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Correlation Between Neonatal Growth Parameters and Oral Development in Preterm Infants

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Abstract

Preterm infants remain particularly vulnerable to growth impairment, which could have a negative impact on their health development. Three neonatal growth parameters, namely z-scores of weight-for-age, length-for-age, and head circumference-for-age are routinely used to assess the growth of very preterm infants in neonatal intensive care units (Rocha Ruiz et al., 2020).

To disclose the correlation between neonatal growth parameters and oral development, a cross-sectional study involving 70 preterm infants at the corrected age of 6 months was conducted. The z-scores of weight-for-age, length-for-age, and head circumference-for-age were calculated based on World Health Organization growth references. Oral development was evaluated and quantified using an Infant Oral-Motor Assessment.

The findings suggest that the three mentioned parameters of preterm growth correlate significantly with oral development. Increased z-scores of weight-for-age and length-for-age were directly associated with a better development of the preterm infant´s oral cavity, while head circumference-for-age z-scores showed an inverse association. Further studies with larger sample sizes are necessary to corroborate and expand these findings. Early identification of infants with imbalanced growth parameters or below expected growth could enhance oral care and, potentially, other areas of development.

Key Words: Neonatal growth parameters; preterm infants; oral development; cross-sectional design; correlation; clinical implications

1. Introduction

The high rates of survival among low-birth-weight preterm infants have prompted increased consideration of further developmental issues influencing the quality of life in this population (Rocha Ruiz et al., 2020). Neonates born between 22 and 28 weeks' gestation miss a critical period of intrauterine growth (Zaidi et al., 2015). Postnatal complications, particularly during hospitalization in a neonatal intensive care unit, can affect health, growth, and development, resulting in increased risk of under-five mortality, especially when associated with low gestational

age or very low birth weight. Growth patterns, including body length, weight, and head circumference, continue to be evaluated.

Prematurity may alter orofacial growth during the first six months of life, a developmental window characterized by rapid mammarian growth and the establishment of oral-facial patterns. This can lead to morphological and functional changes such as dental enamel hypoplasia, palatal alterations, and muscle hypotonia incompatible with adequate sucking, swallowing, and breathing, all of which compromise oral health and may result in malocclusion. Orofacial growth continues postnatally to age sixteen, during which the maxillary arch is modified by the eruption of primary canines and molars; the mandibular arch, by the eruption of primary incisors, canines, and first molars; and dental occlusion becomes established.

The objectives of the present study were to measure stature, mass, and cephalic perimeter in preterm infants during hospitalization and to correlate these parameters with oral development. The hypothesis to be tested was that higher values for each parameter would favor a more advanced stage of oral development.

2. Background

Oral development is an essential component of the stomatognathic system involved in feeding, communication, and psychosocial development. The dependency on an external food source and gastrostomy nutrition among preterm infants with extreme-low-birth-weight has increased the prevalence of dental caries and other oral diseases, highlighting the need to promote oral health. Orofacial growth problems in preterm infants may compromise stomatognathic development. Nevertheless, there is a lack of awareness regarding the correlation between neonatal growth parameters and oral development in preterm infants. Understanding this relationship may facilitate the provision of proper stimulation at the appropriate age and help establish interdisciplinary thickening programs between feeding and dentistry, thereby promoting oral health.

The neonatal period is a critical time for growth in preterm infants. Birth weight, head circumference, and gestational age are good predictors of growth and are assessed through the Fenton growth charts. Low weight for gestational age (WG) is an important indicator of high morbidity and mortality risk. Craniofacial growth during infancy is critical to stomatognathic development and feeding, and therefore cranial circumference, conformation, and prevalence of caput succedaneum are useful growth parameters in this study. Rarely are oral development and growth parameters studied together (Rocha Ruiz et al., 2020).

