

## **Critical Review: Is the Neonatal Oral-Motor Assessment Scale, a valid assessment tool to identify and quantify future infant oral-feeding difficulties or oral-motor dysfunction?**

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This critical review examines the validity of the Neonatal Oral-Motor Assessment Scale to predict infant feeding difficulties or subsequent oral-motor dysfunction or disorganization. Six papers are reviewed, and study designs include: the original pilot study, systematic qualitative review, three prospective observational studies, and one longitudinal observational study. Overall, evidence gathered from this review is inconsistent, but suggestive that the NOMAS only imparts, at best, moderate validity. Recommendations for further research and clinical practice are provided.

### ***Introduction***

Evaluation and treatment of feeding difficulties is often a complex area of practice for speech-language pathologists, especially in the premature infant population. Infants feed by sucking, a complex motor skill that requires oral motor skills to be adequate and also intricately coordinated with swallowing and breathing. A dysfunction or disorganized feeding pattern can lead to difficulty establishing complete oral feeding, failure to thrive or a delay in oral-motor development (Arvedson, 2008). Preterm infants in the neonatal intensive care unit require an additional high level of technical and observational medical care. Caregivers frequently question the 'oral feeding readiness' of preterm infants when considering introduction of oral feeding (Lau & Smith, 2011). As no Gold-Standard tool is available to determine whether an infant is 'ready' to wean from tube feeding, introduction of oral feedings are commonly ordered by attending physicians, sometimes leaving the decision to nurses (Lau & Smith, 2011). Therefore, a psychometrically sound assessment tool that will accurately predict the likelihood an infant (healthy or not) has and/or will develop feeding difficulties is needed and will enable both clinicians and researchers to identify, monitor, and manage feeding problems occurring in the early infant phase (Howe et al., 2007). This tool would also be useful to determine what interventions are required to facilitate sucking and swallowing. It is important for an assessment tool to demonstrate validity, or the extent that the tool measures what it purposes to measure. Evidence on reliability and validity is important in making decisions regarding the potential usefulness of an assessment tool for future research and possible application in clinical settings.

The NOMAS (Neonatal Oral-Motor Assessment Scale) developed in 1986; attempts to identify and quantify normal and deviant oral sensorimotor patterns in neonates that are breast and/or bottle-fed (Braun & Palmer, 1986). In many studies that look at various interventions for feeding problems in infants,

it is the primary method used to assess an infant's feeding abilities (Howe et al., 2008). However, there has been some evidence to suggest that it may not be a reliable or valid tool, and may even be outdated in its assessment methods, due to the advancement of knowledge and research pertaining to infant swallowing and feeding since its development (Howe et al., 2008).

### ***Objectives***

The primary objective of this paper is to provide a critical evaluation of existing literature on the validity of the Neonatal Oral-Motor Assessment Scale so that clinicians can incorporate the evidenced-based results accordingly. The secondary objective is to offer evidence-based recommendations for clinical practice and future research.

### ***Methods***

#### **Search Strategy**

Computerized internet databases were searched, including Pubmed, Medline, and Google Scholar. The following key terms were used: ((Neonatal Oral-Motor Assessment Scale) or (infant feeding)) and ((efficacy) or (validity) or (reliability) or (psychometric)).

#### **Selection Criteria**

Studies selected for inclusion in this critical review were required to be published in English and to examine the validity of the Neonatal Oral-Motor Assessment Scale (NOMAS) by identifying and quantifying subsequent oral feeding difficulties or related oral-motor outcomes of infants that were assessed by this measure. No limits were set of the on the dates of the articles published, study design, or outcome measures.

#### **Data Collection**

Results of the literature search yielded six articles that achieved the aforementioned selection criteria for inclusion in this review. They were of the following types: one systematic qualitative review,

three prospective observational studies, one original pilot study, and one longitudinal observational study.

### **Results**

In the original pilot article by Braun and Palmer (1986), their purpose was to devise a neonatal oral-motor assessment scale (NOMAS) in order to (1) differentiate tongue and jaw movements during both non-nutritive (NNS) and nutritive sucking (NS); (2) identify normal and deviant oral-motor patterns; and (3) quantify oral-motor skills. The study had a small sample size of 11 premature infants, with a mean gestational age of 32 weeks. Participant eligibility criteria were described, and individual risk factors reported in chart form. The convergent validity was examined by comparing the agreement between a dysfunctional or disorganized score on the NOMAS, the identification of feeding problems present in nursing reports, polygraph scores that measured NNS and NS, and a neurological exam. The authors stated that associations between individual risk factors and oral-motor abnormality were tested using a Fisher's exact test, but it was not statistically significant. Additionally, logistic regression was used to test the association between the total number of risk factors and oral motor abnormality and a two sample t-test was used to compare suction/expression ratios, sucking rates and change in sucking rates from NNS to NS. The authors state that no reliability data was collected and that some validity information was found by reviewing nursing notes of the 5 infants identified as problematic retrospectively. Polygraphic data of intraoral sucking pressure correlated with degree of oral motor dysfunction as measured by the NOMAS, but the correlation's statistical method was not reported and was not statistically significant.

