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A Craniometer with a Headband Can Be a Reliable Tool to Measure Plagiocephaly and Brachycephaly in Clinical Practice

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Abstract

Objective: The aim of the study was to determine the intra- and inter-reliability for measuring infants with plagiocephaly and brachycephaly with a craniometer when using a marked headband as landmarks. Subjects: Six physiotherapists and eight infants participated in the study. Methods: The physiotherapists measured all infants twice; each infant was measured with the same headband and craniometer. The physiotherapists were blinded to measurements carried out by their colleagues. The infants with their parents changed places in the room to minimize the possibility that the physiotherapists would remember their first measurements of any infant. Results: There was a high intra- and inter-reliability, for intra-reliability ICC 0.96 to 0.99 and for inter-reliability ICC 0.98. Conclusion: It is possible to achieve a high intra- and inter-reliability when using a headband and craniometer when measuring cranial vault asymmetry for plagiocephaly and cephalic ratio for brachycephaly.

Keywords

Plagiocephaly, Brachycephaly, Measurement, Craniometer, Headband, Infant

1. Introduction

Since the beginning of 1990 parents have been recommended to let their infants sleep supine to decrease the risk of sudden infant death syndrome [1]. The back to sleep campaign has been successful with decreased sudden infant death syndrome as a result [1]. At the same time there is a notable increase in positional plagiocephaly and brachycephaly in infants [2]-[4]. The incidence of plagiocephaly is reported to be up to 46.6% for infants aged 7 to 12 weeks. For most infants (78.3%) it was a mild form of plagiocephaly [5]. Since the back to sleep campaign the major contributing factor in the

increase of the development of positional plagiocephaly and brachycephaly is one-sided positioning in combination with a lot of time in a supine position [6].

Congenital muscular torticollis (CMT) is a common musculoskeletal abnormality in infants [7]. Due to the positional preference there is a high risk that infants with CMT develop positional plagiocephaly [8]-[11]. CMT is a result of shortening or excessive contraction of the sternocleidomastoid (SCM) muscle with limited range of motion (ROM) in both rotation and lateral flexion in the neck and an imbalance in muscle function around the neck [12]-[15]. Infants with plagiocephaly and brachycephaly with or without CMT are often referred to physical therapy [16].

A routine follow-up and reassessment of the infant's head shape is required to establish the level of progress and response to treatment in patients with plagiocephaly and brachycephaly [17]. There are several ways to measure plagiocephaly and brachycephaly e.g. radiograms, CT-scans and optical surface scanners [18] [19]. These have limited clinical relevance as they are not accessible to everyone and they are costly [20]. The "severity scale for assessment of plagiocephaly" is found to have acceptable reliability and higher reliability for more experienced evaluators [20]. However, estimates can be more or less subjective depending on the experience of the evaluator. Schaaf *et al.* found that digital photography was a reliable tool for quantifying cranial deformities [21]. This method can be considered more objective than the use of a caliper but are dependent on the skills to take photographs that show both ears and the tip of the nose of the infant. Plagiocephalometry (PCM) is a non-invasive alternative with high reliability that could be carried out in clinic, however education in the use of this instrument is needed [22]. Another option is to use a caliper, Mortenson and Steinbok found good intra-reliability but poor inter-reliability. They assumed that the identification of landmarks used for the measurements and infant behavior could have affected the results in their study [23]. Infants do not always cooperate to make the measurements easy, quite the opposite the measurements can be a real challenge. A headband with markers used as landmarks can be helpful when measuring (**Figure 1**) [24] [25].

The aim of this study was to investigate the intra-rater and inter-rater reliability when using a calliper with a headband to measure plagiocephaly and brachycephaly.

2. Method

Parents of ten infants agreed to participate in the study, one was not able to attend due to illness on the day of the measurements and one infant who was ten months of age did not cooperate at all, and had to be excluded from the study.

Six physiotherapists measured the remaining eight infants; every physiotherapist measured each infant twice. All infants were measured before the re-measuring of any infant; approximately there was 15 - 25 minutes between measurements for the individual physiotherapist before re-measuring the same infant. The infants were placed on the parent's knee, looking at the parent, the evaluator standing behind the infant (**Figure 2**). Diagonals, length and width of the head were measured, and noted in a coded protocol. The physiotherapists were blinded to their own earlier measurements and the

Figure 1. A headband with markers used as landmarks when measuring.

Figure 2. The infants were placed on the parent's knee, looking at the parent, the evaluator standing behind the infant.

other physiotherapists' measurements. The codes were covered and not visible for the evaluators at any time, the protocol was removed immediately after each measurement. Parents and infants switched places between measurements; the parents were instructed to do this beforehand. The parents themselves chose how to switch places, some also switched infants. Each infant had the same headband and the same craniometer all the time, the parents were responsible to bring the craniometer and protocols with the infant when switching places. The infants wore the headbands during the whole session. The calliper "Mimos Craniometer" manufactured by TPL S.L. (mimospillow.com). Certificate 1709/MDD on 93/42/EEC was used. The headband is prefabricated and is

supplied with the craniometer. There is an arrow that should be aligned with the infants' nose as a landmark and a dot for the middle of the back of the head. Also there are four X marks, two on the forehead and two on the posterior aspect of the head for diagonal measurements.

