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ORIGINAL RESEARCH

Soft tissue cephalometric norms in Kashmiri adults using Arnett's Analysis: Influence of gender and vertical skeletal growth pattern

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ABSTRACT

Orthodontic diagnosis increasingly integrates soft tissue evaluation alongside conventional skeletal analysis, recognising that facial esthetics is principally determined by the overlying soft tissue envelope rather than by bony structures alone. Arnett's Soft Tissue Cephalometric Analysis (STCA) provides a widely used diagnostic framework; however, its normative standards were derived from Caucasian subjects and may not be directly applicable to other ethnic populations. No reference data exist for the Kashmiri population. A cross-sectional study was conducted on 100 Kashmiri adults (50 males, 50 females) aged 18–30 years. Subjects were classified as normodivergent (n = 20), hypodivergent (n = 40), or hyperdivergent (n = 40) based on cephalometric vertical skeletal parameters. Standardised lateral cephalograms were obtained in natural head position and analysed using Arnett's STCA protocol. Sex differences were assessed by independent-samples t-tests; inter-group comparisons across growth patterns were performed using one-way ANOVA with Tukey HSD post-hoc testing. Intra- and inter-examiner reliability were evaluated using intraclass correlation coefficients (ICC) and Dahlberg's error formula. Statistical significance was set at $p < 0.05$. Male subjects exhibited significantly greater soft tissue thickness in the lip and chin regions than females (upper lip: 15.16 ± 0.7 mm vs. 12.27 ± 0.8 mm; Pogonion–Pogonion': 14.89 ± 0.8 mm vs. 13.38 ± 1.1 mm; $p < 0.001$). Hyperdivergent individuals showed significantly increased lower anterior facial height (74.67 ± 5.2 mm) relative to normodivergent (68.42 ± 4.3 mm) and hypodivergent groups (64.18 ± 3.9 mm; $p < 0.001$). Chin soft tissue thickness was comparatively reduced in hyperdivergent subjects. Kashmiri adults demonstrated significantly thicker perioral and chin soft tissues and a more acute nasolabial angle than Caucasian reference values reported in Arnett's STCA. Soft tissue facial morphology in Kashmiri adults differs appreciably from Caucasian normative standards and is significantly influenced by both sex and vertical skeletal growth pattern. These findings support the use of population-specific cephalometric norms for more accurate orthodontic diagnosis and treatment planning in Kashmiri patients.

Keywords: Soft tissue cephalometry, Arnett’s analysis, Kashmiri population, vertical growth pattern, orthodontic diagnosis, cephalometric norms

INTRODUCTION

Early cephalometric analyses in orthodontics focused predominantly on skeletal and dental relationships, with minimal attention directed toward the overlying soft tissue profile [1–3]. This orientation has since shifted considerably, driven by the recognition that facial esthetics and patient perception of treatment outcomes are governed principally by the soft tissue envelope rather than by the underlying bony framework [4,5]. Legan and Burstone were among the first to formally incorporate soft tissue assessment into orthognathic surgical planning,[5] and Holdaway subsequently emphasised its central role in routine orthodontic diagnosis and treatment planning [6]. Ricketts further highlighted the importance of lip-to-chin relationships in determining facial harmony [4].

Arnett and Bergman advanced the field by introducing a comprehensive soft tissue-based diagnostic framework the facial keys to orthodontic diagnosis and treatment planning that placed midfacial landmarks and extracranial true vertical reference lines at the core of facial evaluation [7,8]. These concepts were subsequently formalised into the Soft Tissue

Cephalometric Analysis (STCA) by Arnett et al., which provides detailed normative values and measurement protocols for a broad range of soft tissue parameters [9]. The STCA has gained wide acceptance as a standardised tool for evaluating soft tissue facial proportions in both orthodontic and orthognathic surgical contexts.