This paper demonstrated an interesting and clinically relevant purpose. However, due to the very small sample size, and failed reporting of the values of statistical data analysis, no statistically significant associations can be made, and adequate constructive and predictive validity cannot be concluded. There was no data reported or values given for the Fisher's test, logistic regression or t-test. Although consecutive NOMAS scores were recorded, no time-frame of when the scoring took place was given, and the actual scores were not reported. Validity was tested retrospectively. There was no mention of who the evaluators were, or whether the infants were breast or bottle fed, even though they stated the NOMAS can be used for breast or bottle fed infants. Overall, the level of evidence this paper contributes is equivocal.

In a systematic qualitative review, Howe, T.H., Lin, K.C., Fu, C.P., Su, C.T., & Hsieh, C.L., (2008) appraised the reliability, validity and responsiveness of seven neonatal clinical feeding assessment tools. For the purposes of this review, only the validity results of the NOMAS are discussed here. A clearly described search strategy and comprehensive criterion was used to include and exclude studies from their review, and then 4 relevant studies that assessed the NOMAS were critically examined. Overall, the authors felt no test had satisfactory psychometric properties, but suggested the NOMAS had been examined more thoroughly and demonstrated more consistent results than the other 6 tools. They revealed the following limitations of the NOMAS: it has no objective verification of actual dysfunction of suck, swallow, and breathe. As a result, infants classified as poor feeders had no difficulty initiating movement or swallowing, but they did have difficulty maintaining a rhythmic pattern with a consistent rate of sucking. Additionally, Howe et al., 2008, pointed out the NOMAS can only assess biomechanical components for successful feeding and is therefore not an appropriate assessment tool when clinicians seek to obtain information about environmental factors salient to successful feeding, such as the maternal infant interaction process or infant's states. Finally, the authors suggested that because no study had an adequate sample size; power was substantially reduced and less likely to be representative of population characteristics.

When reviewing Howe et al., 2008, it is evident a clearly defined research question and search strategy was implemented. However, given there was no further statistical data analysis of the papers reviewed; this paper provides more of an expert review of the evidence available for the validity of the NOMAS. Additionally, there was no mention on whether the studies were rated independently and with blinding, and inter-rater agreement was not mentioned. Overall, the level of evidence is suggestive and their results and discussion can be counted as valuable indicators of where research lacks and should continue.

In a longitudinal observational study, Howe, T.H., Sheu, C.F., Hsieh, Y.W., & Hsieh, C.L., (2007) reviewed 147 infant charts to compare feeding performance and results from the revised NOMAS (Palmer et al. 1993). The data collected was originally to be used for a longitudinal study relating the factors of bottle-feeding in preterm infants. An appropriate eligibility criterion was described. Howe, an occupational therapist who had been trained and

certified by M Palmer, performed the assessments. The results of the NOMAS and feeding performance were then obtained from chart review, from the day of initiation of bottle-feeding to day of discharge. Feeding performance was defined as transitional rate, calculated by the ratio of feeding intake (ml) at one observed feeding to the feeding duration (min) from introduction of the bottle to stoppage of sucking. Not all infants received the same amount of recorded feedings, and some records were excluded if major variables (time of feeding, NOMAS scores) were missing. The authors were unable to examine the dysfunction category of the NOMAS, as no infant in their study demonstrated the associated behaviors of dysfunction, most likely due to the fact they excluded infants from the study with documented neurological findings, who may exhibit the dysfunction characteristics such as abnormal jaw and tongue movements. The authors discovered that no actual scoring system was proposed by the original creator of the NOMAS, so they devised a system of 0 or 1 to represent absence or presence of an observed behavior.

Appropriate statistical analysis using Spearman's rank correlation revealed moderate correlation between NOMAS scores and feeding performance for infants 32 to 35 weeks post-menstrual age (PMA). Weaker correlation was found for older infants, possibly due to greater differentiation of oral-motor performance and other factors not assessed by the NOMAS. In addition, this study also reported reliability and responsiveness data for the NOMAS, and therefore provides more useful information for clinicians in determining whether to select the NOMAS for oral-motor measurements in their settings.

