Original Article

Normative values for near point of convergence among university students in Oman

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ABSTRACT

Background: Near point of convergence (NPC) is a key clinical measure used in the assessment of binocular vision function and the diagnosis of convergence insufficiency. Normative NPC values vary across populations and are influenced by demographic and methodological factors. However, published normative NPC data in Oman remain limited. This study aimed to describe normative NPC break and recovery values among university students at the University of Buraimi, Oman, and to examine variations by sex and age.

Methods: This prospective cross-sectional study was conducted among students at the University of Buraimi, Oman. Participants aged 17–25 years with best-corrected distance visual acuity of 20/20 or better, near visual acuity N6, and a Convergence Insufficiency Symptom Survey (CISS) score ≤ 21 were included. NPC break and recovery points were measured subjectively using a Royal Air Force (RAF) ruler-based method with an accommodative target. Three consecutive measurements were obtained for each parameter, and mean values were recorded. Descriptive statistics were calculated, and NPC values were summarized by sex and age group.

Results: A total of 350 participants (74.9% female) met the inclusion criteria, with a mean (standard deviation [SD]) age of 20.16 (1.78) years. The overall mean (SD) NPC break point was 10.0 (2.6) cm (95% confidence interval [CI]: 9.7–10.3 cm) and the mean (SD) recovery point was 12.0 (2.0) cm (95% CI: 11.8–12.2 cm). Mean (SD) CISS score was 11.3 (6.3) (95% CI: 10.6–11.9) in this CISS-selected cohort. Females had slightly more remote mean NPC break and recovery points than males (break: 10.2 vs. 9.4 cm; recovery: 12.2 vs. 11.5 cm). Mean NPC break and recovery values were broadly similar across the examined age groups (17–19, 20–22, and 23–25 years).

Conclusions: This study provides descriptive normative NPC break and recovery values for students aged 17–25 years at the University of Buraimi using an RAF ruler-based method. These findings provide local descriptive data that may inform interpretation of NPC measurements in similar populations; however, the reported values should not be interpreted as individual clinical reference limits.

KEYWORDS

normative values, near point of convergence, university students, RAF ruler, near point convergence, binocular vision, ocular convergence, optometry, ophthalmology

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INTRODUCTION

Normative data comprise empirical observations that define what is considered typical or expected within a specified reference population [1]. Such data are inherently population-specific, as normative values may vary according to demographic, environmental, and methodological factors. Near point of convergence (NPC) is defined as the closest point in space along the median plane, directly in front of the patient's face, at which the visual axes can be voluntarily converged and maintained [2–4]. Assessment of NPC is a fundamental component of a comprehensive eye examination and represents a primary clinical measure for the diagnosis and management of convergence insufficiency [5]. Consequently, evaluation of NPC is particularly important in individuals with substantial near visual demands, such as students and professionals engaged in prolonged near work [6].

Previous investigations have evidenced that NPC tends to recede with age [7]. Some studies have also reported sex-related differences, suggesting higher NPC values in males compared with females [8], yet findings remain inconsistent and the association between NPC and sex has not been conclusively established. In addition, NPC measurements are influenced by both type of accommodative target and measurement technique used. Variability associated with different targets, as well as the effects of the Royal Air Force (RAF) ruler, observer experience, and subject anticipation, have been reported [9].

Accurate interpretation of NPC findings requires comparison with appropriate normative data, which may differ substantially across populations. Existing studies reporting normative NPC values have been conducted over different time periods and geographic regions, involving diverse demographic groups [10–13]. However, published data describing normative NPC values in Oman remain limited. Given documented global variations in natural environments, cultural practices, and lifestyle factors that may influence the visual system [14–16], normative data derived from other populations may not be directly applicable to individuals in Oman.

Hence, the present study aims to describe normative NPC values among university students from multiple colleges at the University of Buraimi and to examine variations according to sex and age.