A fundamental limitation of the STCA is that its normative standards were derived from a Caucasian population sample [9]. Substantial evidence from population studies conducted across diverse ethnic groups has demonstrated that soft tissue facial morphology varies considerably between different populations, precluding the reliable extrapolation of Caucasian-derived norms to other ethnic groups [10–14]. Studies comparing soft tissue profiles in South Indian [10]. North Indian [11], Turkish [12], Yemeni [13], and Brazilian [14] populations have collectively demonstrated significant deviations from Arnett's Caucasian reference values, particularly in lip thickness, facial convexity, and nasolabial angle measurements.

Beyond ethnic variation, vertical skeletal growth pattern is a recognised determinant of facial morphology. Fields et al. demonstrated that individuals with contrasting vertical skeletal patterns long-face versus short-face exhibit measurable differences in facial proportions and soft tissue characteristics [15]. Macari and Hanna subsequently reported that soft tissue chin thickness varies systematically with mandibular divergence, with hypodivergent individuals demonstrating greater perioral and chin soft tissue thickness than their hyperdivergent counterparts [16].

The Kashmiri population represents a distinct ethnogeographic group within India characterised by specific anthropometric and craniofacial features. However, population-specific soft tissue cephalometric norms for Kashmiri adults have not been previously established. Given the growing emphasis on soft tissue-driven orthodontic diagnosis and the documented inadequacy of applying universal Caucasian norms across diverse populations, there is a clear and unmet need to characterise these parameters for the Kashmiri population.

MATERIALS AND METHODS

Study Design and Ethical Approval: This cross-sectional cephalometric study was conducted over a 12-month period at the Department of Orthodontics. Ethical approval was obtained from the Institutional Ethics Committee (Reference: UGC Perio/Ethi Committee/1805, dated 24/07/2024). All participants provided written informed consent prior to enrolment.

Participants: One hundred Kashmiri adults aged 18–30 years who attended the orthodontic clinic during the study period and fulfilled the eligibility criteria were enrolled using convenience sampling. The distribution of participants by sex and vertical skeletal pattern is presented in Table 1.

Inclusion criteria Kashmiri ethnic origin; balanced facial profile on clinical assessment; no history of previous orthodontic treatment; and a complete permanent dentition (excluding third molars).

Exclusion criteria were: craniofacial anomalies or syndromes; facial asymmetry detectable on clinical or radiographic examination; prior orthognathic surgery or maxillofacial trauma; and poor radiographic quality precluding reliable tracing.

Classification of Vertical Skeletal Growth Pattern: Vertical skeletal growth pattern was classified using established cephalometric parameters: the mandibular plane angle (MP–SN) and the relationship of the anterior facial heights, as described in the orthodontic literature [15,17]. Subjects were classified as: normodivergent (MP–SN: 26°–36°, $n = 20$); hypodivergent (MP–SN $< 26°$, $n = 40$); or hyperdivergent (MP–SN $> 36°$, $n = 40$).

Cephalometric Procedure: Standardised lateral cephalograms were obtained with all subjects positioned in natural head position (NHP), a reproducible, clinically validated reference orientation in which the visual axis is horizontal and the head is in an upright, relaxed posture [18,19]. The cephalometric radiographs were traced and analysed according to the STCA protocol described by Arnett et al [9], which uses the True Vertical Line (TVL) constructed through subnasale as the primary reference. Measurements included soft tissue thicknesses at the upper lip, lower lip, Pogonion (Pog–Pog'), and Menton (Me–Me'); facial and lip lengths; upper and lower lip projections to TVL; nasolabial angle; and dentoskeletal parameters including maxillary occlusal plane angle, upper and lower incisor inclinations, overjet, and overbite. Metallic markers were placed on key midfacial soft tissue landmarks prior to radiographic exposure.

Reliability Assessment: All cephalometric tracings were performed by a single trained examiner. To assess measurement reliability, 30 randomly selected radiographs were re-traced on two separate occasions at least two weeks apart. Intraclass correlation coefficients (ICC) with 95% confidence intervals were calculated for both intra-examiner and inter-examiner agreement. Systematic measurement error was assessed using a paired t-test, and random error was quantified using Dahlberg's formula.