This was the largest sample size to date in this area of research. A general protocol was followed for each feeding session. Statistical data analysis design was explained and results given. It should be noted that their results and discussion are limited to the validity of only the disorganized and normal categories of the NOMAS, as no participants were categorized within the dysfunctional category. Overall, this study provides suggestive evidence that there is moderate convergent validity for the normal and disorganized sub-groups of the NOMAS for infants 32 to 35 weeks PMA to feeding performance.

Case-Smith, J., Cooper, P., & Scala, V., (1989) investigated the validity of the revised NOMAS in discriminating between inefficient and efficient feeders in a sample of 26 high-risk premature infants. A second purpose was to identify the significantly

different oral motor behaviors in the two groups. Classification of inefficient or efficient feeders was determined by examining the amount of oral intake in the first 5 minutes. Inefficient feeders consumed less than 15cc of formula and efficient feeders consumed more than 20cc in the first 5 min. Case-Smith trained the other two authors on NOMAS administration, and inter-rater reliability was 91% for the nonnutritive sucking scale and 97% for the nutritive sucking scale. Assessment was done at regular bottle-feeding times, and included the NOMAS and a neurological assessment. Scoring for the NOMAS was reported; a score of 2 was given for a consistent or frequent response, 1 was given for an inconsistent and less frequent response, and a 0 was given if there was no response. Abnormal characteristics were scored as present if seen more than one time. Discriminate analysis was performed to determine if the NOMAS scores accurately classified the participants as efficient or inefficient, and the results were presented. Wilcoxon rank sum was used to determine whether individual item scores for the efficient feeders were higher than the same scores for the inefficient feeders, and to compute an appropriate p-value for each oral-motor behavior. Only the participants classified as inefficient by or efficient by both amount of liquid intake and NOMAS score (22/26) were included for this analysis.

Their findings suggest the NOMAS accurately classified inefficient and efficient feeders, and both nutritive and nonnutritive sucking scores were higher in the efficient feeders. Additionally, lack of rhythm, disorganization in jaw and tongue movements, and pauses of more than 6 seconds were significantly associated with inefficient feeders. Authors concluded the NOMAS was accurate in identifying infants whose liquid intake by mouth is low and may have potential use in determining whether gavage or oral feeding is appropriate for a premature infant. The authors also commented that the infant's behavioral state may have affected performance, and consideration should be given to all aspects of the neonate's sensory environment when beginning oral feeding.

A well-formulated question and rationale was given by the authors, and the study design adequately addressed their question. Participant eligibility criteria was well described and the efficient and inefficient feeders were similar at baseline in important indicators. Unfortunately, the authors were not NOMAS-certified, and the Case-Smith trained the other two authors in its administration. Control group, randomization and blinding were not employed, but not appropriate for this area of

research or study design. Reasonable and valid measures were conducted, and there was no evidence to suggest methods were modified post-hoc. Descriptive statistic analysis was conducted and employed by an outside source (mentioned in the acknowledgements). Inter-rater reliability was not adequately completed, as it only included 5/26 participants and examined 2/3 raters. Mean scores and p-values for all statistical tests were reported. Overall, this study gives suggestive support for the construct validity of the NOMAS as an index of oral motor function in neonates with a gestational age of 34 to 35 weeks.

In a prospective observational study Hawdon, JM., Beauregard, N., Slattery, J., & Kennedy, G., (2000) examined the incidence of feeding problems on a neonatal intensive care unit, described the characteristics of the neonates who were poor feeders, and studied the long-term feeding outcomes in the same infants. Blinded NOMAS assessment was completed on 20 infants by two of the authors (trained and experienced in the use of the NOMAS) once the infants were at least 36 weeks postmenstrual age, and were deemed sufficiently stable to introduce sucking feeds. Bottle or breast feeding was used. The results of the assessment were compared to each infant's clinical history, presence of neurological abnormalities, medical staff's perception of feeding problems from medical notes, and a weaning questionnaire sent to the parents 6 and 12 months post term. The disorganized and dysfunctional NOMAS feeders were grouped together and compared with the normal NOMAS feeders group. Non-parametric statistical methods were used for intergroup comparisons and  $X^2$  and Fisher exact tests were used to compare outcomes between groups.

