Correlations between Central Corneal Power, Axial Length, Anterior Chamber Depth and Central Corneal Thickness of near-Emmetropic Young University Students in Palestine

Mohammed Aljarousha[1, 2], Ansam Abo Daqa[1], Fatma Qanan[1], Haya Murtaja[1], Nadeen Baraka[1]

Abstract

Purpose: To investigate the correlation between the central corneal power (CCP) and a panel of variables which include axial length (AL), axial depth of the anterior chamber (ACD), and the central corneal thickness (CCT) in emmetropic eyes in young students in the Optometry Lab of the Islamic University-Gaza (IUG), Palestine.

Methods: In a prospective analysis, 200 emmetropic students were examined from February to May 2019 by the Ultrasound Scanner (A-scan), Ultrasonic Pachymeter, and Visionix L79 Automated Refractometer Keratometer (ARK)-Topography machines. Only the data of one eye was randomly chosen for investigation. The age range was 18-23 years with spherical equivalent (SE) refractive error of less than ± 0.50 D.

Results: The means and standard deviations (SD) of the CCP, AL, ACD, and CCT of the near-emmetropic male students (n=97) were 43.19 ± 1.34 D, 23.54 ± 0.68 mm, 3.59 ± 0.26 mm, and 549 ± 33 µm , respectively. In addition, the means ± SD in female subjects in 103 near-emmetropic female students of CCP were 43.85 ± 1.43 D, AL 22.94 ± 0.69 mm, ACD 3.35 ± 0.25 mm, and CCT 543 ± 35 µm. There was a significant association between CCP and gender (p=0.00). However, there was no significant difference in CCP values between the age groups (p=0.49). There was a negative significant correlation between CCP and AL for both the males (r=-0.64; p=0.00) and the females (r=-0.71, p=0.00) participants. The values of the correlation (r) were 0.15 and 0.08 between CCP and ACD of the male and female participants respectively. Additionally, no significant correlation was found between CCP and CCT for male and female eyes (p=0.16, p=0.86, respectively).

Conclusion: This study provided information for CCP, AL, ACD, and CCT in near-emmetropic eyes in young students in the optometry lab at the IUG, Palestine. Scores of CCP was normally distributed. CCP was not significantly influenced by age, ACD and CCT. In male students CCP was flatter, and AL was longer when compared with female Palestinian young students

Keywords: Central Corneal Power, Axial Length, Anterior Chamber Depth and Central Corneal Thickness, Emmetropic Eyes.

(J Med J 2021; Vol. 55 (4):169-177)

Received	*Accepted*
July , 15, 2019	*February, 9, 2021*

[1] Department of Optometry, Faculty of Health Science, Islamic University of Gaza, Palestine
[2]Department of Optometry and Visual Science, Kulliyyah of Allied Health Sciences, International Islamic University Malaysia

Correspondence:
Name: Mohammed Aljarousha, MSc.
E-mail: mjaroosha@iug.edu.ps
Mailing Address: Optometry Department, Faculty of Health Sciences, Islamic University-Gaza, Rimal South, Gaza Strip, Palestine.

1. Introduction

Cowan defines emmetropia as ‘‘a state of refraction in which parallel rays of light are brought to focus on the retina when the eye at the resting state’’ [1]. Emmetropia is considered a feature of the normal eye[2]. Researchers have found that the refractive states of the eye are influenced by a variety of variables including central corneal power (CCP) axial length (AL), anterior chamber depth (ACD) and central corneal thickness (CCT)[3-5]. Previous reports have shown that the prevalence of near-emmetropia in Saudi Arabia is 54.1%, Nigeria 71.5%, Germany 37%, Brazil 15.9%, and Pakistan is 36.7% [6,7,8,9,10].

Researchers have shown that the central corneal power is a vital indicator of corneal status which forms two thirds of the focusing power of the eye[11-12]. The same group of researchers found that the axial length is defined as the distance between the anterior corneal surface to an interference peak corresponding to the retinal pigment epithelium/Bruch’s membrane, and AL is usually measured in millimeters. There were previous reports that the ACD is vital in newer theoretical biometric formulas for intraocular lens (IOL) power calculations and for the implantation of phakic IOLs [13] and the depth of the AC is approximately 3.17 mm[8]. According to Doughty and Jonuscheit[14] and Ashwin *et al* [15] the CCT is an indicator of corneal health status and influences applanation tonometry with decisions for refractive surgery dependent on sufficient CCT.