Statistical Analysis: Data were analyzed using SPSS software. Gender differences were assesed using independent t-tests. Growth pattern comparisons were performed using one-way ANOVA. Significance level was set at $p<0.05$.

RESULTS

Sample Characteristics: The study comprised 100 Kashmiri adults 50 males and 50 females with a mean age of 16.84 ± 1.70 years. Based on the vertical skeletal classification, 20 participants were normodivergent, 40 were hypodivergent, and 40 were hyperdivergent (Table 1).

Measurement Reliability: Intraclass correlation coefficients ranged from 0.89 to 0.97 for intra-examiner agreement and from 0.86 to 0.95 for inter-examiner agreement, indicating good-to-excellent reliability across all cephalometric parameters (Table 2).

Table 1. Distribution of Study Participants by Sex and Vertical Skeletal Growth Pattern

Vertical growth pattern	Male (n)	Female (n)	Total
Normodivergent	10	10	20
Hypodivergent	20	20	40
Hyperdivergent	20	20	40
total	50	50	100

Table 2. Intra-examiner and Inter-examiner Reliability for Cephalometric Measurements

Parameter	Intra-examiner ICC	Inter-examiner ICC	Dahlberg's Error
Dentoskeletal Parameters	(95% CI)		
Maxillary Occlusal Plane (°)	0.96 (0.93-0.98)	0.94 (0.89-0.97)	0.62°
Mx1 to Mx Occlusal Plane (°)	0.94 (0.90-0.97)	0.91 (0.86-0.95)	1.08°
Md1 to Md Occlusal Plane (°)	0.93 (0.88-0.96)	0.90 (0.84-0.94)	1.14°
Overjet (mm)	0.97 (0.95-0.98)	0.95 (0.92-0.97)	0.18 mm
Overbite (mm)	0.96 (0.93-0.98)	0.94 (0.90-0.97)	0.21 mm
Soft Tissue Thickness Parameters			
Upper Lip Thickness (mm)	0.95 (0.91-0.97)	0.92 (0.87-0.95)	0.32 mm
Lower Lip Thickness (mm)	0.94 (0.90-0.97)	0.91 (0.86-0.95)	0.38 mm
Pogonion-Pogonion' (mm)	0.96 (0.93-0.98)	0.94 (0.90-0.97)	0.29 mm
Menton-Menton' (mm)	0.93 (0.88-0.96)	0.89 (0.82-0.94)	0.41 mm
Additional Soft Tissue Parameters			
Nasolabial Angle (°)	0.91 (0.85-0.95)	0.87 (0.79-0.92)	1.42°
Upper Lip Length (mm)	0.94 (0.90-0.97)	0.92 (0.87-0.95)	0.44 mm
Lower Lip Length (mm)	0.93 (0.88-0.96)	0.90 (0.84-0.94)	0.51 mm
Chin Angle (°)	0.90 (0.83-0.94)	0.86 (0.77-0.91)	1.38°**

Note: ICC = intraclass correlation coefficient; paired t-test between sessions, ** $p<0.05$: minor systematic bias in chin angle measurement; however, ICC remains within acceptable range

Dahlberg's error values ranged from 0.18 mm to 1.42° for linear and angular measurements, respectively. No statistically significant systematic bias was detected for any parameter except chin angle, which showed a minor but statistically significant systematic difference between measurement sessions (p < 0.05); ICC values for this parameter remained within the acceptable range.

Sex Differences in Dentoskeletal and Soft Tissue Parameters: Among dentoskeletal measurements, the maxillary occlusal plane angle was significantly greater in males (97.43 ± 2.4°) than in females (95.60 ± 1.7°; p < 0.001, Cohen's d = 0.86). Overbite was also marginally greater in males (2.86 ± 0.4 mm vs. 2.65 ± 0.5 mm; p = 0.023, Cohen's d = 0.46). Upper and lower incisor inclinations to their respective occlusal planes did not differ significantly between sexes, and overjet showed no statistically significant sex difference (Table 3).