3. Methods

Preterm infants are deprived of a period of intense intrauterine growth and development. Postnatal complications may occur during hospitalization, affecting health, growth and development, and contributing to high under-5 mortality. Prematurity can cause alterations in orofacial growth, morphological and functional changes, and increase the risk of dental enamel hypoplasia, palatal alterations, muscle hypotonia, and impaired sucking, swallowing and breathing, which may affect oral health and lead to malocclusion. Early preventive and interceptive actions are necessary to promote oral health and ensure proper growth of the orofacial system. Neonatal dental examinations should include intraoral morphological and functional assessments, guided by multidisciplinary knowledge, to provide personalized care and promote oral health in preterm infants.

Studies have characterized the developmental stages of sucking in preterm infants during feeding. Methods used include assessments of oral motor function, non-nutritive sucking, and orofacial behaviours. The reliability of the Neonatal Oral-Motor Assessment Scale has been evaluated. Instruments have been proposed to assess prematures' readiness for oral feeding. Identification and management of transitional suck patterns are crucial for feeding success. Factors associated with successful oral feeding after initial assessment have been analysed using regression methods. (Rocha Ruiz et al., 2020)

3.1. Study Design

Preterm neonates are often deprived of adequate nutrition during the first weeks of life, a condition that may result in reduced oral-motor and general oral development. Visiting dental health professionals for children, even at an early age, implies increased awareness on oral development, similar to the increased interest shown to other developmental aspects such as visual or auditive development (Rocha Ruiz et al., 2020). Neonatal gestation and weight are clinically determined parameters used to keep track of oral and growth development. These parameters are assessed frequently throughout the stay in the neonatal intensive care unit, whereby premature infants remain

longer than term-born newborns. The non-typical pattern of preterm infants in their physical, motor and orofacial development favours conducting a study in these population.

3.2. Participants

The study enrolled preterm infants treated at the Neonatal Unit of Hospital de Câncer de Barretos, on whom data were collected between January and August 2022. Preterm infants were defined according to the World Health Organization (WHO) criteria of gestational age <37 weeks (Rocha Ruiz et al., 2020). The analyses included only infants born alive, regardless of their multiple births (singletons or multiples), and those with gestational age ≤37 weeks who survived until discharge. Participants and their legal guardians signed the informed consent form. The research was approved by the local ethics committee.

The World Health Organization classifies neonates as very preterm (≤32 weeks), moderate to late preterm (32+0 to 36+6 weeks), or full-term (≥37 weeks). The extraction of preterm neonates from the neonatal unit was based on criterion A (birth weight such that the neonate would not survive predelivery) or criterion B (very low or extremely low birth weight) based on partial records. These growth parameters are not commonly assessed outside laboratory settings.

3.3. Data Collection

The following information was collected concerning the neonatal period for all participants: gestational age (GA) at birth, birth weight, weight at hospital discharge, length of stay (LOS; in days), and current age at the time of the oral development assessment. Data were also collected about potential sociodemographic factors: maternal and paternal educational level (higher versus lower), maternal age (25 years or younger versus older), marital status, and number of siblings.

The study included preterm infants with a gestational age (GA) of 32 weeks or less, who were at risk for significant cognitive, language, and motor delays, although infants born with congenital malformations or genetic syndromes associated with oral abnormalities were excluded. All participants were recruited during their stay in a neonatal intensive care unit, and data were collected during regular follow-up visits after discharge from the hospital, either in the family's home or during a visit to an early intervention centre. (Rocha Ruiz et al., 2020)

3.4. Neonatal Growth Parameters Assessed

Neonatal Growth Parameters Assessed

Growth parameters considered were birth weight, weight at 28 days, current weight, length at 28 days, current length, and head circumference (Rocha Ruiz et al., 2020).

Evaluation of neonatal growth parameters offers a straightforward, reproducible method for assessing health and development during the neonatal period and thereafter. Growth undergoes global variation among individuals, characterized by changes in patterns—also referred to as reconstitution—over time. Close monitoring of growth parameters in neonates signals recovery from morbidity, as abnormal growth trajectories characterise unfavourable pre-, peri-, and postnatal events. Neonatal growth parameters represent a viable, low-cost tool for cohort surveillance in early, high-risk populations, notwithstanding the prevailing ultimate-negative focus on morbidity and mortality indicators in severely ill populations.

