Original Article

Growth Parameters in Children with Non-syndromic Cleft Lip and Palate versus Healthy Controls: A Cohort Study from Riyadh, Saudi Arabia

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Abstract

Background: Cleft lip and palate (CLP) can have an impact on the physical development of children; however, data from such studies is currently limited.

Objectives: To compare growth parameters between children with non-syndromic CLP and healthy controls in Saudi Arabia.

Materials and Methods: This case–control retrospective cohort study included Saudi children with CLP and age- and gender-matched healthy children (1:1) who attended a tertiary care center in Riyadh, Saudi Arabia. Growth measurements (weight, length, and head circumference) were taken at the ages of 1 year and 2 years, and the Saudi Growth Chart was used as a reference data.

Results: The study included 86 children in each group ($N = 172$), with 31.4% females and 68.6% males. The mean current age was 3.2 ± 1.7 years. Most patients had a unilateral CLP (96.5%). Multivariable analysis demonstrated that at the age of 1 year, compared with controls, patients with CLP had significantly lower weight (OR: 1.7, $P = 0.026$), weight standard deviation score (SDS) (OR: 0.4, $P = 0.001$), and head circumference SDS (OR: 0.8, $P < 0.001$); however, these did not remain significant at the age of 2 years. In the early repair (age <1 year) and late repair (age ≥1 year) groups, 76.1% and 63.2% of the patients achieved catch-up growth.

Conclusion: This study found that Saudi children with cleft lip and palate had significantly lower weight and head circumference compared with healthy children in the first year of life, but catch-up growth in the second year of life, largely following surgical repair, rendered these differences to be insignificant.

Keywords: Children, cleft lip, cleft lip/classification, cleft lip/etiology, cleft palate, growth disorders

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Submitted: 02-May-2024 **Revised:** 09-Oct-2024 **Accepted:** 06-Nov-2024 **Published:** 21-Apr-2025

INTRODUCTION

Congenital cleft lip and palate (CLP), the most common congenital facial defect, affects the nose and underlying alveolus and can significantly impact a child's nutrition, growth, and overall development.[1] In Saudi Arabia, the prevalence of non-syndromic orofacial clefts is 1–1.17/1000 births.[2-4]

Access this article online	
Quick Response Code:	Website: https://journals.lww.com/sjmm
	DOI: 10.4103/sjmms.sjmms_253_24

How to cite this article: Alkhattabi F, Aljohar A, Alharbi A, Alsalman M, Alhuthil R, Almuabyedh A, *et al*. Growth parameters in children with non-syndromic cleft lip and palate versus healthy controls: A cohort study from Riyadh, Saudi Arabia. Saudi J Med Med Sci 2025;13:142-8.

Numerous studies on the physical development of children with CLP have been published,[5-8] yet it remains unclear whether children with CLP exhibit normal growth patterns compared with typically developing children. Nonetheless, studies have largely reported that children with CLP are lighter and smaller than the control group, especially in their early years of development, but catch-up growth may take place later in childhood.[8,9] Furthermore, it has been suggested that multiple contributing factors, such as poor feeding and frequent respiratory infections, can hinder healthy growth. In general, children with isolated cleft palate or CLP experience growth problems more frequently in early infancy.[7,9]

Most previous studies that assessed growth in patients with CLP had limitations such as relatively small sample size, inclusion criteria of different cleft types, including the syndromic cleft, and using unmatched groups.[10,11] In addition, to the best of the authors' knowledge, only one such study has been conducted in Saudi Arabia with a small sample size.[12] Therefore, to fill this gap and to consolidate existing literature, the current study was conducted with the aim of comparing growth parameters of non-syndromic children with CLP with that of age-and gender-matched healthy children from Saudi Arabia.

MATERIALS AND METHODS

The study was reported according to the STROBE guidelines for observational studies.[13]

Study design, setting, and participants

This case–control retrospective cohort study was conducted at King Faisal Specialist Hospital and Research Centre, a tertiary care center in Riyadh, Saudi Arabia, and included children with CLP and age- and gender-matched healthy children attending the same hospital (1:1). In both groups, the children were Saudi, currently aged <6 years, and attended the pediatric clinic from January 01, 2017, to March 31, 2023. Children with syndromic oral cleft or the presence of systemic disease were excluded from the study. Data for all the children were collected at the ages of 1 year and 2 years from the medical records and phone calls with their caregivers.

Sample size calculation

The sample size was calculated based on the findings of Wu *et al*.,[14] which reported a weight standard deviation of 1.46 for the control group and 1.06 for the CLP group. Using a two-sample test for variances, with a significance level (alpha) of 0.05, a power of 0.80, and a delta of 0.726, the estimated total sample size required was 158 participants, with 79 per group.