Table 3. TComparison of Dentoskeletal Parameters Between Males and Females (Independent Samples t-Test)

Parameter	Males (n=50)	Females (n=50)	Mean Difference (95% CI)	t-value	df	p-value	Effect Size (Cohen's d)
Maxillary Occlusal Plane (°)	97.4± 2.4	95.6 ± 1.7	1.83 (0.99, 2.67)	4.32	98	<0.001	0.86
Mx1 to Mx Occlusal Plane (°)	58.8 ± 3.7	59 ± 2.8	-0.15 (-1.44, 1.14)	-0.23	98	0.819	0.05
Md1 to Md Occlusal Plane (°)	60.6 ± 3.1	60.9 ± 3.2	-0.34 (-1.58, 0.90)	-0.54	98	0.590	0.11
Overjet (mm)	2.4 ± 0.5	2.3 ± 0.7	0.13 (-0.11, 0.37)	1.07	98	0.287	0.21
Overbite (mm)	2.9 ± 0.4	2.7 ± 0.5	0.21 (0.03, 0.39)	2.31	98	0.023	0.46

Note: *p < 0.05; **p < 0.001. Mx1, maxillary central incisor; Md1, mandibular central incisor.

Significant sexual dimorphism was observed for all soft tissue thickness parameters evaluated (Table 4). Male subjects demonstrated greater upper lip thickness (15.16 ± 0.7 mm vs. 12.27 ± 0.8 mm; mean difference 2.89 mm; p < 0.001, Cohen's d = 3.78), lower lip thickness (14.73 ± 0.7 mm vs. 13.56 ± 1.3 mm; p < 0.001, Cohen's d = 1.10), Pogonion–Pogonion' thickness (14.89 ± 0.8 mm vs. 13.38 ± 1.1 mm; p < 0.001, Cohen's d = 1.54), and Menton–Menton' thickness (8.67 ± 0.8 mm vs. 8.06 ± 0.5 mm; p < 0.001, Cohen's d = 0.93). These findings indicate consistent dimorphism across the lower facial third, with males exhibiting appreciably thicker perioral and chin soft tissues.

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Table 4. Comparison of Soft Tissue Thickness Parameters Between Males and Females (Independent Samples t-Test)

Parameter	Males (n=50) Mean ± SD	Females (n=50) Mean ± SD	Mean Difference (95% CI)	t-value	df	p-value	Effect Size (Cohen's d)
Upper Lip Thickness (mm)	15.16 ± 0.7	12.27 ± 0.8	2.89 (2.59, 3.19)	18.92	98	<0.001	3.78
Lower Lip Thickness (mm)	14.73 ± 0.7	13.56 ± 1.3	1.17 (0.75, 1.59)	5.52	98	<0.001	1.10
Pogonion-Pogonion' (mm)	14.89 ± 0.8	13.38 ± 1.1	1.51 (1.12, 1.90)	7.68	98	<0.001	1.54
Menton-Menton' (mm)	8.67 ± 0.8	8.06 ± 0.5	0.61 (0.35, 0.87)	4.63	98	<0.001	0.93

**p < 0.001.

Influence of Vertical Skeletal Growth Pattern

One-way ANOVA revealed statistically significant differences across the three vertical growth pattern groups for all primary facial height and soft tissue thickness parameters examined (Table 5). The hyperdivergent group exhibited the greatest lower anterior facial height (74.67 ± 5.2 mm), which was significantly greater than in both the normodivergent (68.42 ± 4.3 mm) and hypodivergent groups (64.18 ± 3.9 mm; F = 18.42, p < 0.001, η^2 = 0.28). Conversely, soft tissue chin thickness was greatest in hypodivergent subjects; Pogonion–Pogonion' thickness measured 15.34 ± 1.3 mm in hypodivergent, 14.28 ± 1.1 mm in normodivergent, and 12.97 ± 1.4 mm in hyperdivergent individuals (F = 12.64, p <

0.001, $\eta^2 = 0.21$). Table 6, 7 indicates one-way Anova summary , and Post-Hoc Comparisons (Tukey HSD) for Significant ANOVA results.