It is important for practitioners to know about normal values for ocular parameters in near-emmetropic students in order to initiate proper management and assessment for patients. To evaluate the ocular component values of near-emmetropic students, we performed a prospective analysis using A-Scan Ultrasound Biometry, Pachymetry, and Autorefractor Keratometer. The results of this investigation may enhance the understanding of the relationship between CCP, AL, ACD and CCT in a sample of normal Palestinian young eyes.

Materials and Methods

A prospective study was carried out using a convenience sampling method based on the assessment of near-emmetropic students attending the Optometry Lab of the IUG, Palestine. Only the data of one eye was randomly chosen for investigation. The study protocol received approved from the local Ethics Committee. In this study, 200 young students were examined from February to May 2019. The appropriate sample size was determined based on OpenEpi software (Sullivan, Atlanta, GA, USA) [16].

The age group of the present study was 18-23 years with spherical equivalent (SE) refractive error of less than ± 0.50 D. The clinical examinations included CCP, AL, ACD, and CCT measurements. The CCP, AL, ACD, and CCT were measured with the Ultrasonic Pachymeter (Sonomed PacScan 300AP and Combination A-Scan Pachymeter) with topical anesthesia (0.1% HCL Localin). The technique was measured at the apical corneal position by adjusting the tip of probe with minimal corneal compression. Three consecutive readings were recorded and then the average was used in the current research. We measured the central corneal power by using the Visionix L79 Automated Refractometer Keratometer (ARK)-Topography device. For each participant, the chin was rested on a chin rest and forehead against forehead rest of L79ARK-Topography. Values of the CCP were obtained prospectively in the present research. In this study, all students had uncompensated visual acuities (VA) between 6/6 to 6/7.5. Individuals with previous ocular surgeries or laser treatment, contact lens wear and those who are taking any form of medications such as antihistamines, diuretics and drugs used to treat high blood pressure were excluded from the study.

Data analysis was conducted using IBM SPSS (Version 20, SPSS Inc., Chicago, Illinois, USA). Scores were reported as means and standard deviation (SD) in near-emmetropic students, and significance was calculated at $p<0.05$. In this study, the distribution of CCP variable was shown by using the histogram chart. Independent sample t-test was applied to compare CCP values between male and female groups, and one-way ANOVA was applied to compare CCP scores between the age groups.

In addition, Pearson's correlation coefficient was used to evaluate the correlations between the CCP and a panel of variables. The dependent factors included AL, ACD and CCT.

Results

A total of 200 students were examined aged between 18 and 23 years in the Optometry Lab of the IUG, Palestine. The means and SD of the CCP, AL, ACD, and CCT of the near-emmetropic male students (*n*=97) were 43.19 ± 1.34 D, 23.54 ± 0.68 mm, 3.59 ± 0.26 mm, and 549 ± 33 µm respectively. In addition, the means ± SD in female students in 103 near-emmetropic female participants of CCP were 43.85 ± 1.43 D, AL 22.94 ± 0.69 mm, ACD 3.35 ± 0.25 mm, and CCT 543 ± 35 µm (Table 1). Based on the finding of normality test, scores of CCP was normally distributed, as can be presented in Figure 1.

Table 1. Characteristics for 200 students (97 males and 103 females), aged 18-23 years

	Variable	CCP (D)	AL (mm)	ACD (mm)	CCT (µm)
Male	Mean ± SD	43.19 ± 1.34 D	23.54 ± 0.68 mm	3.59 ± 0.26 mm	549 ± 33 µm
	Range	48.25 – 40.25	20.66 – 24.96	2.80 – 4.31	475 – 644
Female	Mean ± SD	43. 85 ± 1.43 D	22.94 ± 0.69 mm	3.35 ± 0.25 mm	543 ± 35 µm
	Range	47.25 – 40.00	21.11 – 24.86	2.72 – 4.09	427 – 625

SD: standard deviation; CCP: central corneal power; AL: axial length; ACD: anterior chamber depth; CCT: central corneal thickness; mm: millimeters; D: Dioptre; µm: micrometers.