Measurements

Growth measurements (weight, length, and head circumference) were taken at the ages of 1 year and 2 years. Height and sitting height were measured using a Harpenden Stadiometer, while head circumference was assessed with a tape measure. The Saudi Growth Chart was used as a reference data to define small size if length, weight, and head circumference were greater than two standard deviations below the median or below the third percentile for age and gender.[15] The Saudi Growth Chart was used because the study population consisted exclusively of Saudi children.

Data analysis

All patients' records were assigned to unique codes. The database was designed on REDCap (10.8.0-© 2025 Vanderbilt University). Data were analyzed using STATA software version 17 for Windows. All measurements are expressed as standard deviations (SD), and standard values were presented as z-scores. Continuous data are reported as mean and SD. Categorical data are reported as frequency and percentages. Missing data imputation using the multivariate imputation by chained equations with linear regression was used, as few patients had missing data from the growth data. For each imputed variable (mid-parental height, weight, height, head circumference, and growth velocity), a regression model was built using the independent variables (i.e., age, gender, and exposure) as predictors. Furthermore, independent *t*-test and Chi-square analysis were done to compare growth parameters between children with CLP and healthy controls. In addition, multivariable logistic regression was used to adjust for significance. Kaplan–Meier failure function and the Logrank test were used to estimate the probability of growth catch-up in CLP patients and to compare those who underwent early repair (age <1 year old) versus delayed repair (age ≥1 year old). A *P* value <0.05 was considered significant.

RESULTS

Participants

A total of 172 participants were included: 86 each in the CLP and the healthy control groups. Both groups were matched on age and gender: 54 (31.4%) females and 118 (68.6%) males with a mean current age of 3.2 ± 1.7 years. The mean gestational age at birth was 37.9 ± 1.5 weeks, and most were from Riyadh province (63.4%) [Table 1].

Characteristics of the patients with cleft lip and palate

Most CLP patients presented to the hospital before the age of 1 year (90.7%). Most patients had unilateral CLP (96.5%), and underwent an early surgical repair (77.9%). Positive family history was reported in 15 (17.9%) patients [Table 2].

In terms of dietary history during early childhood, 43 (50.0%) had solid feeding, 39 (45.3%) used bottle feeding, and 12 (13.9%) had breastfeeding; 2 (2.3%) patients required tube feeding, indicating severe feeding difficulties in a small subset [Table 2].

Growth parameters

In patients with CLP, 69.8% of the patients were in the underweight (5th) percentile at the age of 1 year. Further, compared with healthy controls, at the age of 1 year, patients with CLP had significantly lower weight (9.3 ± 1.6 kg vs. 10.4 ± 1.9 kg, $P < 0.001$) (odds ratio [OR]: 1.7, 95% CI: 1.07–2.78, $P = 0.026$), weight standard deviation score (SDS) (−2.3 ± 2.3 vs. 0.3 ± 1.6, $P < 0.001$) (OR: 0.4, 95% CI: 0.26–0.71; $P = 0.001$), and head circumference SDS (−3.7 ± 4.9 vs. 0.02 ± 2.8, $P < 0.001$) (OR: 0.8, 95% CI: 0.66–0.89, $P < 0.001$). In addition, patients with CLP also had significantly lower height SDS (71.7 ± 11.0 vs. 76.5 ± 5.0, $P = 0.003$) but the odds ratio was not significant (OR: 1.0: 0.9–1.05, $P = 0.495$). At the age of 2 years, in the univariate analysis, patients with CLP had significantly lower weight/height percentile ($P = 0.040$) and higher number in underweight percentile ($P < 0.001$), although these did not remain significant in the multivariable analysis [Table 3].

Table 1: Baseline characteristics of the study participants (*N*=172)

Parameter	*n* (%)
Group classification	
With CLP	86 (50.0)
Healthy controls	86 (50.0)
Gender	
Male	118 (68.6)
Female	54 (31.4)
Gestational age at birth (weeks), mean±SD	37.9±1.5
Age at presentation (months), mean±SD	4.3±8.5
Current age (years), mean±SD	3.2±1.7
Geographical distribution (Province)	
Riyadh	109 (63.4)
Eastern	14 (8.1)
Aseer	11 (6.4)
Al Qassim	8 (4.6)
Makkah	8 (4.6)
Najran	5 (2.9)
Northern Borders	4 (2.3)
Tabuk	4 (2.3)
Hail	3 (1.7)
Jizan	2 (1.2)
Madinah	2 (1.2)
Al Baha	1 (0.6)
Al Jawf	1 (0.6)