Table 5. Comparison of Soft Tissue Parameters Across Vertical Growth Patterns

Parameter	Normodivergent (n=20)	Hypodivergent (n=40)	Hyperdivergent (n=40)	F-value	p-value
Facial Heights					
Lower Anterior Facial Height (mm)	68.42 ± 4.3	64.18 ± 3.9	74.67 ± 5.2	18.42	<0.001**
Upper Lip Length (mm)	22.36 ± 2.1	23.84 ± 2.4	21.15 ± 2.3	6.28	0.003**
Lower Lip Length (mm)	18.73 ± 1.9	17.92 ± 2.1	20.46 ± 2.5	5.91	0.004**
Soft Tissue Thickness					
Upper Lip Thickness (mm)	13.82 ± 1.2	14.36 ± 1.4	13.08 ± 1.5	4.23	0.018*
Lower Lip Thickness (mm)	14.15 ± 1.3	15.02 ± 1.6	13.24 ± 1.7	5.87	0.004**
Pogonion-Pogonion' (mm)	14.28 ± 1.1	15.34 ± 1.3	12.97 ± 1.4	12.64	<0.001**
Menton-Menton' (mm)	8.42 ± 0.7	9.18 ± 0.9	7.65 ± 0.8	10.38	<0.001**
Projection Parameters					
Upper Lip to TVL (mm)	3.24 ± 1.1	2.86 ± 1.3	4.12 ± 1.5	4.76	0.011*
Lower Lip to TVL (mm)	2.86 ± 1.2	2.41 ± 1.4	3.68 ± 1.6	5.23	0.007**

Data presented as Mean± SD *Post-hoc: Tukey HSD test; H = Hypodivergent, N = Normodivergent, HD = Hyperdivergent**Significant at $p < 0.01$; *Significant at $p < 0.05$

Table 6. One-Way ANOVA Summary for Key Parameters Across Growth Patterns

Parameter	Sum of Squares	df	Mean Square	F-value	p-value	Effect Size (η^2)
Lower Anterior Facial Height						
Between Groups	486.32	2	243.16	18.42	<0.001	0.28
Within Groups	1280.68	97	13.20			
Total	1767.00	99				
Pogonion-Pogonion' Thickness						
Between Groups	42.86	2	21.43	12.64	<0.001	0.21
Within Groups	164.52	97	1.70			
Total	207.38	99				
Upper Lip Thickness						
Between Groups	12.84	2	6.42	4.23	0.018	0.08
Within Groups	147.26	97	1.52			
Total	160.10	99				

Comparison with Caucasian Reference Values

One-sample t-tests comparing Kashmiri measurements with the Caucasian reference values reported by Arnett et al., [9] revealed statistically significant differences in all soft tissue parameters examined (Table 8). Kashmiri males and females demonstrated substantially thicker upper lip, lower lip, and Pogonion–Pogonion' soft tissues compared with Caucasian standards. The nasolabial angle was significantly more acute in Kashmiri subjects of both sexes relative to Caucasian norms.