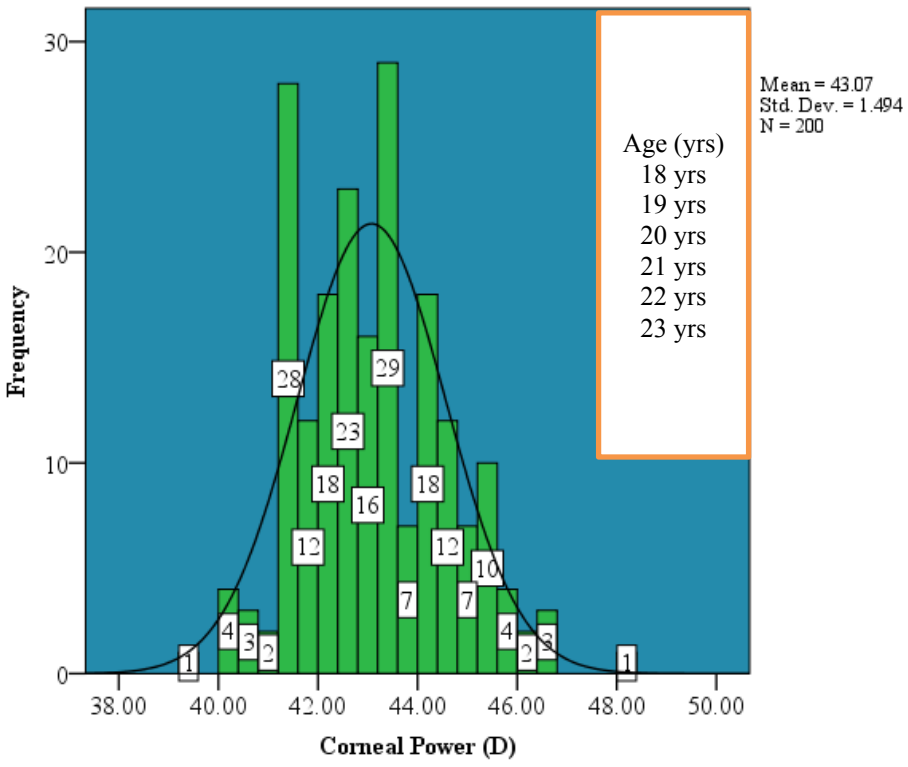

Figure 1. Histogram presenting the distribution of CCP of near-emmetropic (97 males and 103 females) students, aged 18-23 years

Mean CCP scores by gender and age were shown in Tables 2 and 3. There was a significant association between CCP and gender (p=0.00). However, there was no significant difference in CCP values between the age groups (p=0.49).

Table 2. Distribution of CCP in near-emmetropic students from 97 males and 103 females

	CCP* CP* Mean ± SD	
Age	Male	Female
18y	43.35 ± 1.55 D	43.94 ± 1.63 D
19y	42.84 ± 1.21D	43.34 ± 1.50 D
20y	42.82 ± 1.56 D	43.64 ± 1.53 D
21y	42.45 ± 0.99 D	43.10 ± 1.30 D
22y	42.72 ± 1.40 D	43.20 ± 1.94 D
23y	42.59 ± 0.66 D	44.38 ± 1.24 D

CCP: central corneal power; D: dioptre; SD: standard deviation; y: year. * Independent sample t-test

Table 3. Distribution of CCP in near-emmetropic students in the age range 18–23 years, mean 20.5 years

Variable	18y (n=19)	19y (n=60)	20y (n=47)	21y (n=32)	22y (36)	23y (n=6)
CCP* Mean ± SD	43.75 ± 1.59 D	43.01 ± 1.32 D	43.07 ± 1.68 D	42.90 ± 1.23 D	42.97 ± 1.70 D	43.18 ± 1.92 D

CCP: central corneal power; D: dioptre; SD: standard deviation; n: number; y: year. * One way ANOVA test for mean difference of CCP due to age, P=0.49

There was a negative significant correlation between CCP and AL for both the males (*r*=-0.64; *p*=0.00) and the females (*r*=-0.71, *p*=0.00) subjects (Figures 2 and 3). The values of the correlation (*r*) were 0.15 and 0.08 between CCP and ACD of the male and female students respectively (Table 4). Additionally, no significant correlation was found between CCP and CCT for male and female eyes (*p*=0.16, *p*=0.86, respectively).