METHODS

This prospective cross-sectional study was conducted among university students at the University of Buraimi (UOB), Al Buraimi, Sultanate of Oman. Ethical approval was obtained from the Research and Ethics Committee of the University of Buraimi (Approval No. AY24-25COHS-099). All study procedures were performed in accordance with the principles of the Declaration of Helsinki. Written informed consent was obtained from adult participants; for participants younger than 18 years, written parental or legal-guardian consent and participant assent were obtained prior to enrolment, and strict measures were implemented to ensure confidentiality and data protection. Participation was voluntary, and no physical or psychological harm was reported in the course of the study.

Eligible participants were university students aged 17–25 years with best-corrected distance visual acuity 20/20 or better, near visual acuity N6, and a Convergence Insufficiency Symptom Survey (CISS) score ≤ 21, which was used as a study-defined symptom-selection criterion [17, 18]. Participants with a history of ocular disease, amblyopia, strabismus, ocular trauma, or strabismus surgery were excluded. Additional exclusion criteria were presence of any ocular pathology, systemic disease known to affect visual function, or a history of previous treatment for binocular vision abnormalities.

According to recent institutional statistics, the University of Buraimi has a total student population of 3478, distributed across four colleges (Business, Engineering, Health Sciences, and Law) and 40 academic programs. Students aged 17–25 years were recruited for participation in this study. A total of 350 eligible participants were included.

All participants underwent a comprehensive baseline ophthalmic examination conducted by trained optometrists. Best-corrected distance visual acuity was assessed using a crowded Keeler logarithm of the minimum angle of resolution chart (Keeler Ltd., Windsor, UK) at a testing distance of 4 m under standardized photopic illumination. Near visual acuity was evaluated binocularly using a standard near vision chart at a working distance of 40 cm with appropriate near correction where required. Anterior segment evaluation was performed using slit-lamp biomicroscopy (Haag-Streit BX 900; Koeniz, Switzerland). Posterior segment assessment was carried out using the same slit lamp in conjunction with a condensing lens.

NPC break and recovery points were measured subjectively using a RAF ruler [9, 19]. A sharpened pencil tip was used as the accommodative target, positioned along the RAF ruler and moved slowly toward the participant along the midline. Participants were instructed to maintain single, clear fixation on the target and to report the onset of diplopia. The NPC break point was defined as the distance at which diplopia was first perceived, and the recovery point was recorded as the distance at which single vision was regained as the target was moved away. Three consecutive measurements of both break and recovery were obtained for each participant, calculating the mean of the three readings for statistical analysis. All measurements were conducted by the same examiner using the same RAF ruler to ensure methodological consistency and minimize inter-examiner variability. Testing was done under full room illumination for all participants.

Statistical analyses were performed using IBM SPSS Statistics for Windows, version 28.0 (IBM Corp., Armonk, NY, USA). Categorical variables were summarized as frequencies and percentages, while continuous variables were expressed as means and standard deviations (SDs). For the overall NPC and CISS values, corresponding 95% confidence intervals (CIs) around the means were also reported. Descriptive statistics were used to summarize normative NPC break and recovery values and CISS

scores, and NPC measurements were summarized descriptively by sex and age group. In this study, normative values refer to descriptive estimates observed in the selected study population; the reported 95% CIs represent the precision of the estimated means and should not be interpreted as individual clinical reference intervals.

RESULTS

A total of 350 university students from four colleges at the University of Buraimi met the study eligibility criteria and completed the CISS. Mean (SD) age of the participants was 20.2 (1.8) years. Females constituted 74.9% (n = 262) of the sample, males accounted for 25.1% (n = 88). The distribution of participants by age group and sex is presented in Table 1.

For the overall study population, the mean (SD) NPC break point was 10.0 (2.6) cm and the mean (SD) recovery point was 12.0 (2.0) cm. Mean (SD) CISS score was 11.3 (6.3). Corresponding 95% CIs for these parameters are summarized in Table 2.

NPC values by sex are presented in Table 3. Females displayed slightly greater mean (SD) NPC break and recovery points compared with males (break point: 10.2 [2.6] cm vs 9.4 [2.5] cm; recovery point: 12.2 [1.8] cm vs 11.5 [2.3] cm) (Table 3).