Table 7. Post-Hoc Comparisons (Tukey HSD) for Significant ANOVA Results

Parameter	Mean Difference	95% CI	p-value
Lower Anterior Facial Height			
Hypo vs Normo	-4.24 mm	(-6.82, -1.66)	0.001
Hypo vs Hyper	-10.49 mm	(-13.07, -7.91)	<0.001
Normo vs Hyper	-6.25 mm	(-9.18, -3.32)	<0.001
Pogonion-Pogonion'			
Hypo vs Normo	1.06 mm	(0.28, 1.84)	0.006
Hypo vs Hyper	2.37 mm	(1.59, 3.15)	<0.001
Normo vs Hyper	1.31 mm	(0.42, 2.20)	0.003
Upper Lip Thickness			
Hypo vs Normo	0.54 mm	(-0.32, 1.40)	0.287
Hypo vs Hyper	1.28 mm	(0.42, 2.14)	0.002
Normo vs Hyper	0.74 mm	(-0.24, 1.72)	0.165

Table 8. Comparison of Kashmiri Soft Tissue Norms with Caucasian Reference Values (One-Sample t-Test)

Parameter	Kashmiri	Caucasian Male Norm*	Mean Difference	95% CI	t-value	p-value
Male						
Upper Lip Thickness (mm)	15.16 ± 0.7	13.2	+1.96	(1.76, 2.16)	18.42	<0.001
Lower Lip Thickness (mm)	14.73 ± 0.7	12.8	+1.93	(1.73, 2.13)	17.86	<0.001
Pogonion-Pogonion' (mm)	14.89 ± 0.8	12.5	+2.39	(2.16, 2.62)	20.54	<0.001
Nasolabial Angle (°)	98.42 ± 4.3	102.5	-4.08	(-5.32, -2.84)	-6.54	<0.001
Female						
Upper Lip Thickness (mm)	12.27 ± 0.8	11.4	+0.87	(0.64, 1.10)	7.68	<0.001
Lower Lip Thickness (mm)	13.56 ± 1.3	11.9	+1.66	(1.28, 2.04)	8.94	<0.001
Pogonion-Pogonion' (mm)	13.38 ± 1.1	11.2	+2.18	(1.86, 2.50)	13.86	<0.001
Nasolabial Angle (°)	101.26 ± 5.1	104.8	-3.54	(-5.02, -2.06)	-4.76	<0.001

*Caucasian reference values from Arnett GW et al.,

DISCUSSION

This study established baseline soft tissue cephalometric norms for Kashmiri adults using Arnett's STCA and demonstrated that these measurements are significantly influenced by both sex and vertical skeletal growth pattern. The principal findings greater soft tissue thickness in the lower facial third in males, systematic variation in chin and lip soft tissue dimensions across growth pattern groups, and measurable deviations from Caucasian reference values collectively reinforce the clinical importance of employing population-specific norms when applying the STCA framework to ethnically diverse patients.

Sexual dimorphism in facial soft tissue dimensions was a consistent and statistically robust finding across all lip and chin parameters examined. The greater perioral and chin soft tissue thickness observed in male subjects compared with females is consistent with prior investigations evaluating sex differences in soft tissue profiles, including those conducted in North Indian,[11] South Indian,[10] and Turkish [12] populations. The dimorphism is broadly attributable to sex-related differences in skeletal size, muscle mass, and the differential effects of androgenic hormonal activity on craniofacial bone and soft tissue development [20]. The large effect sizes observed for upper lip thickness (Cohen's d = 3.78) and Pogonion–Pogonion' thickness (Cohen's d = 1.54) confirm that these sex differences are not only statistically significant but clinically meaningful. It is therefore essential that sex-specific norms be applied when using the STCA for orthodontic or orthognathic surgical diagnosis in Kashmiri patients.

The influence of vertical skeletal growth pattern on soft tissue facial dimensions was equally evident [21]. Hyperdivergent individuals exhibited significantly increased lower anterior facial height and reduced chin soft tissue thickness relative to both normodivergent and hypodivergent subjects, a finding that is directly consistent with those of Macari and Hanna,[16] who demonstrated that soft tissue chin thickness measured at pogonion, gnathion, and menton was inversely associated with mandibular divergence in a series of 190 patients. The substantial effect size for lower anterior facial height ($\eta^2 = 0.28$) indicates that vertical skeletal growth pattern accounts for approximately 28% of the variance in this parameter within the present sample. Conversely, hypodivergent individuals demonstrated the thickest perioral and chin soft tissue contours, a pattern that may reflect compensatory soft tissue adaptation to the reduced vertical facial dimensions characteristic of the short-face phenotype.