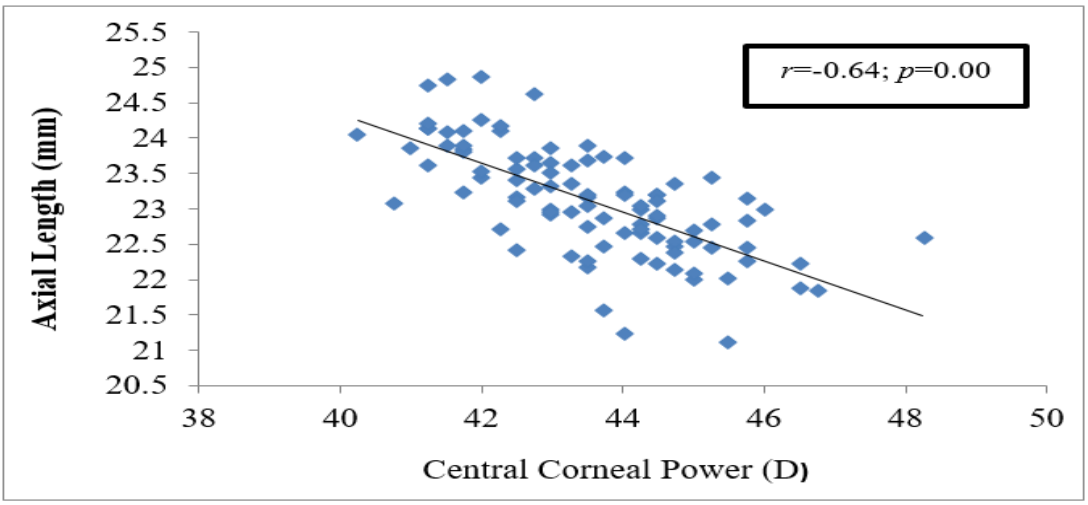

Figure 2. Negative significant correlation between CCP and AL in male students (n=97)

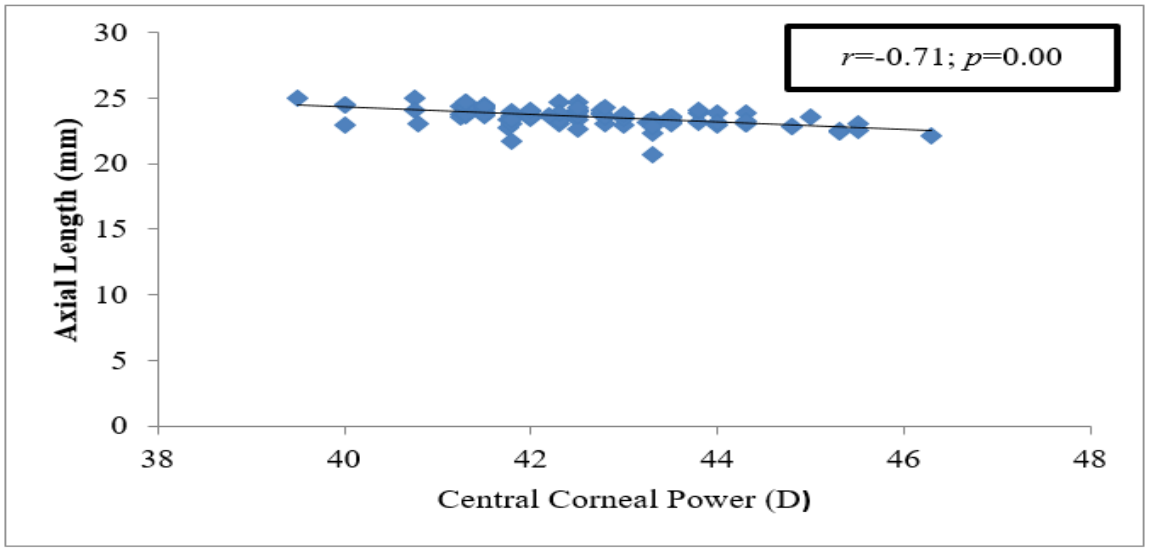

Figure 3. Negative significant correlation between CCP and AL in female students (n=103)

Table 4. Pearson's correlation between CCP and a panel of biometric variables in male and female participants

	CCP	
Dependent variables	**Male** ***n*= (97)**	**Female** ***n*= (103)**
AL (mm)	*r*= -0.64; p=0.00	*r*=-0.71, *p*=0.00
ACD (mm)	*r*= 0.15; *p*=0.86	*r*= 0.08; *p*=0.25
CCT (µm)	*r*= -0.12; *p*=0.16	*r*= -0.14; *p*=0.86

