Reference Values for Range of Motion and Muscle Function of the Neck in Infants

Anna Maria Öhman, PT, MSc, and Eva R.E. Beckung, PT, PhD

Department of Physiotherapy, The Queen Silvia Children's Hospital, Sahlgrenska University Hospital/Ostra, Göteborg, Sweden

Purpose: To determine reference values for cervical range of motion (ROM) in rotation and lateral flexion and for muscle function in the lateral neck flexors in a sample of infants who were healthy. Method: ROM was measured, and muscle function was estimated in 38 infants at the ages of 2, 4, 6, and 10 months. Results: For rotation the mean ROM was 110° and for lateral flexion it was 70°. Infants of 2 months of age had a median muscle function score of 1 (interquartile range, 1–2). Muscle function increased to score 3 to 4 by 10 months. Conclusion: Infants below 1 year of age have good ROM in rotation (≥110°) and lateral flexion (≥65°) of the neck. These reference values for passive ROM and muscle function of the neck may have clinical utility in assessing and documenting the initial evaluation and progress of infants with congenital muscular torticollis. (Pediatr Phys Ther 2008;20:53–58)

Key words: human movement system, infant, muscle strength, neck, range of motion, reference values

INTRODUCTION

Congenital muscular torticollis (CMT) is a result of shortening or excessive contraction of the sternocleidomastoid muscle, often with limited range of motion (ROM) in rotation on the affected side and in lateral flexion on the nonaffected side. The reported incidence in the world is 0.4% to 2.0%. In recent years, we have noticed an increase in infants with CMT that might be related to the fact that many infants spend little or no awake time in the prone position. Measuring ROM is an essential part of the physiotherapy assessment for children with CMT for grading the severity of CMT and when evaluating the outcome after intervention.

According to different authors, ROM in neck rotation is considered to be normal or excellent at 75° to 120°. In lateral flexion the variation is 40° to 90° (Table 1). All these studies were performed on infants with CMT and there are no reference values to be found in the literature for infants who are healthy. The current study is unique in that it examines infants without CMT who are healthy. To be able to compare treatment results between centers or investigators there is a need for reference values for cervical spine mobility.

The pediatric cervical spine approaches the adult configuration at 8 years of age. The atlas, axis, and sub-axial spine each have unique patterns of ossification. General agreement exists among investigators regarding the age-related effect on ROM of the extremity joints of newborns, infants, and young children up to about 2 years of age. Mean values for these age groups differ by more than 2 standard deviations (SD) from adult mean values published by the American Academy of Orthopedic Surgeons, the American Medical Association, and Boone and Azen, according to Norkin et al. It may also be possible that ROM in the neck differs by more than 2 SD from adults mean values. Youdas et al found cervical rotation and lateral flexion to be significantly associated with age. They believe that both genders lose approximately 3° of rotation and lateral flexion after every 10 years.

For many children with CMT there is also an imbalance in muscle function, ie, they have a lack of muscular strength and endurance around the neck on the nonaffected side and sometimes excessive muscular strength on the affected side. Several authors have described the lateral head righting reaction on the contralateral side as weaker compared with the affected side. The imbalance of
muscle function is often either briefly mentioned or not mentioned at all in publications on CMT. The muscle function scale (MFS) was originally developed at the Astrid Lindgrens Children’s Hospital, Sweden specifically to assess lateral head righting in infants. The MFS was originally developed as a three-point ordinal scale (0 = below horizontal, 1 = at horizontal line, and 2 = above horizontal) and was expanded to five-point scale at Queen Silvia Children’s Hospital, Sweden as detailed in Appendix A. The MFS is used in clinic and was tested for content and construct validity by a panel of experts. The panel consisted of five pediatric physical therapists with a mean of 23 years experience in assessment of muscle function in children with muscle diseases. Reliability was tested during spring 2006; 10 physiotherapists and four students tested inter and intrarater reliability. Sixty-eight photos of infants with the head in different positions were observed and test and retest reliability was done with at least 1 week between observations. In the panel of experts the content and construct validity was found to be good, and the weighted Kappa score for intrarater and interrater was greater than 0.9.