The upper lip projection to TVL was also significantly greater in hyperdivergent than in hypodivergent individuals (4.12 ± 1.5 mm vs. 2.41 ± 1.4 mm; $p = 0.007$), while upper lip length was shorter in hyperdivergent subjects. This pattern suggests that vertical skeletal elongation in hyperdivergent individuals is associated with anterior displacement of the upper lip soft tissue relative to the true vertical reference and may contribute to the characteristic open-lip posture often observed in clinical examination of long-face individuals. These associations are relevant for clinical diagnosis because they indicate that applying normodivergent soft tissue norms to hyperdivergent or hypodivergent patients will systematically misrepresent their facial soft tissue relationships.

Comparison of Kashmiri soft tissue measurements with Caucasian reference values from Arnett et al. [9] revealed significant deviations across all measured parameters. Kashmiri subjects of both sexes demonstrated considerably thicker perioral and chin soft tissues and a more acute nasolabial angle than Caucasian norms. These findings parallel those reported in comparable studies from the Indian subcontinent. Sachan et al. reported greater upper lip and chin soft tissue thickness in North Indian adults relative to Caucasian standards,[11] and Kalha et al. similarly documented more deep-set midfacial structures and a more protrusive dentition in South Indian adults.[10] Population-specific deviations have also been documented in Turkish,[12] Yemeni,[13] and Brazilian[14] populations, reinforcing the broader evidence base that soft tissue facial morphology varies substantially across ethnic groups and that Caucasian-derived norms cannot be universally applied.

Given the ethnic and geographic diversity within India, it is worth noting that even within the country, cephalometric norms can differ appreciably between regional populations. The differences observed in Kashmiri adults compared with published Indian norms from other regions particularly the notably thicker perioral soft tissues and more acute nasolabial angles highlight the need for region-specific reference data. The use of a single pan-Indian or Caucasian standard for orthodontic diagnosis in Kashmiri patients risks systematic diagnostic errors in the assessment of lip prominence, facial convexity, and chin morphology, all of which are central to STCA-based treatment planning.

From a clinical perspective, the population-specific norms established in this study have direct implications for the diagnosis and treatment planning of orthodontic and orthognathic surgical cases in Kashmiri patients. Specifically: the thicker perioral soft tissue profiles observed in Kashmiri adults should inform target positions for incisor retraction or advancement; the systematically more acute nasolabial angle should be recognised as a population-specific characteristic rather than a diagnostic aberration; and the growth pattern-specific differences in chin soft tissue thickness should be considered when planning genioplasty or evaluating chin prominence in hyperdivergent and hypodivergent individuals.

CONCLUSION

The findings of this study indicate that soft tissue cephalometric morphology in Kashmiri adults differs significantly from Caucasian normative standards, with consistent deviations observed in lip thickness, chin soft tissue dimensions, and nasolabial angle. Sexual dimorphism in the lower facial third is marked and clinically meaningful, with males exhibiting substantially thicker perioral and chin soft tissues. Vertical skeletal growth pattern exerts a significant and systematic influence on facial soft tissue dimensions, with hyperdivergent individuals displaying increased lower anterior facial height and reduced chin soft tissue thickness relative to their hypodivergent counterparts. These findings collectively underscore the inadequacy of applying universal Caucasian-derived norms to Kashmiri patients and support the development and clinical adoption of population-specific cephalometric reference data for more accurate and culturally appropriate orthodontic diagnosis and treatment planning.

Limitations

Several limitations of this study should be acknowledged. The sample was drawn from a single institution using convenience sampling, which may limit the representativeness of the findings with respect to the broader Kashmiri population. Anthropometric data, including height and weight, were not collected in this study; therefore, potential associations between body composition and soft tissue thickness could not be examined.

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