SD – Standard deviation; CLP – Cleft lip and palate

Table 2: Characteristics of patients with cleft lip and palate (*N*=86)

Parameter	*n* (%)
Age at presentation (years)	
<1	78 (90.7)
1–3	6 (7.0)
4–6	2 (2.3)
Positive family history of CLP	15 (17.9)
Mode of feeding*	
Solids	43 (50.0)
Bottle feeding	39 (45.3)
Breastfeeding	12 (13.9)
Feeding method	
Tube feeding	2 (2.3)
Oral feeding	82 (95.4)
Not mentioned	2 (2.3)
Type of cleft	
Unilateral	83 (96.5)
Bilateral	3 (3.5)
Age at surgical CLP repair (year old)	
Early repair group (<1)	67 (77.9)
Delayed repair group (≥1)	19 (22.1)

*Eight patients had more than one mode of feeding. CLP – Cleft lip and palate

Figure 1 illustrates the growth percentile of two males: a patient with CLP compared with a matched, unaffected peer, with their growth tracked from ages 2 months to 24 months. The CLP patient demonstrated a significantly lower percentile across all ages compared with his unaffected peer. At 2 months, the CLP patient was in the 2nd percentile, while the healthy child was in the 30th percentile. After the CLP patient's surgical correction at 6 months, his weight improved slightly to the 5th percentile yet lagged that of the healthy child (43rd percentile).

Among the CLP cases, the median time to growth catch-up was 20 months in the early repair group (age <1 year old) versus 24 months in the delayed repair group (age ≥1 year old). A total of 47 patients achieved growth catch-up in the early repair group, compared with 12 patients in the delayed repair group ($P < 0.001$) [Figure 2].

DISCUSSION

Children with CLP face considerable challenges with feeding, particularly in the early months of life.[1] This study aimed to compare the growth parameters of

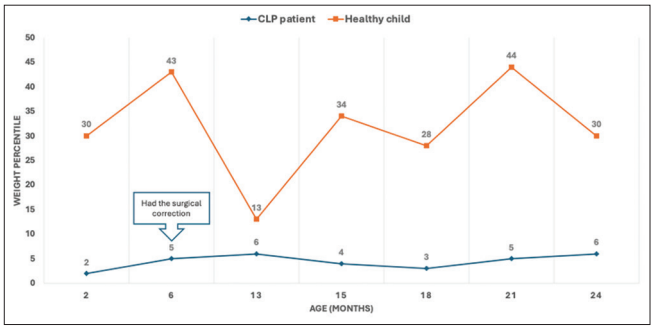

Figure 1: Growth percentile comparison of a male with cleft lip and palate (CLP) versus an unaffected healthy peer from 2 to 24 months of age

Table 3: Comparative analysis of clinical characteristics between patients with cleft lip and palate versus healthy controls

Parameters	Univariate analysis			Multivariable analysis	
	CLP (*N*=86), *n* (%)/mean±SD	Controls (*N*=86), *n* (%)/mean±SD	*P*	OR (95% CI)	*P*
Demographics					
Male gender	59 (68.6)	59 (68.6)	1.000	2.1 (0.59–7.46)	0.254
Gestational age at birth (weeks)	37.9±1.3	38.0±1.8	0.606	1.2 (0.86–1.55)	0.348
Mid-parental height (cm)	167.9±8.7	169.2±7.2	0.260	1.0 (0.93–1.07)	0.906
Growth data at 1 year of age					
Growth velocity	9.7±13.3	9.7±8.4	0.979	1.0 (0.98–1.08)	0.210
Weight (kg)	9.3±1.6	10.4±1.9	<0.001*	1.7 (1.07–2.78)	**0.026***
Weight SDS	−2.3±2.3	0.3±1.6	**<0.001***	0.4 (0.26–0.71)	**0.001***
Height (cm)	71.7±11.0	76.5±5.0	**0.003***	1.0 (0.9–1.05)	0.495
Height SDS	−3.9±5.6	0.5±2.3	**<0.001***	0.9 (0.77–1.01)	0.061
Head circumference SDS	−3.7±4.9	0.02±2.8	**<0.001***	0.8 (0.66–0.89)	**<0.001***
Weight/height percentile	48.8±42.7	52.5±36.5	0.553	1.0 (0.99–1.02)	0.234
Underweight <5th percentile	60 (69.8)	5 (5.8)	**<0.001***	2.8 (0.42–19.18)	0.289
Growth data at 2 years of age					
Growth velocity	6.5±7.1	8.6±6.1	**0.045***	1.0 (0.9–1.06)	0.552
Weight (kg)	12.5±3.1	14.3±3.3	**<0.001***	1.0 (0.79–1.15)	0.646
Weight SDS	0.96±5.1	1.2±3.7	0.717	1.1 (0.93–1.23)	0.329
Height (cm)	85.7±5.8	87.8±4.5	**0.007***	1.0 (0.88–1.07)	0.514
Height SDS	−1.3±9.4	0.2±5.5	0.213	1.0 (0.92–1.03)	0.419
Head circumference SDS	0.72±1.7	0.75±1.7	0.928	1.0 (0.74–1.35)	0.989
Weight/height percentile	37.4±35.6	48.6±35.1	**0.040***	1.0 (0.98–1.01)	0.681
Underweight <5th percentile	24 (27.9)	3 (3.5)	**<0.001***	1.5 (0.24–9.84)	0.647

