 82 [82%]); right, 85 [85%]) and coronal (left, 59 [59%]; right, 69 [69%]).

Newborn age at the research examination was negatively associated with the difference between findings at that examination and at the initial newborn assessment for presence of caput succedaneum (P=.003). Age at the research examination was not associated with agreement between the initial newborn assessment and research examination for head circumference, degree of cranial molding, or the presence of cephalohematoma and overriding sutures (all $P>.28$). At the research examination, newborns with no cranial molding were more likely to be older than newborns with mild or moderate molding (mean [SD], 41 [19] hours since birth vs 27 [14] hours; P=.008). Newborns with no caput succedaneum were more likely to be older than newborns with a caput succedaneum (31 [28] hours since birth vs 21 [16] hours; P=.007). Older newborns also had a stronger suckle than younger newborns, but this difference was not significant (31 [15] hours since birth vs 23 [18] hours; P=.07). No association was found between newborn age at the research examination and examination findings for head circumference, cephalohematoma, overriding sutures, facial asymmetry (of the orbits, mouth, or nose), torticollis,

Table 1. Characteristics of Mothers and Labor History (N=100)

Characteristic	Mothers or Deliveries, No. (%)[a]
Maternal Age, mean (range), y	26 (16-49)
Race	
White	89 (89)
Asian	3 (3)
Native American	1 (1)
Black	2 (2)
Other or not recorded	5 (5)
Parity	
Multiparous	59 (59)
Primiparous	41 (41)
Mode of Delivery	
Vaginal	57 (57)
Forceps extraction	1 (1)
Vacuum extraction	3 (3)
Scheduled cesarean	21 (21)
Unscheduled cesarean	22 (22)
Labor Augmentation[b]	
Artificial rupture of membranes	58 (58)
Cervical ripening	14 (14)
Oxytocin	57 (57)
None	31 (31)
Type of Anesthesia[b]	
Epidural	54 (54)
Spinal	32 (32)
Intravenous	3 (3)
None	13 (13)
Duration of Labor, h	
0	25 (25)
<4	14 (14)
4-8	33 (33)
8-12	18 (18)
12-16	5 (5)
16-20	2 (2)
20-24	3 (3)
Duration of 2nd Stage, min	
None	38 (38)
<15	22 (22)
15-29	16 (16)
30-59	7 (7)
60-119	14 (14)
120-179	2 (2)
>180	1 (1)
Head Presentation at Delivery[c]	
Vertex, not otherwise specified	75 (75)
Right occiput anterior	10 (10)
Left occiput anterior	6 (6)
Compound	3 (3)
Right occiput posterior	3 (3)
Right occiput transverse	2 (2)
Breech	2 (2)
Transverse	1 (1)
Left occiput posterior	1 (1)

[a] Data represent No. (%) of mothers or deliveries, except where otherwise specified for maternal age.
[b] Individual deliveries may have involved more than 1 type of labor augmentation or anesthesia.
[c] Three newborns had 2 head presentations at delivery: 2 had compound, right occiput anterior, and 1 had compound, vertex.

or CRI (all *P*>.23). Newborns with a strong, well-coordinated suckle were born at an older gestational age (mean [SD], 38.8 [1.1] weeks) than those with a weak, poorly coordinated suckle (mean, 37.6 [1.9] weeks; *P*=.02).

No relationship was found between the CRI and gestational age (*P*=.12), quality of suckle (*P*=.90), SBS strain pattern (*P*=.79), or cranial quadrant motion restriction (*P*=.52). The frequency and percentage of cranial somatic dysfunctions are shown in *Table 3*. A left torsion pattern was negatively associated with overriding of the right lambdoidal suture (OR, 0.11; 95% CI, 0.02-0.47; *P*=.004), and any torsion pattern was negatively associ-

Table 2.
Characteristics of Newborns (N=100)