The purpose of this study was to find reference values for cervical ROM in rotation, and lateral flexion and reference values for muscle function of the lateral flexor muscles of the neck for infants younger than 1 year who are healthy. As a part of the study, screening for potential correlation between muscle function score and birth weight and between muscle function score and birth length was carried out. Also screening was carried out to investigate any potential difference between genders.

METHOD

Between October 2004 and October 2005, the parents of infants under the age of 2 months were invited to participate through two of the 28 Child Health Centers in Gothenburg, Sweden. The majority of the inhabitants in Sweden are of the same ethnicity (85% Caucasian), and in light of this it was a homogeneous group of infants who participated in this study.

Thirty-eight infants (19 girls and 19 boys) who were born full-term and were healthy participated. Infants with any known disease or syndrome were excluded from the study. Each infant was evaluated on two to four occasions at the ages 2, 4, 6, or 10 months (±1 week), at the Department of Physiotherapy at the Queen Silvia Children’s Hospital in Gothenburg. The local ethical committee of Gothenburg University approved the study.

Neck rotation was measured with an arthrodial protractor.1 The infant was lying supine on the examination table with the shoulders stabilized. The examiner supported the head and neck in the neutral position, over the edge of the examination table (Fig. 1). In this position the neck could be rotated and moved freely in all directions. According to Cheng et al1 there is an interexaminer reliability correlation coefficient of 0.71 for neck ROM in infants.

Lateral flexion was measured with the infant lying in supine on a large protractor with the shoulders stabilized (Fig. 2).11,13 This method was found to have a high intrarater reliability with the interclass correlation coefficient reported as 0.94 to 0.98.14

The maximal values for passive ROM (PROM) in rotation and lateral flexion of the cervical spine were recorded; both left and right sides were measured. The infant’s mood and willingness to cooperate indicated when to stop; if any infant was tense and uncooperative the measurements were discontinued.
Muscle function of the lateral flexor muscles of the neck was estimated in the same sample of infants using the MFS, a 5-degree scale with scores from 0 to 4 (Appendix A). By holding the infant horizontally around the trunk without support for the head (Fig. 3), the lateral head righting reaction was estimated. If the infant held the head below the horizontal line a score of 0 was given, holding the head on the horizontal line scored 1, holding slightly over the horizontal line scored 2, holding high over the horizontal line scored 3, and very high over the horizontal line was scored 4. The infant had to hold the head for at least 5 seconds on one level to achieve the score for that level otherwise it would be scored at the level below. In the current study, one pediatric physiotherapist (A.M.O.) who is experienced in evaluating infants with CMT using these methods was responsible for carrying out all the measurements. Her intrarater reliability for ROM measures is 0.90 to 0.99 (interclass correlation coefficient) and for the MFS estimates interrater reliability was 0.97 and for intrarater reliability 0.99 (weighted Kappa). The infant’s birth weight and length were recorded from parents report.

**Statistical Analysis**

The mean, the SD, and the ranges were determined for PROM in rotation and lateral flexion. Mean and ranges were calculated for the MFS score.

For each measured age, the Pearson correlation test was used to screen for possible correlation between birth weight and MFS score and between birth length and MFS score. The Mann-Whitney test was used to screen for any difference between genders. The SPSS statistical programme was used and p-values of 0.05 or less were considered evidence of statistically significant findings.

**RESULTS**

One hundred four measurements of rotation, 112 measurements of lateral flexion, and 128 estimates of muscle function were performed (Table 2). One infant participated only on one occasion because the parents felt that traveling to the hospital was too time consuming; all other infants participated on two to four occasions.

In neck rotation the mean PROM was 110° (SD 6.2°). In lateral flexion the mean PROM was 70° (SD 2.2°) (Table 3). The measurements of rotation at 2 months of age were about 5° less than the measurements at 4, 6, and 10 months of age (Table 4). For infants measured on several occasions there was a variation between occasions of maximal PROM in rotation of ±5° to 10°. There were no definite trends observed with regard to these variations within each infant.