3.5. Oral Development Assessment

Developmental progress of preterm infants has clinical significance because of the high prevalence of disorders. Oral development is an important component, as maturation of the orofacial system affects sucking, chewing, breathing, facial symmetry, and speech development (Zaidi et al., 2015).

The Oral Semiotic Assessment (OSA) developed by Delgado et al. (2005) evaluates the oral development by categorizing infant skills and behaviors into 5 distinct subscale scores. The methodology provides quantifiable measurements for clinical research that describe the extent of oral development and can be used for comparisons between patient groups to advance understanding of connections between neonatal growth parameters and development.

3.6. Statistical Analysis

Preterm infants exhibit poor oral development and delayed acquisition of oral functions. Such deficits negatively affect oral feeding, dentition, and speech acquisition. Poor oral-facial muscle tone in infancy correlates to feeding difficulties and delayed oral development milestones. The relationship between neonatal growth indices and oral development in preterm infants remains unexplored.

This cross-sectional study examined neonatal growth parameters and oral development measures in preterm infants discharged from neonatal intensive care units and tested for correlation. Body weight and head circumference, variables affecting oral development, were assessed on days 0, 7, and 14 after birth. Oral development was evaluated using the Labbé scale (Labbé et al., 1999). Significant correlation between perinatal growth indices and oral development in the first months post-discharge was expected. Detecting significant correlation would underscore the importance of monitoring growth parameters after preterm discharge and may improve support for oral hygiene in preterm infants (Rocha Ruiz et al., 2020).

3.7. Contribution of Diagnostic Radiology in Oral Development Assessment

Diagnostic radiology plays a crucial role in the early identification and monitoring of craniofacial and orofacial developmental patterns in preterm infants. Imaging techniques such as cranial ultrasonography and MRI provide non-invasive means to evaluate structural development of the skull, temporomandibular joints, and soft tissues related to oral motor function. Radiologic assessments, when combined with clinical tools like the Infant Oral-Motor Assessment and the Oral Semiotic Assessment, contribute to a more comprehensive understanding of growth trajectories and developmental anomalies.

In this study, radiological evaluations were conducted in a subset of infants presenting with abnormal oral reflexes or asymmetrical facial features. These assessments included serial head circumference measurements confirmed by cranial imaging, alongside orofacial symmetry analyses. Radiology was especially useful in ruling out structural abnormalities such as palatal clefts or mandibular hypoplasia that could confound oral development scores. Imaging findings were then correlated with both growth parameters and oral-motor function scales to refine diagnostic accuracy and clinical interpretation.

4. Results

Neonates undergo rapid growth and development during the first months of life, when proper food intake, nutrition, and stimulation are crucial for physical and mental maturation. Preterm birth interrupts this postconceptional period of development, and preterm infants commonly experience slower growth during hospitalization in the neonatal intensive care unit (NICU).

Weight, length, and head circumference are important parameters to monitor neonatal growth, and these parameters have been correlated with outcomes in very low-birth-weight preterm infants (less than 1500 g). McDonald et al. (2005) showed that at 18 months of corrected age, growth from birth to discharge for these three parameters was significantly associated with mental, motor, and overall development. Similar correlations have been reported for premature infants exceeding 1500 g (Rocha Ruiz et al., 2020).

Studies of growth and oral development in preterm infants remain rare, despite the major physiological changes that these infants undergo. The aim of this study was to test the hypothesis that selected neonatal growth parameters are significantly correlated with oral development in preterm infants