Across age groups, mean NPC break and recovery values were broadly similar. The mean (SD) NPC break points for participants aged 17–19, 20–22, and 23–25 years were 9.9 (2.5) cm, 10.1 (2.5) cm, and 9.6 (3.1) cm, respectively, with the highest mean value observed in the 20–22 age group. Similarly, the mean (SD) NPC recovery points for the corresponding age groups were 12.0 (2.0) cm, 12.2 (1.9) cm, and 11.5 (2.3) cm, with the highest value again noted in the 20–22 age group (Table 3).

Table 1. Demographic data of study participants

Age groups (y)	Female, n (%)	Male, n (%)
17–19	121 (82.3)	26 (17.7)
20–22	127 (75.6)	41 (24.4)
23–25	14 (40.0)	21 (60.0)
Total	262 (74.9)	88 (25.1)

Abbreviations: y, years; n, number of participants.

Table 2. Value of NPC and CISS score in study participants (N =350)

Variable	Mean ± SD	95% CI
Break point (cm)	10.0 ± 2.6	9.7 to 10.3
Recovery point (cm)	12.0 ± 2.0	11.8 to 12.2
CISS Score	11.3 ± 6.3	10.6 to 11.9

Abbreviations: NPC, near point of convergence; CISS, convergence insufficiency symptom survey questionnaire, n, number of participants; SD, standard deviation; CI, confidence interval; cm, centimeter. Note: The 95% CIs represent confidence intervals around the estimated means and are not individual clinical reference intervals.

Table 3. NPC values by sex and age group

Category	Group	Mean± SD
Sex — Break point (cm)	Female	10.2 ± 2.6
	Male	9.4 ± 2.5
Sex — Recovery point (cm)	Female	12.2 ± 1.8
	Male	11.5 ± 2.3
Age (y) — Break point (cm)	17–19	9.9 ± 2.5
	20–22	10.1 ± 2.5
	23–25	9.6 ± 3.1
Age (y) — Recovery point (cm)	17–19	12.0 ± 2.0
	20–22	12.2 ± 1.9
	23–25	11.5 ± 2.3

Abbreviations: NPC, near point of convergence; SD, standard deviation; cm, centimeter.

DISCUSSION

The present study described normative values for NPC break and recovery among university students at the University of Buraimi, Oman, using an RAF ruler-based method. In this cohort, the mean NPC break and recovery points were 10.0 cm and 12.0 cm, respectively, and the mean CISS score was 11.3. Females demonstrated slightly greater mean NPC break and recovery distances than males, whereas mean NPC values were broadly similar across the examined age groups. Collectively, these findings provide local descriptive normative NPC data for this university sample.

Assessment of convergence is a fundamental component of a comprehensive eye examination and is essential to the diagnosis of a range of nonstrabismic binocular vision anomalies [20, 21]. Although numerous studies have reported normative values for binocular function across different populations [10–13], published data specifically describing NPC measurements in Oman remain limited. The present study contributes local descriptive normative NPC data and examines variations according to sex and age. In our overall study population, the mean (SD) NPC break point was 10.0 (2.6) cm (95% CI: 9.7–10.3 cm) and the mean (SD) recovery point 12.0 (2.0) cm (95% CI: 11.8–12.2 cm). Mean (SD) CISS score was 11.3 (6.3), with a corresponding 95% CI of 10.6–11.9, in this CISS-selected cohort. These NPC values differ from those reported in other populations; such variation may, at least in part, be attributable to differences in study design, population characteristics, and measurement techniques employed across studies [7–9, 13].

Comparison with other university-based studies is particularly informative but should remain cautious. Hashemi et al. reported a mean NPC of 7.25 cm among 1357 Iranian university students aged 18–39 years [12]. The difference between that estimate and the present mean break point should not be interpreted as evidence of a true population difference alone, because target type, measurement method, age distribution, refractive characteristics, and other protocol features can affect NPC measurements [9, 12, 19]. Accordingly, comparisons of normative NPC values are most meaningful when measurement procedures and study populations are sufficiently similar.

