



Defining the nature and implications of head turn preference in the preterm infant



Sonya Dunsirn^a, Christopher Smyser^{b,c,e}, Steve Liao^b, Terrie Inder^d, Roberta Pineda^{a,b,*}

^a Program in Occupational Therapy, Washington University School of Medicine, St. Louis, MO, United States

^b Department of Pediatrics, Washington University School of Medicine, St. Louis, MO, United States

^c Department of Radiology, Washington University School of Medicine, St. Louis, MO, United States

^d Department of Pediatric Newborn Medicine, Brigham and Women's Hospital, Boston, MA, United States

^e Department of Neurology, Washington University School of Medicine, St. Louis, MO, United States

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ABSTRACT

Aim: To determine the relationship of head turn preference in the preterm infant to: 1) perinatal medical factors, 2) neonatal neurobehavior, and/or 3) infant neurodevelopmental outcomes.

Methods: Seventy preterm infants born ≤ 30 weeks gestation were enrolled at birth. Detailed information regarding neonatal intensive care unit (NICU) medical course was compiled for each infant. Neurobehavioral testing was performed during NICU hospitalization. Head turn preference was quantified at term equivalent age using a newly developed scale. Infants returned at age two years for standardized developmental testing.

Results: All infants demonstrated a head turning preference, with most preferring the right side ($n = 51, 77\%$). Fifty-five infants (79%) had moderate to severe head turn preference. Head turn preference was associated with 1) medical severity (hours of inotrope use, $p = 0.02$; oxygen requirement at 36 weeks postmenstrual age, $p = 0.03$), 2) worse neurobehavioral performance (decreased self-regulation, $p = 0.007$; more sub-optimal reflexes $p = 0.006$), and 3) worse developmental outcome at age two years (poorer fine motor, $p = 0.02$).

Interpretation: Medical factors in the NICU appear to be associated with the development of a head turn preference. Increased severity of head turn preference may be a marker for poor developmental outcome. Early identification may inform therapeutic interventions designed to minimize symptoms and optimize neurodevelopmental outcome.

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Head turn preference in the newborn infant is defined as preferred positioning of the head to one side, a strong push of the head into rotation to one side, and/or an inability to achieve or maintain the head in midline position. Head turning during the neonatal period has been described as a typical developmental phenomenon, and may also be implicated in the development of laterality and hand-preference [1–3]. Neonatal head turning to the right is more common, consistent with the larger proportion of people who are right handed [4]. The persistence of head turning to the right into adulthood, within various activities of daily living that do not utilize handedness, has also been reported [5].

While some head turning during the neonatal period and beyond may be normal and developmentally-regulated, significant head turn preference may negatively impact developmental progression. Head turn preference in high risk infants can impact function, as head rotation results in reflexive extension of the extremities on the side of the head turn and flexion on the opposite side, leading to asymmetric movement patterns [6,7]. Prolonged time with the head rotated to one side can impact reflex patterns, muscle tone, and movement for later function. In addition,

severe head turn preferences may promote asymmetric movements in early infancy [8,9] and lead to future complications in posture [10–12]. Postural asymmetries, including infantile postural scoliosis, torticollis, and an asymmetrical skull shape including deformational plagiocephaly also result from prolonged head turn preference [13–17]. Visual orientation and social interaction also rely on midline head orientation [18,19].

It remains unclear what factors may be influencing severe head turn preference and when its presence can be related to altered developmental trajectory [20]. Neonatal head turning can be influenced by caretaking, specifically right-handed caregivers or those who approach predominately on the right side, which encourages head positioning to the right [21]. While this head turning may resolve as environmental interactions become balanced, this may not be the case with preterm infants who spend several months in an environment with imposed positioning. Medical interventions during the neonatal intensive care unit (NICU) hospitalization may also play a role in the development of head turn preference in preterm infants. Some interventions, such as endotracheal intubation, often result in passive rotation of the neck to one side for prolonged periods of time, contributing to development of head turn preference. These variables likely contribute to the higher rates of head turn preference present in preterm infants compared to their term-born peers [16,22,23]. While normal environmental factors

* Corresponding author at: PhD, OTR/L Washington University School of Medicine Program in Occupational Therapy, 4444 Forest Park Parkway, St. Louis, MO 63116, United States.

can influence sidedness [24], it remains unclear how the early environment as well as medical complications, including cerebral injury, can influence severe head turn preference in preterm infants.

While head turn preference has been described using assessments of active and passive range of motion, there are few bedside clinical tools to assess head turn preference. To better understand head turn preference in the high-risk infant and discriminate mild head turning from more severe forms of head turn preference, we developed a new head turn preference scale. This tool was subsequently used to determine if head turn preference among preterm infants is: 1) associated with NICU medical factors, 2) related to early neurobehavior, and 3) a marker for adverse developmental outcome at two years of age.