Significant correlation at ($p<0.05$); *n*: indicates the number of subjects; *r*: Pearson's correlation coefficient; CCP: central corneal power; AL: axial length; ACD: Anterior chamber depth; CCT: central corneal thickness; mm: millimeters; D: dioptre; µm: micrometers

Discussion

To our knowledge, this is the first prospective analysis on the normal central corneal power in Gaza Strip, Palestine. Results from the current study showed that the mean ± SD for corneal power values were 43.19 ± 1.34 D for males and 43.85 ± 1.43 D for females. All students were near-emmetropic, healthy volunteers. The present findings are comparable to Mallen *et al* [17] who determined the normal central corneal power in near-emmetropic subjects in Jordan, although with different population age, sample size, methodologies and clinical tests used (Table 5). In male students CCP was flatter, and AL was longer when compared with female Palestinian young students. This reason might be due to female corneas were significantly thinner than male corneas as observed in Table 5 [8,18]. The present study revealed that the results for ACD were 3.59 ± 0.26 mm in male and 3.35 ± 0.25 mm in female near-emmetropic subjects. This is consistent with a previous study from Denemark[19]. Our mean CCT, 549 ± 33 µm in male and 543 ± 35 µm in female participants, are slightly lower than the earlier finding[20]. This might be due to variations in demographics, race, lifestyles, and diagnostic criteria used.

Histogram found that the CCP of our participants was normally distributed (see Figure 1). The normal distribution of CCP had been previously reported [20-21]. In the current study, a significant correlation was observed between CCP and AL in near-emmetropic subjects (see Table 4) and this is in agreement with previous reports[17-18]. R. P. C. LIRA *et al* [9] have also demonstrated that steeper corneas tended to have shorter axial length. In our study, no correlation

was found between CCP and ACD in near-emmetropic eyes. On the other hand, previous report from Taiwan found a significant relationship between CCP and ACD[18]. Asian eyes tend to have tighter eyelids and narrow palpebral apertures that could perhaps explain the different results between the present study and previous clinical study. No significant correlation was obtained between CCP and CCT in our finding. This result was corroborated by a more recent study from Germany[8]. In contrast, Shimmyo *et al* [22] reported that CCP had negatively correlated with CCT.

It can be concluded that this study provided information for CCP, AL, ACD, and CCT in near-emmetropic eyes in young health in the optometry lab at the IUG, Palestine. Scores of CCP was normally distributed. Steep cornea tended to have shorter AL. Male had flatter corneas and longer AL than female Palestinian young adults. In contrast, CCP was not significantly influenced by age, ACD and CCT.

The information about the prevalence of emmetropia and the three types of refractive error (RE) [(myopia, hypermetropia, and astigmatism) and the three severity of RE (mild, moderate, and severe)] were not available in the current study. This is a limitation of this present study which should be addressed in future research. Intraocular pressure test (IOP) was not carried out in this study. This is also a limitation of the study.

Table 5. Summary of reports presenting the correlation between CCP and a panel of variables which include AL, ACD, CCT, gender, and age

Authors	Country/ Area	Gender	Mean age/ Range age (yrs)	No of subjects	CCP (D)	AL (mm)	ACD (mm)	CCT (µm)	CCP vs. AL	CCP vs. ACD	CCP vs. CCT	CCP vs. Gender	CCP vs. Age
Mallen *et al* [17]	Jordan	Males Females	29.28 yrs 27.39 yrs	1093	43.49 D 44.00 D	23.33 mm 22.99 mm	3.17 mm 3.21 mm	N/A	S	N/A	N/A	S	N/A
M .J. Chen *et al* [18]	Taiwan	Males Females	61.30 yrs 60.50 yrs	500	43.50 D 44.30 D	23.50 mm 23.00 mm	3.00 mm 2.90 mm	555 µm 553 µm	S	S	NS	S	N/A
Olsen *et al*[19]	Denmark	Males Females	67.90 yrs 68.10 yrs	723	43.41 D 43.73 D	23.74 mm 23.20 mm	3.20 mm 3.08 mm	N/A	S	N/A	N/A	S	N/A
Zocher *et al*[8]	Germany	Males Females	43.00 yrs 44.00 yrs	245	42.88 D 43.46 D	24.20 mm 23.40 mm	2.92 mm 2.74 mm	559 µm 549 µm	S	S	N/A	S	S
R. P. C. LIRA *et al*[21]	Brazil	Males Females	6–17 yrs 6–17 yrs	1100	43.30 D 43.80 D	16.70 mm 16.30 mm	3.17 mm 3.06 mm	539 µm 537 µm	S	S	S	NS	NS
Iyamu and Osuobeni[20]	Nigeria	Males Females	48.22 yrs 47.15 yrs	130	42.83 D 43.19 D	N/A	N/A	551 µm 546 µm	N/A	N/A	S	NS	NS
Current study	Palestine	Males Females	20.17 yrs 22.00 yrs	200	43.19 D 43. 85 D	23.54 mm 22.94 mm	3.59 mm 3.35 mm	549 µm 543 µm	S	NS	NS	S	NS