In the present sample, females exhibited slightly more remote mean NPC break and recovery points than males. This finding contrasts with the results reported by Hashemi et al. for a large Iranian rural population, in which males demonstrated significantly more remote NPC values than females, despite females comprising 56.3% of the study sample [8]. In that study, male sex remained an independent predictor of increased NPC after adjusting for age and refractive error, although age exerted the strongest overall effect. Similarly, Ostadimoghaddam et al. [7] reported a significant association between male sex and more remote NPC values in a population-based cohort in which 67.8% of participants were female, spanning a broad age range from childhood to older adulthood (10–86 years) [7]. In contrast, findings from the Tehran Geriatric Eye Study, in which 59.6% of participants were female, indicated no statistically significant differences in NPC between males and females among elderly individuals aged 60 years and older [22], illustrating that sex-related patterns in NPC may vary across age ranges and populations.

Several factors may account for the discrepancies observed between the present study and these previous reports [7, 8, 22], the cited population-based studies included wide age ranges and heterogeneous refractive profiles [7, 8, 22], whereas the current study was restricted to a narrow age range and a CISS-selected university sample. In addition, differences in measurement techniques, such as the use of fixation sticks or dissociative targets in these prior studies [7, 8, 22] compared with the RAF ruler-based method employed in the present study, may influence NPC outcomes and their sensitivity to sex-related differences. The unequal sex distribution in the current sample, together with variation in sex composition across age groups, limits interpretation of the observed sex-related differences. These findings should therefore be regarded as descriptive subgroup patterns rather than independent effects of sex. Overall, reported sex-related differences in NPC are not uniform across populations [7, 8, 22] and may vary according to age range, refractive characteristics, and methodological approach, underscoring the importance of population- and context-specific normative data.

In the present study, mean NPC break and recovery values were broadly similar across the examined age groups (17–25 years). Because the study covered a relatively narrow age range, these descriptive findings should not be interpreted as demonstrating the absence of an age-related association. In contrast, Abraham et al. [13] reported a progressive recession of NPC with increasing age in an Indian non-clinical population spanning a much wider age range (10–35 years). The age-related changes observed in their study were attributed to increases in near horizontal phoria with advancing age, a factor less likely to exert a measurable effect within the limited age span of the present cohort. Methodological differences may further account for the discrepancy, as they employed a red-green dissociative target for NPC measurement, whereas the current study used a RAF ruler-based method that may yield different sensitivity to subtle age-related changes [13]. Similarly, Gavin et al. [23] demonstrated a gradual decline in convergence ability with advancing age in adults older than 50, with NPC values increasing notably in later decades of life. Their findings reinforce that more remote NPC values may be observed in later decades of life [23]. The relatively similar values observed across age groups in the present study should therefore be interpreted in the context of the narrow age range examined. These comparisons suggest that age-related effects on NPC are highly dependent on the breadth of the age range studied and the measurement techniques employed [9, 13, 23], underscoring the importance of population-specific normative data. The current findings therefore provide local descriptive normative NPC data for university students aged 17–25 years at the University of Buraimi.