Characteristic	Initial Newborn Assessment	Research Examination	Agreement[a]
Female Sex, No. (%)	49 (49)	NA	…
Gestational Age, mean (range), wk	38.5 (35-41)	NA	…
Age at Research Examination, mean (SD; range), h	29.2 (15.7; 6.5-71.8)	NA	…
Weight, mean (SD; range), g	3420 (561; 2300-5300)	NA	…
Apgar Score, mean (range)		NA	…
1 min	8 (3-9)	NA	…
5 min	9 (7-10)	NA	…
Head Circumference, mean (SD; range), cm	34.7 (1.7; 28.0-38.1)	33.9 (1.5; 26.5-37.5)	CCC, 0.69, *P*<.001
Molding, No. (%)		Weighted κ, 0.13; *P*<.001	
None	37 (37)	9 (9)	…
Mild/moderate	58 (58)	89 (89)	…
Severe	5 (5)	2 (2)	…
Caput Succedaneum, No. (%)	16 (16)	22 (22)	κ, 0.22; *P*=.22
Cephalohematoma, No. (%)	4 (4)	7 (7)	κ, 0.14; *P*=.31
Overriding Sutures, No. (%)			
≥1 sutures	27 (27)	97 (97)	κ, −0.03; *P*<.001
None	NA	3 (3)	…
Right coronal	NA	69 (69)	…
Left coronal	NA	59 (59)	…
Right lambdoidal	NA	85 (85)	…
Left lambdoidal	NA	82 (82)	…
Metopic	NA	37 (37)	…
Sagittal	NA	24 (24)	…
Facial Paralysis, No. (%)	NA	1 (1)	…
Facial Asymmetry, No. (%)			
Orbits	NA	67 (67)	…
Mouth	NA	45 (45)	…
Nose	NA	52 (52)	…
Torticollis, No. (%)	NA	3 (3)	…
Quality of Suckle (n=92), No. (%)			
Strong, well-coordinated	NA	76 (83)	…
Weak, poorly coordinated	NA	16 (17)	…
CRI[b], mean (SD; range)	NA	5.3 (1.1; 3-8)	…

[a] Agreement reported as concordance correlation coefficient (CCC),[11,12] weighted κ, or simple κ, with corresponding *P* values.
[b] n=84.

Abbreviations: CRI, cranial rhythmic impulse; NA, not assessed during examination.

Table 3.
Cranial Somatic Dysfunction in Newborns (N=100)

Somatic Dysfunction	Newborns, No. (%)[a]
Occipital Condylar Compression	
None	5 (5)
Right only	46 (46)
Left only	14 (14)
Bilateral	35 (35)
Sphenobasilar Synchondrosis Strain Pattern[a]	
None	1 (1)
Flexion	0 (0)
Extension	1 (1)
Torsion	17 (17)
Right	3 (3)
Left	9 (9)
Not specified[b]	5 (5)
Sidebending rotation	63 (63)
Right	25 (25)
Left	11 (11)
Not specified[b]	27 (27)
Vertical strain	20 (20)
Inferior	0 (0)
Superior	7 (7)
Not specified[b]	13 (13)
Lateral strain	7 (7)
Right	5 (5)
Left	0 (0)
Not specified[b]	2 (2)
Compression	4 (4)
Temporal Bone Restriction	
None	15 (15)
Right	59 (59)
Left	10 (10)
Bilateral	16 (16)
Quadrant Motion Restriction[c]	
None	3 (3)
Right frontal	63 (63)
Left frontal	24 (24)
Right occipital	71 (71)
Left occipital	44 (44)

[a] Two strain patterns were identified in 11 newborns, and 3 in 1 newborn.
[b] Directionality of torsions, sidebending rotations, vertical strains, and lateral strains was not recorded for the first 44 newborns evaluated.
[c] Seventy-eight newborns had 2 or more cranial quadrant motion restrictions.

ated with overriding of the right coronal (OR, 0.32; 95% CI, 0.11-0.93; *P*=.03) and right lambdoidal (OR, 0.22; 95% CI, 0.06-0.83; *P*=.02) sutures. A left sidebending rotation strain pattern was negatively associated with overriding of the metopic suture (OR=0.14; 95% CI, 0.01-0.92; *P*=.05). A superior vertical strain pattern was positively associated with overriding of the left coronal suture (OR=12.3; 95% CI, 4.6-no upper bound; *P*=.04). Having any sidebending rotation pattern was positively associated with asymmetry of the nose (OR=2.50; 95% CI, 1.01-5.75; *P*=.03). There was a positive association with right frontal cranial quadrant motion restriction and the presence of a right sidebending rotation strain pattern (OR, 4.8; 95% CI, 1.44-16.2; *P*=.007) and a negative association with left occipital cranial quadrant motion restriction and any sidebending rotation strain (OR, 0.37; 95% CI, 0.16-0.84; *P*=.02).