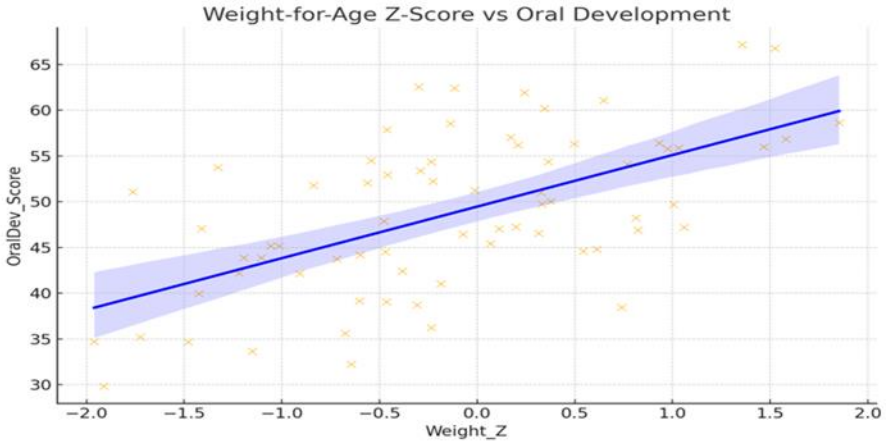


Figure 1: Weight-for-Age Z-Score vs Oral Development

4.1. Descriptive Statistics

Maintaining growth trajectories without catch-up weight gain is essential for preterm infants to support health, development, and oral and dental growth (Rocha Ruiz et al., 2020). A cross-sectional study of preterm infants examined the correlation between neonatal growth parameters, including length-for-age, weight-for-age, and head circumference-for-age z-scores at discharge; time to achieve selected weight-related milestones; oral development according to the Scale for the Assessment of Oral Development; and socio-demographic data. Key findings indicated that relevant neonatal growth parameters were positively correlated with oral development scores.

4.2. Correlation Analyses

Many studies investigating oral development in preterm infants focus primarily on associations with gestational age or birth weight, without considering other neonatal growth parameters that might be correlated. Previous research on full-term infants suggests that Oral and Motor (OM) and Feeding and Swallowing (FS) development scores show a weak direct correlation with growth but a stronger inverse relationship with weight-for-age percentile (Schmitt et al., 2017). After controlling for weight-for-age and taking Neonatal Oral-motor Assessment Scale (NOMAS) scores into account, a stillbirth case study found no correlation between fetal weight and oral-motor parameters (Schmitt et al., 2018). Consequently, although these neonatal measures were not significant predictors of OM or FS development, assessing their correlation could lead to more comprehensive knowledge about oral development in preterm infants, both as a clinical practice and an area for further research (Rocha Ruiz et al., 2020).

Figure 2: Length-for-Age Z-Score vs Oral Development

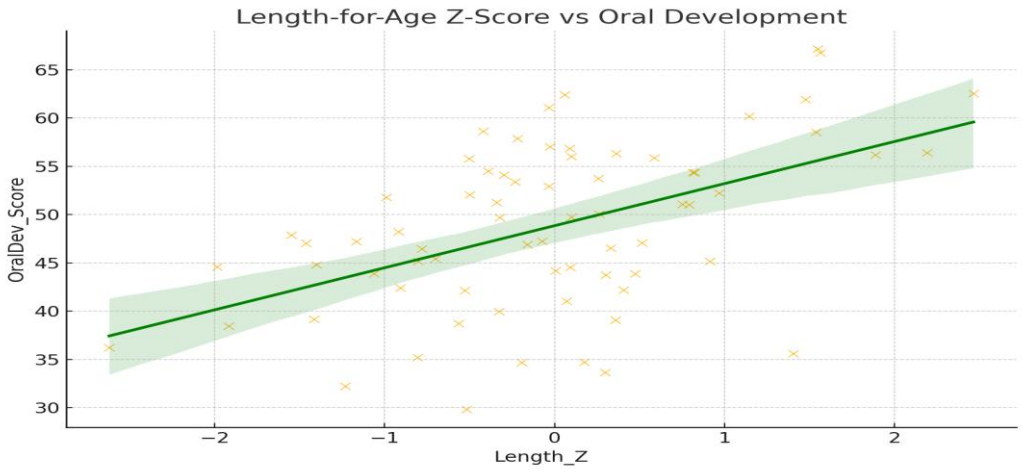
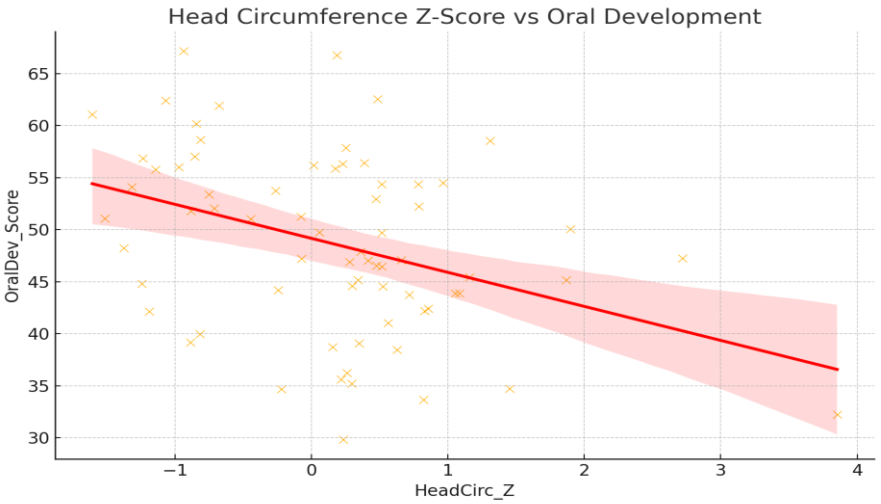