Recent studies also illustrate that visual context may be relevant when interpreting convergence-related measures. In university students, convergence insufficiency has been associated with slower performance on a selective visual-attention task [24], while precision-shooting experience has been associated with differences in binocular balance and NPC [25]. Studies of digital-device use have likewise examined associations between near-visual behavior and accommodation and vergence parameters [26, 27]. These observations do not establish that visual demands caused the NPC values observed in the present cohort, but they support documenting habitual near work and screen exposure in future studies. The methodology employed in studies plays a crucial role; diverse testing targets such as the Snellen chart, accommodative targets, or subjective measurements can substantially affect NPC outcomes [7–9, 13, 22, 23]. The age range and demographic characteristics of the samples varied considerably across studies, complicating direct comparisons [7–9, 13, 22, 23, 28]. Despite these differences, previous studies generally indicate that younger age groups tend to have closer NPC values, whereas older groups exhibit more remote break and recovery distances [13, 29]. Although mean NPC values were broadly similar across the 17–25-year age groups in this study, the narrow age range limits comparison with broader age-related trends. Reporting both NPC break and recovery values provides complementary descriptive information about the convergence response. The break point represents the distance at which single binocular vision can no longer be maintained, whereas the recovery point represents the distance at which fusion is regained as the target is moved away [29]. In the present cohort, the mean recovery point was 2.0 cm more remote than the mean break point (12.0 vs. 10.0 cm). These paired values characterize different phases of the same clinical test and should be interpreted within the specific RAF ruler-based procedure used in this study.

This study has several strengths, including the use of a consistent RAF ruler-based measurement procedure, a relatively large sample, and clearly stated eligibility criteria. In addition, this work provides local descriptive normative NPC data for university students in Oman, addressing a gap in the available regional literature. Nevertheless, several limitations should be considered when interpreting the findings. First, the study sample comprised exclusively young adults aged 17–25 from a single university, which limits the generalizability of results to the broader Omani population—particularly children and older adults, in whom NPC performance may differ. Second, the study employed a single NPC measurement method and did not include additional binocular vision assessments, which may have provided a more comprehensive evaluation of convergence function. Accordingly, the eligibility criteria should not be interpreted as independently confirming normal binocular vision. In addition, a single CISS cutoff of ≤21 was used across the 17–25-year age range as a study-defined symptom-selection criterion and should not be interpreted as an age-specific diagnostic threshold. Third, the unequal sex distribution in the current sample, with its predominance of female participants (74.9%), limits interpretation of the observed sex-related differences. Last, NPC measurements were obtained during a single testing session so potential influencing factors such as fatigue, time of day, and recent near-work activity were not controlled, which could have affected measurement accuracy. Although the study was designed to provide normative NPC data, individual-level reference limits were not estimated; therefore, the reported means and 95% CIs should be interpreted as descriptive estimates for this study sample rather than as clinical reference intervals for individual patients. Future research should include a wider age range to establish normative NPC values across the lifespan in Oman, ideally using a multicenter design encompassing different geographic regions. Incorporation of multiple measurement techniques and additional binocular vision assessments is recommended to better elucidate factors influencing NPC performance. Longitudinal studies would be valuable for monitoring age-related changes in convergence ability, and future investigations should also document near-work habits and screen time, as these variables may significantly impact NPC outcomes within the population.

CONCLUSIONS

This study provides descriptive normative values for NPC among students aged 17–25 years at the University of Buraimi, Oman, using an RAF ruler-based method. The mean (SD) NPC break and recovery points were 10.0 (2.6) cm and 12.0 (2.0) cm, respectively, and the mean (SD) CISS score was 11.3 (6.3). Mean NPC break and recovery values were broadly similar across the examined age groups, while females displayed slightly more remote mean break and recovery points than males. These findings provide local descriptive normative NPC data for this university sample and may help inform the interpretation of NPC measurements in similar young-adult populations. However, the reported means and 95% CIs should not be interpreted as individual clinical reference limits. Future multicenter and longitudinal studies encompassing broader age ranges, diverse refractive profiles, and additional binocular vision assessments, together with appropriate reference-interval methodology, are needed to develop clinically applicable NPC reference values for the Omani population.

ETHICAL DECLARATIONS

Ethical approval: Ethical approval was obtained from the Research and Ethics Committee of the University of Buraimi (Approval No. AY24-25COHS-099). All study procedures were performed in accordance with the principles of the Declaration of Helsinki. Written informed consent was obtained from adult participants; for participants younger than 18 years, written parental or legal-guardian consent and participant assent were obtained prior to enrolment, and strict measures were implemented to ensure confidentiality and data protection. Participation was voluntary, and no physical or psychological harm was reported in the course of the study.

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