yrs: years; No: number; CCP: central corneal power; AL: axial length; ACD: Anterior chamber depth; CCT: central corneal thickness; mm: millimeters; D: dioptre; µm: micrometers; S: statistically significant association; NS: statistically insignificant association; N/A: not applicable; vs. versus

References

1. Cowan A. Emmetropia. *Am J Ophthalmol*. 1951;34(7):1021-1024.
2. AtchisonDA, JonesCE, SchmidKL, et al. Eye shape in emmetropia and myopia. Invest Ophthalmol Vis Sci. 2004; 45:3380–3386.
3. K. P. Mashige, "A review of corneal diameter, curvature and thickness values and influencing factors," Afr. Vis. Eye Health, 72 (4), 185 – 194 (2013).
4. Al Hammami HA, Hashem Ali H (2020) Anterior Segment Optical Biometric Parameters and Refractive Errors in a Sample of Iraqi Population. Prensa Med Argent, Volume 106:5. 283.
5. Orucoglu F, Akman M, Onal S (2015) Analysis of age, refractive error and gender related changes of the cornea and the anterior segment of the eye with Scheimpflug imaging. Cont Lens Anterior Eye 38: 245-350.
6. Parrey MUR, Elmorsy E. Prevalence and pattern of refractive errors among Saudi adults. Pak J Med Sci. 2019; 35(2):394–398.
7. Onua AA, Pedro-Egbe CN, Babatunde S. Prevalence of refractive error in a rural Ogoni community in Southern Nigeria. Niger J Ophthalmol 2012; 20:30-2.
8. Zocher, M. T. et al. Biometry and visual function of a healthy cohort in Leipzig, Germany. BMC Ophthalmol 16, 79, (2016).
9. Rodrigo Pessoa Cavalcanti Lira, Carlos Eduardo Leite Arieta, Thaís Helena Moreira Passos, Diana Maziero, Gustavo Lima do Valle Astur, Ítalo Fernandes do Espírito Santo, Ana Cláudia Bertolani, Luis Fernando Pozzi, Rosane Silvestre de Castro & Álvaro Antônio Bandeira Ferraz (2016): Distribution of Ocular Component Measures and Refraction in Brazilian School Children, Ophthalmic Epidemiology
10. Iqbal F, Khalil I, Zahid M. Prevalence of refractive errors in school going children in district Faisalabad, Pakistan. Adv Ophthalmol Vis Syst. 2020;10(1):4–6
11. Ruskell GL, Bergmanson JPG. Anatomy and physiology of the cornea and related structures. In: Phillip AJ, Speedwell L, eds. Contact Lenses. 5th Ed. Oxford: Butterworth-Heinemann, (2006).
12. Bene P, Synek S, Petrová S. Corneal shape and eccentricity in population. Coll Antropol 2013 37117-120.
13. Jivrajka, R., Shammas, M. C., Boenzi, T., Swearingen, M. & Shammas, H. J. Variability of axial length, anterior chamber depth, and lens thickness in the cataractous eye. Journal of cataract and refractive surgery 34, 289–294, (2008).
14. Doughty M, Jonuscheit S. Pachymetry Part 1: Defining normal corneal thickness and normal IOP measures. Optician 2005 230 27-31.
15. P. T. Ashwin, S. Shah, S. Pushpoth, L. Wehbeh, and B. Ilango, "The relationship of central corneal thickness (CCT) to thinnest central cornea (TCC) in healthy adults," Contact Lens and Anterior Eye, vol. 32, no. 2, pp. 64–67, (2009).
16. Kevin M. Sullivan. Open Source Statistics for Public Health [Online] [Cited 2020 Feb 3]. Available from: URL: http://www. openepi.com/ Sample Size/SSPropor.htm.
17. Mallen EA, Gammoh Y, Al Bdour M & Sayegh FN (2005): Refractive error and ocular biometry in Jordanian adults. Ophthalmic Physiol Opt 25: 302–309.
18. Chen MJ, Liu YT, Tsai CC, Chen YC, Chou CK, Lee SM: Relationship between central corneal thickness, refractive error, corneal curvature, anterior chamber depth and axial length. J Chin Med Assoc 2009; 72:133–137.
19. Olsen T Arnarsson A Sasaki H Sasaki K

Jonasson F. On the ocular refractive components: the Reykjavik Eye Study. Acta Ophthalmol Scand. 2007; 85: 361–366.