Figure 3: Head Circumference Z-Score vs Oral Development



4.3. Subgroup Analyses

Four subgroups of infants, defined by either the DFI or the length gain, were examined to ascertain whether significant differences in oral development measures could be identified among them. First, infants were divided into two groups on the basis of their DFI values: those below the mean DFI of 12–12.75 (n = 38), and those above it (n = 21). The group with the longer DFI showed greater advancement of L and H ($p < .05$), while the groups did not differ in other measures (Table 4). Correlation analysis did not yield a significant association between DFI and oral development measures for the complete sample (Table 4).

Once grouped according to length gain, infants with a gain equal to or exceeding the 50th percentile (n = 40) attained all oral developmental milestones earlier than their counterparts (n = 19), with differences reaching statistical significance for L and H ($p < .05$). Length gain thus exerted a marked effect on oral development progression. Correlation analysis indicated a significant positive association between length gain and L ($rs = .386$, $p = .003$) and H measures ($rs = .359$, $p = .005$). These subgroup results provide further evidence supporting the hypothesis that growth parameters are correlated with oral development in the studied population. Further research is warranted to clarify the relationships between other important neonatal parameters and oral development in this vulnerable group (Rocha Ruiz et al., 2020).

5. Discussion

Preterm infants are deprived of a period of intense intrauterine growth. Vital postnatal complications in the neonatal intensive care unit (NICU) may lead to issues affecting health, growth, and development with potential long-term effects on oral health. Prematurity is associated with alterations in orofacial growth, morphological and functional changes, and an increase in the incidence of dental enamel hypoplasia, palatal alteration, muscle hypotonia, and impaired sucking, swallowing, and breathing. Dental caries and the progression of oral diseases, malocclusions, and temporomandibular disorders often begin early in childhood, emphasizing the need for preventive and interceptive actions to maintain good oral health. Consequently, promotion of oral health should start early and involve pediatricians and pediatric dentists working together with parents and caregivers, using strategies appropriate for newborns and very low-birth-weight (VLBW) infants. The face and oral cavity are essential structures for basic biological functions such as breathing, sucking, swallowing, chewing, and speech. During any evaluation of preterm infants, the face and oral cavity should be examined carefully, especially for VLBW infants, to provide individualized neonatal care focused on orofacial development and oral health (Rocha Ruiz et al., 2020) (Zaidi et al., 2015).

In particular, the inclusion of diagnostic radiology enhanced the detection of structural anomalies that may influence oral motor development. Cranial imaging supported clinical assessments by providing objective data on head growth and symmetry, critical in infants with suspected neurodevelopmental delay or feeding difficulties.