Although only 20 infants were assessed by the authors, 35 infants were recruited for the study and 21 of them had normal feeding patterns, 12 had a disorganized pattern and 2 were dysfunctional feeders. There was 100% agreement by the authors in allocation to NOMAS feeding group. A Mann-Whitney test was used to compare the clinical history of the two groups, and the babies in the disorganized/dysfunctional feeding group had a longer median duration of ventilator support, duration of parenteral and gavage feeds was significantly longer, the age of introduction of oral feeds was later, and time to establishment of full oral feeds was longer than the normal feeder group. Medical notes identified feeding problems in 6/18 infants in the dysfunctional/disorganized group and 4/21 in the normal group. At 6 months, the overall incidence of feeding problems in the dysfunctional/disorganized

group was twice that of the normal feeders group. At 12 months, those with disorganized/dysfunctional feeding were nine times more likely to cough with meals than normal feeders. 1/20 of the normal feeder group and 9/14 in the dysfunctional/disorganized feeder group had neurological problems at follow-up. Many parents in both groups expressed concern regarding their infants feeding and would have requested more advice on discharge from the NICU.

There was a clear question for this study to address, and many comparisons were made to various factors associated with infant feeding difficulties. The clinical history of the participants was clearly described, and included the presenting symptoms, disease severity, co-morbidity and any other differential diagnosis. The overall protocol for NOMAS administration was followed and the authors were trained. However, throughout the methods and results of each comparison, there was an inconsistency in the numbers reported for the total amount of infants in the normal or disorganized or dysfunctional feeder groups. Not all of the infants were assessed by the NOMAS, so how the extra infants were allocated into NOMAS feeding groups is unknown. The questionnaire was not provided and it was not clear how many questionnaires were returned or analyzed in the study. Clinically, the study presents very interesting comparisons, but a better statistical level of evidence needs to be provided before the predictive validity of the NOMAS, and their results can be taken as compelling. Overall, although many of their results were reported to be significant, the data analysis and subsequently level of evidence for this study is equivocal.

The purpose of the prospective, observational study by Bingham, P., Ashikaga, T., & Abbasi, S., (2012) was to examine how well the NOMAS predicts premature infants' transition from tube to oral feeding. Data was used from a previous prospective study of sucking behavior as a predictor of feeding skills (Bingham et al., 2009). The NOMAS was administered by certified users to 51 tube-fed, premature infants soon (<72 hours) after oral feeding was initiated, a weekly thereafter, until infants reached full oral feeding. Breast and/or bottle feeding was used. A timed measure of feeding efficiency was also completed as oral feeding was initiated. A standardized, permissive protocol for feeding advance was used. Consistency in NOMAS scoring was confirmed via the NOMAS certification process. Other baseline measures that might identify infants who will experience feeding difficulty and protracted tube-feeding were also compared and analyzed. Subjects with orofacial anomalies, neurologic

problems, or those undergoing major procedures were excluded. Reliability of the items for the NOMAS sub-score was assessed with Cronbach's alpha. Test-Retest reliability and the relationship of baseline clinical observations to NOMAS sub-score values were assessed with Pearson's correlation coefficients. The first three serial NOMAS scores were used for reliability and temporal validity assessments. Repeated measures ANOVA was used to assess changes in NOMAS sub-scores over time, and Cox proportional hazard models were used to examine the relationship of the transition time and gestational age at full oral feeding to NOMAS sub-scores, and to other baseline characteristics and feeding efficiency measures. A set p-value of <0.05 was defined for analyses relating nominal predictors and feeding performance.

Relatively few infants showed feeding dysfunction on the NOMAS. The results demonstrated that gestational age at birth, birth weight, and initial feeding efficiency predicted shorter transition and earlier acquisition to full oral feeding. The NOMAS scores were found to not predict feeding outcomes (transition time or gestational age of full oral feeding). Significant negative correlations resulted between baseline timed feeding scores and the NOMAS dysfunction sub-scores. The NOMAS showed moderate Test-Retest correlations and only moderate validity for the NOMAS as an indicator of maturation of feeding skills was found.

Bingham et al., 2012 had a clearly defined research question. Appropriate methodological design capable of replication was provided. As infants with orofacial anomalies, neurologic problems and those undergoing major procedures were excluded from the study, their results may be biased to a more normal population (i.e. not many infants showed feeding dysfunction). Statistical data analysis design and subsequent results were reported and provides support their results are compelling evidence that the NOMAS's has little predictive validity for infant feeding outcomes.