*Bold values denote statistical significance at $P>0.05$. Independent *t*-tests for continuous variables and Chi-square for categorical variables were used in the univariate analysis. Multivariable analysis was done using logistic regression. SD – Standard deviation; CLP – Cleft lip and palate; SDS – SD score; OR: Odds ratio; CI – Confidence interval

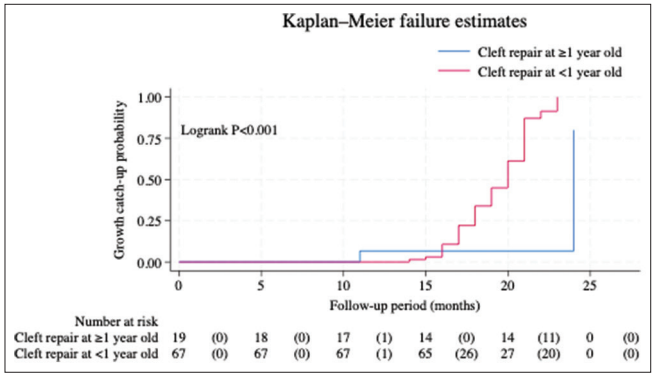

Figure 2: Kaplan–Meier failure function estimating the probability of growth catch-up in CLP patients (*N* = 86) who underwent surgical correction before 1 year of age compared with those who did not. The median time to growth catch-up was 20 months in the early repair group (age <1 year old) versus 24 months in the delayed repair group (age ≥1 year old). A total of 47 patients achieved growth catch-up in the early repair group, compared to 12 patients in the delayed repair group. Logrank test: *P* <0.001. The number in parenthesis indicates the number of patients who had the growth catch-up

non-syndromic CLP versus normal children in the Saudi population. Most of the affected cases in our study had unilateral CLP (96.5%) and were males (68.6%), which is similar to that reported in other studies.[16-18] Most patients were from the Riyadh province, which could be due to the population in Riyadh being larger than that of other provinces in Saudi Arabia,[19] and also our hospital being located in Riyadh.

A striking 69.8% of CLP patients were underweight (below the 5th percentile), compared to only 5.8% of controls ($P < 0.001$), highlighting severe growth challenges in CLP children, particularly in the first year of life. Given that our study population only comprised Saudi children, we used the Saudi Growth Chart as reference data[15] rather than the NCHS's growth chart, which is based on American children.[20] A previous study has found that Saudi children are slightly shorter and thinner compared to their American counterparts when evaluated against the NCHS standards,[21] thereby we opted to use the Saudi Growth Chart.

Several studies have investigated the growth patterns and parameters in children with CLP.[14,22-27] Wu *et al*. examined the physical growth status and feeding methods of Chinese infants aged <1 year with cleft lip, with or without cleft palate, and found that these children had lower weight, height, and body mass index compared with the general population.[14] Similarly, in our study, patients with CLP had significantly lower weight and head circumference at the age of 1 year in the multivariable analysis.

In addition to anthropometric measurements, studies have also explored the impact of cleft lip on specific growth parameters, such as head circumference. A recent study found that children with syndromic and non-syndromic CLP had smaller head circumferences compared to unaffected children (0.79 cm and 0.09 cm mean difference,

respectively), indicating potential craniofacial growth restrictions. These findings have implications for early intervention and monitoring of neurodevelopmental outcomes in children with CLP.[22] Likewise, in this study, the head circumference was significantly lower in patients with CLP than in healthy controls at the ages of 1 year and 2 years. Besides, neurological disorder was reported in six patients; seven patients had hearing loss, and two had developmental delay.