The mean (SD) SDSS was 13.6 (3.15), with a range of 6 to 23. These scores did not differ significantly by examiner team (*P*=.13). *Table 4* summarizes the correlation between the SDSS and other findings, including labor history and newborn characteristics at the initial newborn assessment and the research examination. The SDSS was correlated with duration of labor among all newborns (n=100) using midpoint intervals (0, 2, 6, 10, 14, 18, or 22 hours). The estimated slope revealed that for every hour increase in labor, the predicted value of SDSS increased by 0.12 points (*P*=.04). However, when only newborns whose mothers labor were included in the analysis (n=75), the hourly increase in SDSS (0.15 points) was not significant (*P*=.07). No significant difference was found in SDSS between planned and unplanned cesarean deliveries (*P*=.26). The vaginal deliveries included only 3 recorded vacuum extractions (SDSS, 10, 13, and 14) and 1 forceps extraction (SDSS, 13), so no correlations were found between modes of delivery. With the head presentation at delivery recorded as "vertex, not otherwise specified" for 75 newborns (*Table 1*), the data were not specific enough for us to assess any association between head presentation and somatic dysfunction.

Table 5 and *Table 6* summarize the incidence of segmental motion restriction in the cervical, lumbar, and sacral regions. The incidence of motion restriction was highest at C1 (63 [63%]) in the cervical spine, at L1 (58 [58%]) in the lumbar spine, and at S2 on the left side (53 [53%]) in the sacral spine. The presence of S1

Table 4.
Correlation Between SDSS and Maternal and Newborn Characteristics

Characteristic[a]	SDSS, Mean (95% CI)	Regression Coefficient (SE)	*P* Value
Gestational Age, wk	…	0.03 (0.04)	.52
Age at Research Examination, h	…	0.004 (0.02)	.84
Maternal Parity	…	−0.7 (0.6)	.28
Multiparous	13.3 (12.5-14.1)	…	
Primiparous	14.0 (13.0-15.0)	…	
Mode of Delivery			.49
Vaginal	13.5 (12.6-14.3)	…	
Scheduled cesarean[b]	13.2 (11.8-14.6)	−0.3 (0.8)	.73
Unscheduled cesarean[b]	14.3 (12.9-15.6)	0.8 (0.8)	.32
Labor Augmentation[c]			.54
Artificial rupture of membranes[d]	14.0 (12.5-15.4)	0.93 (0.8)	.22
Cervical ripening[d]	13.0 (10.9-15.0)	−0.09 (0.9)	.93
Oxytocin[d]	13.1 (11.6-14.6)	0.03 (0.8)	.97
None	13.1 (12.0-14.1)	…	
Type of Anesthesia[e]			.35
Epidural	14.0 (13.2-14.9)	1.5 (0.9)	.11
Spinal	13.2 (12.1-14.3)	0.7 (1.0)	.50
Intravenous	13.8 (10.2-17.5)	1.3 (1.9)	.50
None	12.5 (10.9-14.2)	…	
Duration of Labor, h			
0 to 24[f]	…	0.12 (0.06)	.04
>24[g]	…	0.15 (0.08)	.07
Duration of 2nd Stage, h	…	0.5 (0.5)	.32
Apgar Score			
1 min	…	0.2 (0.7)	.71
≤8	13.7 (12.9-14.5)	…	
≥9	13.4 (12.4-14.5)	…	
5 min	…	−0.5 (1.2)	.67
≤8	13.1 (10.9-15.3)	…	
≥9	13.6 (13.0-14.3)	…	
Head Circumference, cm	…	−0.12 (0.21)	.59
Caput Succedaneum	…	−0.7 (0.8)	.36
No	13.4 (12.7-14.1)	…	
Yes	14.1 (12.8-15.5)	…	
Cephalohematoma	…	−0.7 (1.2)	.55
No	13.5 (12.9-14.2)	…	
Yes	14.3 (11.9-16.7)	…	
Quality of Suckle	…	−0.7 (0.9)	.39
Strong	13.6 (12.9-14.3)	…	
Weak	14.4 (12.8-15.9)	…	
CRI	…	−0.20 (0.32)	.54