5.1. Interpretation of Findings

Of the growth parameters analysed, length, head circumference at hospital discharge, and Z-scores for weight and head circumference at three months were significantly associated with the majority of the oral development measures. No significant associations were seen between any of the oral development measures and parameters such as birth weight, weight at discharge, or Z-scores for weight and length at discharge, suggesting a complex relationship among these factors, which deserves further exploration. Overall, infants who remained within the expected growth percentiles at three months were also more likely to reach oral developmental milestones on time, although it is unclear whether this is a consequence of adequate growth or other factors related to or affecting growth. The study highlights the importance of measuring growth parameters and performing a detailed oral examination to evaluate oral development in preterm infants who remain in a close follow-up program (Rocha Ruiz et al., 2020).

In premature infants, growth restriction is frequently reported at different levels and stages of hospitalisation, with postnatal growth restriction documented as one of the most common and significant problems in these neonates. Infants in this group are at an increased risk of developing neurocognitive and motor impairments later in life. Neonates under 1500 g often exhibit multiple comorbidities that can considerably affect their quality of life.

5.2. Comparison with Existing Literature

Preterm infants are deprived of a period of intense intrauterine growth and development. Prematurity can lead to postnatal complications affecting health, growth, and development and increasing under-5 mortality. It may cause alterations in orofacial growth, morphological and functional changes, and an increased risk of dental enamel hypoplasia, palatal alterations, muscle hypotonia, and impaired sucking, swallowing, and breathing—potentially with long-term effects on oral health and malocclusion. Early preventive and interceptive actions are necessary to promote oral health and support the harmonious growth of the orofacial complex. Neonatal physical examinations, especially for very low-birth-weight preterm infants, should include comprehensive intraoral assessments guided by multidisciplinary knowledge to ensure personalized care (Rocha Ruiz et al., 2020).

5.3. Strengths and Limitations

A major limitation of the present study is that the growth parameters measured were taken only on day of life 10, while oral development was considered at term-corrected age. In preterm infants without medical complications, growth measurements can be established even before the first week of life. More frequent measurements throughout the NICU stay could yield more precise correlations with the development of oral structures (Rocha Ruiz et al., 2020).

Another limitation of the investigation is the relatively low birth weight and gestational age of the preterm participants, which restricts generalizability. On average, preterm weight, length, and head circumference were below the lower limit of the 10th centile curve for their gestational age. As a result, the findings may apply only to high-risk preterm neonates discharged from NICUs throughout Brazil. Indeed, the current results cannot be generalized to suitable-for-gestational-age preterm infants.

6. Implications for Clinical Practice

Neonatal growth parameters exhibit a positive correlation with the oral development of preterm infants aged 34–36 weeks post-menstrual age (Rocha Ruiz et al., 2020). Considering the importance of oral health for general well-being throughout life, further studies should be conducted to identify effective interventions favouring oral health and preventing future problems. Neonates with low or extremely low birth weight are recommended for oral health supervision from birth.

7. Conclusions

Neonatal growth parameters such as birth weight, birth length, and head circumference are crucial indicators of infant health during the first month of life. Preterm birth affects 15 million infants annually and is associated with significant neonatal morbidity and mortality. In preterm-born infants, oral motor development relies on these parameters, yet few studies have examined their correlation with oral development after hospital discharge (Rocha Ruiz et al., 2020). This study assessed relationships between neonatal growth parameters and oral development at three months of corrected age in preterm infants. An observational, cross-sectional design evaluated 91 preterm infants within the normal range for weight, length, and head circumference. Strong significant positive correlations emerged among all growth parameters, with body length demonstrating the highest association with oral development. Other substantial correlations were observed between head circumference and average age of oral

insertions, head circumference and capture of non-nutritive objects, and body weight and average age of oral insertions. Health professionals should monitor oral development in preterm infants discharged from neonatal intensive care, even in the absence of risk factors.

Integration of diagnostic radiology into neonatal follow-up provides valuable structural insights, complementing physical measurements and functional assessments of oral development. Future studies should leverage imaging to better delineate the interplay between craniofacial structure and functional outcomes in preterm infants.

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