### ***Discussion***

Successful independent oral feeding is one of the criteria recommended by the American Academy of Pediatrics for hospital discharge of preterm infants (REF). An infant's inability to wean from tube feeding will delay hospital discharge and mother-infant reunion, while increasing medical cost and maternal stress (Lau & Smith, 2011). There are two dilemmas caregivers face when addressing oral feeding difficulties; (1) infant ability to complete their feedings safely and (2) the appropriate rate of

advancement to independent oral feeding (Lau & Smith, 2011). Assessing infants' oral feeding skills has been difficult due to the lack of well-defined outcomes and a psychometrically sound assessment tool. For example, the validity of the Neonatal Oral-Motor Assessment Scale, developed by Palmer et al. (1986) has been called into question by a number of studies due to its subjective nature and lack of direct measure of specific outcomes. The literature reviewed here is suggestive that there is at best, only moderate validity for the NOMAS to identify oral feeding difficulties in premature infants 32 to 35 weeks PMA.

All of the studies reviewed illustrated a moderate to nil effect for the validity of the NOMAS to appropriately quantify and predict oral feeding difficulties. However, all of the studies reported a different outcome measure to define oral feeding difficulties. Not all of the studies' reported significant results. This may be accounted for by some of the limitations in these studies, including; lack of detailed and adequate statistical analysis, small sample sizes, and inadequate outcome measures for comparison. Additionally, most studies were not able to adequately examine the dysfunction category of the NOMAS.

The original pilot study by Braun & Palmer (1986), had a number of statistically methodological issues, and therefore only demonstrated equivocal evidence for the validity of their instrument. Bingham et al., (2012) concluded the NOMAS may have validity as an indicator of maturation of feeding skills, but it does not appear to reflect key, performance-related features of premature infants' feeding behavior. Additionally, the authors suggested that the advantages of the NOMAS include that it is quickly performed (2minutes); it involves an actual trial of oral feeding and thus integrates necessary oral motor skills; and it includes measures that pertain to both maturational features (the disorganization sub-score) and pathologic signs (the dysfunction sub-score). The level of evidence for their results was compelling. Howe et al., (2008) pointed out that the majority of studies have only validated the NOMAS for bottle-feeding behaviors, although the original article suggested it could also be used for breast-feeding. Therefore, most studies have not fully represented the target population the NOMAS was designed to assess. Howe et al., (2008) also suggested the NOMAS was only designed to assess the biomechanical components for successful feeding and therefore it would not be appropriate to select the NOMAS as an assessment tool if clinicians wished to obtain information on different aspects of feeding,

such as the maternal-infant interaction or infants state during feeding. Although the level of evidence for their results was equivocal, Hawdon et al., 2000 suggested that it is difficult for medical and nursing staff to routinely detect babies with immature or disordered feeding patterns, as well as predict those who will experience long-term feeding difficulties, and this idea is prevalent among the other studies reviewed. Additionally, there was no general consensus of the literature regarding the components that comprise successful feeding behavioral signs such as readiness, endurance, and caregiver factors. Finally, because the NOMAS does not have a clear scoring method, many studies had to devise their own method of scoring. This is a big limitation of the NOMAS, and the method of scoring must be taken into account when interpreting the results of studies.

#### *Future research considerations*

The following is a summary of the specific areas in which research should be focused in the future (Howe et al., 2008), (Bingham et al., 2012);

- (1) Identification of the key components of successful feeding as the foundation for content and construct validities.
- (2) Establish predictive validity based on relevant criteria and responsiveness of assessment tools for determining developmental and clinical changes.
- (3) Include large representative samples for study to improve the strength of external validity, especially with infants demonstrating the “dysfunctional” category of the NOMAS.

There are also related avenues for study that will aid clinical guidelines for this population (Hawdon et al., 2000), (Howe et al., 2007);

- (1) Feeding outcomes of infants discharged from neonatal intensive care is minimal and as it is likely long-term feeding difficulties contribute to nutritional problems with failure to thrive and present major practical and emotional problems to families, it is important that this aspect be formally studied and antecedent risk factors fully understood.
- (2) The assessment of the benefits of early interventions, which may prevent feeding problems.

#### ***Clinical Implications***

Infant feeding is a highly complex and integrated process involving numerous body systems. In addition to determining an infant’s oral-motor functioning, a global assessment tool should also take into account infant – maternal interaction and behavioral state. To date, the NOMAS has only demonstrated moderate validity in identifying infant

oral feeding difficulties, and only measures an infant’s oral-motor functioning. Clinicians who use the NOMAS for clinical and research purposes should take into account this lack of evidence of psychometric soundness and interpret results of assessment with caution (Howe et al., 2008).

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