Two-month-old infants had a mean MFS score of 1.0 and range of 0 to 2, those 4 months of age had a mean score of 2.6 and range of 1 to 4, those 6 months of age had a mean score of 3.0 and range of 2 to 4, and those 10 months of age had a mean score of 3.4 and range of 3 to 4 (Table 5). No correlation between MFS score and birth weight or between MFS score and birth length was found. Also there was no significant difference found in muscle function between genders. One infant had a difference of 5° between the right and left side in rotation. Two infants had a difference in muscle function of one point between the right and left sides with one of these infants having a tendency to tilt her head marginally. All the other infants had symmetric muscle function according to the MFS.

**DISCUSSION**

The purpose of this study was to find reference values, by examining infants who are healthy and below 1 year of age, for

![Fig. 3. Testing muscle function, ie, strength/endurance.](image)
cervical ROM in rotation and lateral flexion and for muscle function in the lateral flexor muscles in the neck. Such reference values may be useful when evaluating infants with CMT. The reference values describe the examined sample of infants; these results may not generalize to other samples from other populations. The term reference value is preferable to normal because it cannot be claimed that everyone who falls outside the reference range is abnormal.

In our study, mean neck rotation was 110°, which differs from that reported by some authors. Taylor et al. stated that 75° or more is excellent, while Golden et al. and Cheng et al. stated that 90° is normal, and Cheng et al. that 110° is normal. In addition Emery and Bartlett stated that 100° to 120° is normal. Bartlett is sometimes used as reference for normal rotation of the neck of 110°. This value of 110° was found by Bartlett on the nonaffected side for children with CMT, but rotation was not investigated on healthy infants (Personal communication, 2006). Based on our results and those of other authors, 75° reported by Taylor et al. as excellent ROM seems low. We recommend 100° or greater to be used as reference value for excellent ROM in rotation.

In our point of view during examination it is important to eliminate external conditions that can limit neck rotation, eg, the infant lying with the head on a surface. Our experience is that the surface limits the rotation to about 70°. Rotation should be performed as isolated as possible to avoid purposely measuring mixed motions.

For infants who were measured on several occasions there was a variation of ±5° to 10° in rotation from the mean value of these infants. The infants at 2 months of age had approximately 5° lower mean in rotation than infants of other ages. This could be due to measurement error and also the infant’s mood and distractibility could have had some effect on the measured values. The infant’s neck length, adipose tissue, and cheek size may result in potential differences in neck ROM.

The method for measuring PROM in lateral flexion in our study was used in three other studies that evaluated the status of children who had already received treatment for CMT. Golden et al. considered lateral flexion to be normal if the ear on one side could be brought gently to the shoulder without incurring a muscular restriction while stabilizing the other shoulder. This is often observed in clinic as children with CMT typically have very good movement in the nonaffected side. In our study mean lateral flexion was 70°, which differs from reports of some authors. Taylor et al. considered a PROM of lateral flexion of 40° or more to be excellent. From our point of view lateral flexion of 40° represents limited ROM and is considered poor for an infant. Emery and Bartlett claimed that normal ROM for lateral flexion is 85° to 90°. In this study, it was impossible to obtain 90° mobility because of the position of the cheek. At most we achieved 75°, Bartlett measured lateral flexion with a slight forward flexion and a rotation of approximately 10°. This may explain the difference in values found in our study and those reported by Bartlett.