3. Statistics

The inter-rater and intra-rater reliability was calculated with the intraclass correlation coefficient ICC-model with 95% confidence interval (CI). P-values of 0.05 or less were considered evidence of statistically significant findings.

4. Result

The eight infants participating in the study had a mean age of 5.8 months (range 4.5 to 8 months), five were female and three male. All had some degree of plagiocephaly or brachycephaly, from very mild to severe (Table 1). They had all received physiotherapy treatment and it had been on-going from one month to several months, all still had some degree of plagiocephaly or brachycephaly.

Six physiotherapists participated, three from Stockholm and three from Gothenburg, they had been practicing physiotherapists for a mean of 24.7 years (range 15 to 32 years). They had used the craniometer for measurements for a mean of 2.5 years (range 0 to 4 years). They measured with the craniometer each week at a mean of 7.3 occasions (Range 0 to 30).

All infants were measured twelve times; each infant kept the same headband and craniometer during all measurements. The infants were supposed to sit on the parents knee facing the parent, some infants became tired and restless sometimes sitting in a slightly different position during the measurement, one infant fell asleep. All six physiotherapists accomplished two measurements on each of the eight infants.

Table 1. Cranial Vault Asymmetry Index (CVAI) for plagiocephaly and Cranial Index (CI) for brachycephaly; for the eight infants that participated in the study.

Infant	CVA	CVAI *B > A	CVAI *A > B	CI	Age, months	Gender
1	4	2.9	2.9	89.2	5	Male
2	14.5	11.1	10.0	81.3	5.5	Male
3	6.5	5.1	4.8	83.0	5.5	Female
4	7.5	5.4	5.0	86.4	7	Female
5	3.5	2.6	2.5	87.1	4.5	Female
6	6.5	4.8	4.6	84.8	6	Female
7	6.0	4.7	4.3	98.1	4.5	Female
8	5.0	3.4	3.2	84.6	8	Male

The intra rater reliability was found to be high, ICC was between 0.96 and 0.99, one physiotherapist had ICC 0.96 the remaining five had ICC 0.99 ($P < 0.0001$). The inter rater reliability was ICC 0.98 ($P < 0.0001$)

5. Discussion

This study showed both high intra- and inter-reliability for measurements with the craniometer when using a headband. The physiotherapist who had only briefly used the craniometer before the study also achieved very high intra-reliability. However, this physiotherapist has long experience with other measurements and therefore it cannot be assumed that an inexperienced physiotherapist would be able to perform these measurements equally well. Testing the reliability of the examiner can reveal weaknesses even in a well-trained examiner. Also it is recommended that intra-observer testing should be used to assess the measurement skills of newly trained examiners [26]. The examiner's skill is the most important requirement for the accuracy of measurements. Skills in measurement depend more on the number of subjects examined per year than of years of "doing the measurements" [26]. All physiotherapists working with infants with plagiocephaly and brachycephaly ought to test their intra- and inter-reliability on the method they use for assessment.

We obtained better inter-reliability than the study by Mortenson and Steinbeck [23] this may partly be due to the fact that a headband with marks was used and the fact that the headband was on during the whole session. Wilbrand *et al.* found that calipers can provide highly precise information, they had an assistant holding the infants head during assessment [27]. In the clinical setting it is not always realistic to have an assistant. For a trained therapist a headband may compensate to some degree for the lack of a second person. It would be preferred if the same examiner always assesses the same infant, however sometimes this is not possible due to practical reasons.

For plagiocephaly Cranial Vault Asymmetry (CVA), Cranial Vault Asymmetry Index (CVAI) or Oblique Cranial Length Ratio (OCRL) can be used [7] [23] [28]. CVAI is found to be calculated differently in several studies, the same formula (A-B/A x 100) but some considered A > B and some B > A [29]-[33]. When B > A are calculated CVAI becomes higher, for mild plagiocephaly there is a minor difference but in more severe cases the difference becomes greater. When communicating with parents it might be best to use CVA, *i.e.* the difference between the diagonals in millimetres. When comparing different studies it is important to be observant on how CVAI is calculated, and it is preferred if the CVA is also reported. For brachycephaly cephalic ratio or cephalic index is calculated (cranial width/length × 100) [32], it is the same formula for both, only different terminology. Profile photos can be taken relatively easily and can be used to compare development of the profile shape of the head in infants with brachycephaly.

Limitations

The infants wore the headband during the whole session. It could have been difficult for an infant to accept the headband being removed and put on 12 times during the

session. This approach reduced the risk for inconsistency due to placing the headband different and is a limitation in this study. The marked arrow is aligned with the infant's nose, which enables the headband to be placed in the same position repeatedly. However, we can't be sure that all physiotherapists would position the headband in exactly the same way.

The small number of participants can have affected the result. At the time of the study most of the infants had a mild plagiocephaly, a mild plagiocephaly might be easier to measure than a severe plagiocephaly.

6. Conclusion

Having reliable measurements is essential when assessing infants with plagiocephaly and brachycephaly. In this study the craniometer with a headband showed reliability to measure mild plagiocephaly and brachycephaly. The result cannot be generalized due to the small sample and rather mild cases. Future studies with a larger sample and more variation of degree of plagiocephaly are needed. It may also be of benefit to include photographs in the next study.

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Declaration of Interest

The authors report no conflicts of interest. The authors alone are responsible for the content and the writing of the paper.

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