1. Methods

1.1. Study site and participants

Infants were prospectively enrolled as part of an overarching study aimed at investigating longitudinal neurodevelopment of preterm infants. Infants were born at ≤ 30 weeks estimated gestational age (EGA) from 2007 to 2010, free of congenital anomalies, and enrolled within the first 72 h of life from a level III–IV NICU. Infants received routine care in the NICU and also underwent magnetic resonance imaging (MRI) and videotaped neurobehavioral testing during their NICU course. Participants returned for developmental testing at two years of age. This study used a subset of infants from the parent study, which included all infants who underwent videotaped neurobehavioral assessments that were of adequate quality to enable head turn preference assessment. This study was approved by the Human Research Protection Office at Washington University, and the parents of all participating infants provided informed consent.

1.2. Early medical factors

For all infants, information was collected from the electronic medical record on medical factors including: EGA at birth, birth weight, number of days on mechanical and high frequency oscillatory ventilation, number of days on continuous positive airway pressure (CPAP), hours of oxygen use (ventilation, CPAP, or oxygen delivered by nasal cannula), oxygen requirement at 36 weeks, hours of inotrope use, Clinical Risk Index for Babies score [25], number of days on total parental nutrition, patent ductus arteriosus (treated with indomethacin or surgical ligation), necrotizing enterocolitis (all stages), cerebral injury, and postmenstrual age (PMA) at discharge. Cerebral injury was identified using routine cranial ultrasound and MRI and defined as the presence of grade III or IV intraventricular hemorrhage, cystic periventricular leukomalacia, and/or cerebellar hemorrhage. A single trained neonatal neurologist (author TI) defined the presence or absence of cerebral injury based on imaging findings.

1.3. Neurobehavioral testing

Neurobehavioral testing was conducted at 34 weeks PMA and again at term equivalent age (37–41 weeks PMA), using the NICU Network Neurobehavioral Scale (NNNS). These videotaped assessments were conducted at the infant's bedside by a single certified examiner (author RG). The NNNS yields 13 summary scores including measures of habituation, orientation, arousal, self-regulation, hypertonia, hypotonia, stress, lethargy, excitability, sub-optimal reflexes, asymmetry, quality of movement, and tolerance of handling [26].

1.4. Head Turn Preference Scale Score

From the videotaped neurobehavioral evaluations, head turn preference was quantified using a newly developed scale (see Appendix A). Scores on the Head Turn Preference Scale range from 0 to 10, with

higher scores indicating greater head turn preference. Numerical scores are then categorized into no (score of 0), minimal (scores of 1–3), moderate (scores of 4–6), or severe (scores of 7–10) head turn preference. The score measures head turn preference by identifying: 1) whether a head turn preference is present at rest, and if so, how much cervical rotation is entailed, 2) the severity of head turn preference by observing the force exerted by the head to move into the preferred position, and 3) whether there are restrictions in neck rotation during passive range of motion. The scale was developed in an attempt to quantify head turn preference while discriminating mild head turning from severe forms of head turn preference that result in strong pushing and decreased range of motion of neck rotation.

Reliability of the Head Turn Preference Scale was determined using four trained occupational therapists. The therapists engaged in a training session in which the scale was described and videos were reviewed and scored until agreement was reached (three videos). Following the training period, five videos were randomly selected from the cohort and presented in random order to the therapists. Inter-rater reliability was assessed using Fleiss' Kappa statistics. There was 100% agreement in defining the head turn preference category (none, minimal, moderate, severe), resulting in a Fleiss' Kappa value of 1. The Fleiss' Kappa value for Domain 1 was 0.01 (Item 1 in Domain 1: 0.55; Item 2 in Domain 1: 0.30; Item 3 in Domain 1: 0.08; Item 4 in Domain 1: 0.26); Domain 2 was 0.59; and Domain 3 was 0.38. This demonstrates good reliability using the categorical variable, but poor reliability of individual items. Therefore, the categorical variable was used for all analyses.

1.5. Developmental outcome at age two years

Infants returned for developmental testing at two years of age using the Bayley Scales of Infant and Toddler Development-Third Edition (Bayley-III) [27]. Bayley-III composite scores for cognitive, language, and motor outcome as well as subscale scores for expressive and receptive language and fine and gross motor outcome were used to determine the associations between head turn preference and developmental outcome at age two years.

1.6. Statistical analyses

Early medical factors were explored for associations with the Head Turn Preference Scale score with chi-square analysis and logistic regression using $\alpha = .05$. Associations between Head Turn Preference Scale score and developmental outcomes (NNNS summary scores and composite and subscale scores on the Bayley-III at age two years) were investigated using logistic regression models. A multivariate model was also used to investigate relationships between head turn preference and developmental outcomes, while controlling for clinical factors related to head turn preference and known to affect developmental outcome. This was an exploratory study, aimed at defining relationships between head turn preference and medical factors and developmental outcome.

2. Results

Seventy infants in the cohort underwent videotaped neurobehavioral assessments and were used for this investigation. See Table 1 for sample descriptives and relationships between NICU factors and head turn preference.

2.1. Head turn preference

All participants demonstrated a head turn preference with 15 (21%) being mild, 17 (24%) being moderate, and 38 (54%) being severe. The Head Turn Preference Scale score ranged from 1 to 9 with a mean (standard deviation) of 5.9 (2.4). Fifty-one (77%) preferred the right, 15 (23%) preferred the left and 4 (18%) varied their preference with head

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