Taylor et al. found that the lateral head righting reaction was incomplete for all children with CMT before treatment; this is commonly seen in clinic. The MFS enabled us to assess for potential neck muscle imbalance in children with CMT. The scale has clinical utility in that it may provide an objective measure at initial evaluation and of progress after intervention. The importance of reference values is that they offer the possibility to estimate potential weakness or extreme strength. Our clinical experience is that it is common to find a difference of two to three MFS scores between the affected and nonaffected side in infants with CMT. Our results suggest that this is rare for infants who are healthy to have an imbalance. Only two infants in our study had a left–right difference and only by one point. It is possible that these two infants had a very mild form of CMT; one of them had a tendency to tilt her head marginally. Most of the infants who were healthy at 2 months of age scored 1 on the MFS in our study; our experience shows that infants with CMT. The scale has clinical utility in that it may provide an objective measure at initial evaluation and of progress after intervention. The importance of reference values is that they offer the possibility to estimate potential weakness or extreme strength. Our clinical experience is that it is common to find a difference of two to three MFS scores between the affected and nonaffected side in infants with CMT. Our results suggest that this is rare for infants who are healthy to have an imbalance. Only two infants in our study had a left–right difference and only by one point. It is possible that these two infants had a very mild form of CMT; one of them had a tendency to tilt her head marginally. Most of the infants who were healthy at 2 months of age scored 1 on the MFS in our study; our experience shows that infants with CMT usually score 0 in the nonaffected side at this age.

General muscle strength in older children increases with age, weight, and height and differs between genders. Similarly, infants increase in strength according to the MFS during their first year. We did not find any significant correlation between the MFS score and birth weight or birth length nor any difference between genders. Nystrom Eek et al. did not find any major differences in torque between genders until the age of 12 years.

The strength of this study is that it was performed on infants who were healthy and that the same evaluator examined all the infants. The limitations of the study are that there were a rather small number of participants all of whom were healthy.

### TABLE 4
Mean Measurements of Rotation and Lateral Flexion at the Ages of 2, 4, 6, and 10 Months

<table>
<thead>
<tr>
<th>Measurement</th>
<th>At 2 Months of Age (°)</th>
<th>At 4 Months of Age (°)</th>
<th>At 6 Months of Age (°)</th>
<th>At 10 Months of Age (°)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotation mean</td>
<td>105.2</td>
<td>111.8</td>
<td>112.4</td>
<td>111.7</td>
</tr>
<tr>
<td>Lateral flexion mean</td>
<td>68.1</td>
<td>69.5</td>
<td>69.2</td>
<td>70</td>
</tr>
</tbody>
</table>

### TABLE 5
Norms for Muscle Function, ie, Strength/Endurance for Healthy Infants According to an Ordinal Muscle Function Scale 0 to 4

<table>
<thead>
<tr>
<th>Strength/Endurance At Ages</th>
<th>Mean</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 months</td>
<td>1.0</td>
<td>0–2</td>
</tr>
<tr>
<td>4 months</td>
<td>2.6</td>
<td>1–4</td>
</tr>
<tr>
<td>6 months</td>
<td>3.0</td>
<td>2–4</td>
</tr>
<tr>
<td>10 months</td>
<td>3.4</td>
<td>3–4</td>
</tr>
</tbody>
</table>

Muscle function estimated by holding the infant horizontally using the lateral head righting reaction. Head position estimated in relation to the horizontal line, 0 = below, 1 = on the line, 2 = slightly over, 3 high over, and 4 = very high over.
which were of Caucasian origin. It would be preferable to carry out a more broadly based population study in the future to overcome these limitations.

CONCLUSION

Reference values for PROM in infants aged 2 to 10 months neck ranged from 100° to 120° (mean 110°) for neck rotation and from 65° to 75° (mean 70°) for lateral flexion. Muscle function in lateral head righting as measured by the MFS demonstrated that most 2-month-old infants, when held in a horizontal position, were able to maintain the head in line with the body. By 10 months of age, the infants were able to right their heads either high or very high above the horizontal. These reference values for PROM and muscle function of the neck may have clinical utility in assessing and documenting progress of infants with CMT.

ACKNOWLEDGMENTS

The authors acknowledge the infants and parents who participated in the study, the Child Health Centre that informed the parents about the study, and colleagues who assisted in measuring the children.

REFERENCES

APPENDIX A

Muscle function scale (MFS) for infants

4. Head very high over the horizontal.

3. Head high over horizontal.

2. Head slightly over the horizontal.

1. Head in the horizontal

0. Head below horizontal.