A study by Cavalheiro *et al*. compared the gross motor, fine motor, social-personal, and language skills in 30 children with non-syndromic CLP (ages 36–47 months) with healthy age- and gender-matchedfc children and found significant differences in gross motor, adaptive fine motor, and both receptive and expressive language skills between the groups. Although children with CLP showed below-expected performance in social-personal skills, no significant differences were noted.[23]

Surgical correction (lip/palate repair) is crucial for the management of CLP, most of our cases had early repair (i.e., before the age of 1 year), which resulted in a growth catch-up at the age of 2 years, with the proportion of underweight children also decreasing from 69.8% to 27.9%. Surgical correction helped restore function and improve aesthetics, subsequently improving feeding ability and overall growth outcomes. Similarly, another study on children with cleft lip found that surgical intervention resulted in catch-up growth, with significant improvements in weight and height in the postoperative period.[24] Nevertheless, despite the post-surgery progress, patients with CLP remained at a lower weight percentile than their unaffected peers in our study. Similarly, one study found that children with CLP had lower growth than their peers, regardless of surgical correction, and dental management was essential for these children due to primary teeth instability and caries.[22] Another study found that children with cleft palate who underwent cheiloplasty had significant catch-up growth in height and weight by adolescence. Patients with malnourishment had improvements, but values had remained low until adolescence.[25]

Various factors contribute to the growth challenges observed in children with CLP. A recent study conducted in the United States investigated growth in orofacial cleft patients aged 0–36 months, and found that in the first year of life, infants with cleft reported considerably worse growth when compared with the World Health Organization standards. In addition, poor growth was associated with comorbidities and type of cleft.[26] This highlights the need for further investigation into other contributing factors when investigating growth in CLP patients.

Feeding difficulties are common in patients with CLP because of impaired suction due to the anatomical differences in their oral structures, leading to inadequate calorie intake and suboptimal weight gain. A recent study reported that children with CLP required initial care and assistance with feeding practices, as they may have stunted growth in the first few months of life due to nutritional concerns.[27] However, after the age of 2 years, the majority of the patients grow and have nutritional status that are comparable to those of their peers.[27] In our study, only 12 children with CLP (13.9%) had been breastfed, while 2 required feeding tubes. These findings highlight the need for ongoing nutritional assessment and support for children with CLP to ensure optimal growth and development.

An approach to address malnutrition in patients with CLP involves the use of ready-to-use therapeutic foods (RUTF), a nutrient-dense peanut paste rich in proteins, carbohydrates, lipids, and other essential nutrients that have proven to be effective in treating children with moderate to severe malnutrition, particularly in low- and middle-income countries. RUTF offers a home-based treatment option that is shelf-stable, does not need refrigeration or cooking, and has low water content, which helps prevent bacterial growth.[28] Using RUFT has also been shown to be valuable in emergency situations where malnutrition prevents children with orofacial clefts from accessing surgical care, even when offered for free, leading to a significant disparity in surgical access.[28,29] A recent study showed that in about 6 weeks and at a cost of approximately US$25 per patient, RUTF helped about >60% of children with orofacial cleft transition from malnutrition to meeting the nutritional criteria for surgery, demonstrating its effectiveness as a short-term preoperative nutritional intervention.[29]

Limitations

This study has the inherent limitations of a retrospective study design. In addition, few patients had missing growth data, and thus multivariate imputation was required to circumvent this issue. Finally, the correlation between age at surgical repair and feeding method was not investigated in this study.

CONCLUSION

This study found that Saudi children with cleft lip and palate had significantly lower weight and head circumference compared with healthy children in the first year of life. Notably, most patients with cleft lip and palate who

underwent early surgical repair (i.e., before the age of 1 year) had a catch-up growth at the age of 2 years, signifying that early intervention and specialized care are crucial for supporting growth and development in infants with cleft lip and palate.

Ethical considerations

Ethical approval was obtained from the Office of Research Affairs at King Faisal Specialist Hospital and Research Centre (Ref. no.: 2231074), Riyadh, Saudi Arabia. All caregivers provided consent for participation. The study adhered to the principles of the Declaration of Helsinki, 2013.

Peer review

This article was peer-reviewed by two independent and anonymous reviewers.

Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author contributions

Conceptualization: A.A. and F.A.; Methodology: M.A., A.Alharbi, R.A. and E.A.; Data analysis: R.A., A.Alsagheir and A.Almuabyedh; Writing–original draft preparation: A.A., F.A., M.A., A.Alharbi and A.Almuabyedh; Review and editing: R.A., E.A., A.Alsagheir; Supervision: A.A. and F.A.

All authors have read and agreed to the published version of the manuscript.

Financial support and sponsorship

None

Conflicts of interest

There are no conflicts of interest.

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