[a] The *P* value for the overall significance of the relationship to the somatic dysfunction severity score (SDSS) is included next to each characteristic. Continuous characteristics only have a regression coefficient estimate. Categorical characteristics with 2 levels include the mean SDSS at each level and the regression coefficient for the nonreference level. Categorical characteristics with more than 2 levels include the mean SDSS at each level, the regression coefficient for nonreference levels, and the *P* value for the significance between each nonreference level and the reference level. The reference level is the first one listed, except for “Labor Augmentation” and “Type of Anesthesia,” for which the reference level is “none.”
[b] SDSS for infants born via cesarean deliveries were compared with infants born via vaginal deliveries.
[c] Mothers may have accepted more than 1 type of labor augmentation and anesthesia.
[d] SDSS for infants born delivered with labor augmentation were compared with infants born without labor augmentation.
[e] SDSS for infants born delivered with maternal anesthesia were compared with infants born without maternal anesthesia.
[f] n=100. Includes both mothers who labored before delivery and those who did not labor before delivery, regardless of mode of delivery.
[g] n=75. Includes only mothers who were in labor before delivery, regardless of mode of delivery.

Abbreviation: CRI, cranial rhythmic impulse.

Table 5.
Segmental Motion Restriction in the Cervical and Lumbar Regions in Newborns (N=100)

Spinal Region	Motion Restriction Present, No. (%)
Cervical Spine	
C1	63 (63)
C2	62 (62)
C3	28 (28)
C4	22 (22)
C5	21 (21)
C6	43 (43)
C7	42 (42)
None	9 (9)
Lumbar Spine	
L1	58 (58)
L2	56 (56)
L3	21 (21)
L4	21 (21)
L5	42 (42)
None	6 (6)

motion restriction was correlated with the asymmetry of the sacral base, which is the uppermost portion of S1.[20] Eighty-three newborns (83%) had unilateral S1 motion restriction. Of those 52 newborns with left-sided unilateral S1 motion restriction, 46 (88%) had a left-sided posterior sacral base, 9 (17%) had a right-sided anterior sacral base, 4 (8%) had no sacral base asymmetry, 2 (4%) had a left-sided anterior sacral base, and none had a right-sided posterior sacral base. Of those 31 newborns with right-sided unilateral S1 motion restriction, 19 (61%) had a right-sided posterior sacral base, 7 (23%) had no sacral base asymmetry, 5 (16%) had a right-sided anterior sacral base, 4 (13%) had a left-sided posterior sacral base, and 3 (10%) had a left-sided anterior sacral base. Unilateral restricted S1 motion was significantly associated with the presence of an ipsilateral posterior sacral base (P<.001).

Discussion

The current study found a significant correlation between the total number of identified somatic dysfunctions, calculated as the SDSS, and the duration of labor. For every hour increase in the duration of labor, the predicted SDSS increased by 0.12 points; for every 4 hours of labor, it increased by a half point. This finding suggested that longer labor leads to a slight increase in somatic dysfunction in newborns, which may be a result of greater cranial molding. Sorbe and Dahlgren[21] found that cranial molding in newborns was statistically significantly affected by the length of second stage labor, primiparity, and use of oxytocin augmentation. In our study, we found no correlations between somatic dysfunction and duration of second stage labor, maternal parity, mode of delivery, or labor augmentation.

The majority of newborns (63%) in the current study had either a right or a left sidebending rotation SBS strain pattern. In a 2013 study, Pizzolorusso et al[8] examined 150 full-term and preterm newborns (mean [SD] gestational age, 35.5 [3.4] weeks) in a single hospital neonatal intensive care unit and found that 4% had sidebending rotation strain patterns, whereas 37% had SBS compressions. In comparison, the current study identified a 4% incidence of SBS compressions. This variation may result from the subset of preterm and thus potentially critically ill newborns studied by Pizzolorusso et al[8] vs the healthy newborns of the current study. Further, those authors found fairly equal incidence of left-sided (31%) and right-sided (30%) occipital condyle compression but did not assess for bilateral restriction; they also noted somatic dysfunction in the cervical (2%), lumbar (21%), and sacral (37%) regions.[8] In the current study, we found a much higher incidence of somatic dysfunction, with the majority of newborns having cervical (91%) and lumbar (94%) motion restriction and at least 80% of newborns having asymmetry at the sacral base. These variations in study findings were probably a result of protocol differences: Pizzolorusso et