20. E. Iyamu, E. Osuobeni. Age, gender, corneal diameter, corneal curvature and central corneal Thickness in Nigerians with normal intraocular pressure. J Optom, 5 (2012), pp. 87-97.
21. Heydarian S, Hashemi H, Shokrollahzadeh F, Yekta AA, Ostadimoghaddam H, Derakhshan A et al. The normal distribution of corneal eccentricity and its determinants in two rural areas of north and south of Iran. J Curr Ophthalmol. 2018; 30(2):147-151.
22. M. Shimmyo, A.J. Ross, A. Moy, R. Mostafavi. Intraocular pressure, Goldmann applanation tension, corneal thickness, and corneal curvature in Caucasians, Asians, Hispanics, and African Americans. Am J Ophthalmol, 136 (2003), pp. 603-613.

العلاقة مابين قوة القرنية المركزية، طول العين، عمق الغرفة الأمامية للعين، سماكة القرنية المركزية في الطلاب الجامعيين الطبيعين في فلسطين

محمد الجاروشة[1.2]، أنسام أبو دقة[1]، فاطمة قنن[1]، هيا مرتجى[1]، ندين بركة[1]

1 قسم البصريات ،كلية علوم الصحة،جامعة غزة الاسلامية
2 قسم البصريات والعلوم البصرية،الجامعة الاسلامية الدولية،ماليزيا

الملخص

الهدف: تم إجراء الدراسة للتحقق من العلاقة مابين مركز قوة تحدب القرنية ومجموعة من العوامل المختلفة مثل طول العين، غرفة العين الأمامية، مركز سماكة القرنية في الأشخاص الطبيعين في مختبر البصريات في الجامعة الأسلامية–غزة، فلسطين.

منهجية البحث: تم إجراء دراسة وصفية لحوالي 200 طالب جامعي من شهر فبراير إلى مايو 2019 بإستخدام كل من جهاز طول العين، سماكة القرنية، القوة الإنكسارية للعين، وتضاريس القرنية. هذه الدراسة أجريت فقط لعين واحدة والفئة العمرية مابين (18 إلى 23) سنة ولايمتلك أخطاء إنكسارية في العين.

نتائج البحث: قيمة *الانحراف* المعياري في الطلاب الذكور لمركز قوة تحدب القرنية 1.34±43.19، وطول العين 0.68±23.54، غرفة العين الأمامية 0.26±3.59، و سماكة القرنية 33±549. بينما في الطلاب الأناث لمركز قوة تحدب القرنية 1.43±43.85، وطول العين 0.96 ± 22.94، غرفة العين الأمامية 0.25±3.35، و سماكة القرنية 35±543. يوجد علاقة مابين مركز تحدب القرنية وكلا الجنسين. مع ذلك، لايوجد علاقة مابين تحدب القرنية والفئات العمرية المختلفة ولامابين تحدب القرنية ومركز سماكة القرنية. أخيرا يوجد علاقة عكسية مابين طول العين وتحدب القرنية في الذكور والأناث.

الخاتمة: هذه الدراسة زودت الباحثين بمعلومات متعلقة بمقدار الانحراف المعياري لكل من طول العين، وتحدب القرنية، غرفة العين الأمامية وأيضا سماكة القرنية للأشخاص الطبيعين في قطاع غزة، فلسطين. نتائج مركز تحدب القرنية تمتللك توزيع طبيعي في كلا الجنسين بينما لايتأثر بالعمر أو الغرفة الأمامية أو مركز القرنية. أخير، الطلاب الذكور يمتلكون أطوال للعين أعلى من الطالبات الأناث بينما تحدب القرنية أقل تحدبا من الطالبات الأناث.

الكلمات الدالة: قوة سماكة القرنية، طول العين، عمق الغرفة الأمامية، سماكة القرنية.