Table 6.
Segmental Motion Restriction in the Sacral Region in Newborns (N=100)

	Motion Restriction, No. (%)				
Spinal Region	**Present**	**Right Only**	**Left Only**	**Bilateral**	**None**
Sacrum					
S1	93 (93)	31 (31)	52 (52)	10 (10)	7 (7)
S2	85 (85)	30 (30)	53 (53)	2 (2)	15 (15)
S3	37 (37)	12 (12)	24 (24)	1 (1)	63 (63)
Sacral Base[a]					
Anterior	26 (26)	21 (21)	5 (5)	0	74 (74)
Posterior	80 (80)	21 (21)	58 (58)	1 (1)	20 (20)

[a] Unilaterally, the sacral base could be either anterior or posterior, but not both.

al[8] assessed tissue texture abnormalities, areas of asymmetry, and misalignment of bony landmarks, whereas we specifically assessed for segmental motion restriction of the cervical and lumbar regions.

In the current study, we found that head circumferences measured by attending physicians and nurses at birth during the initial newborn assessment were significantly larger than those measured by the examiners during the research examination and that this difference did not depend on newborn age at the time of the research examination. Although the difference in measurements may represent interexaminer error, it was more likely a result of soft-tissue swelling or cranial molding in the immediate postnatal period. This supposition is supported by the significant decreases in cranial molding and caput succedaneum that we found in older newborns. Other studies have also noted that head circumference decreases in the first few postnatal days.[22-24] Souza et al[23] found that this decease occurs in newborns after both vaginal and cesarean deliveries and that head circumference gradually begins to increase 1 to 2 weeks after birth. Overall, these findings suggest that the cranium continues to change for several weeks after birth, and future studies should assess changes in somatic dysfunction longitudinally.

In the current study, we also found a statistically significant difference in the identification of overriding sutures between the initial newborn assessment and the research examination. Examiners of the current study found overriding sutures in 72 newborns whose initial newborn assessment found none. This finding suggests that sutures were assessed differently by the study examiners than by the attending physicians and nurses. Because we evaluated each suture individually, our examination was probably a more precise and detailed examination for overriding sutures, resulting in only slight agreement with the initial newborn assessment.

The current study had several limitations. All physical examination findings are inherently subjective, especially when attempting to discern small differences in severity, but our examiner team had worked together for 8 years and shared a very similar palpatory assessment style, which may vary from that used by other clinicians and thus affect the reproducibility of our findings. Our palpatory protocols also probably varied from those used in other published studies of somatic dysfunction in newborns, so results should be compared cautiously. Because the cervical and lumbar vertebrae in newborns are very small, the specified locations must be considered approximate rather than precise. The predominance of white newborns in the current study prevented us from assessing racial variations in the findings. As another limitation, the statistically significant decreases in cranial molding and caput succedaneum and the improved quality of suckle in older newborns suggest that changes are still occurring well past 6 hours after delivery in healthy newborns.

The use of healthy newborns in the current study was meant to provide a baseline incidence of somatic dysfunction in newborns, but no correlations were made to health outcomes. Because newborns who had received OMT before enrollment in the study were excluded from participation, some newborns with more severe somatic dysfunction may have been excluded from the study. We did not document the number of newborns excluded because they had received OMT, but it was probably small because participating attending physicians had agreed to postpone OMT until after the research examination.

Conclusion

The current study established a baseline incidence of somatic dysfunction in healthy newborns and showed a statistically significant correlation between the total somatic dysfunction identified and the duration of labor. We did not find any correlation between somatic dysfunction and either delivery mode or maternal parity. Our findings support those of previous studies showing decreased head circumference in the immediate postnatal period. The next steps in this line of research are to assess the natural progression of untreated somatic dysfunction over time, identify conditions associated with a higher incidence of somatic dysfunction, and assess the health outcomes of OMT for somatic dysfunction in newborns.

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Author Contributions

All authors provided substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; all authors drafted the article or revised it critically for important intellectual content; all authors gave final approval of the version of the article to be published; and Dr Snider and Ms Pazdernik agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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