

Original article

A Correlation between Body Mass Index and Refractive Errors

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SUMMARY

Background. Body mass index (BMI) is a person's weight in kilograms (or pounds) divided by the square of height in meters (or feet). Obesity affects a wide spectrum of age groups, from the young to the elderly, and there are several eye diseases related to obesity like diabetic retinopathy, floppy eyelid syndrome, retinal vein occlusion, stroke-related vision loss, age-related macular degeneration, and possibly, refractive errors. Refractive errors (RE) are optical imperfections related to the focusing ability of the eye and are the main cause of visual impairment which may result in missed education and employment opportunities, lower productivity and impaired quality of life.

Aim. The study aimed to find an association between body mass index (BMI) and refractive errors.

Methodology. A cross-sectional study was designed to involve a representative sample of medical students in Al-Kindy College of medicine, from December 8, 2021 to January 10, 2022. Weight and height were measured. BMI was estimated, and their refractive error was assessed.

Results. A total of 400 students participated in the study, of which 191 (47.8%) had refractive errors, whereas 209 (52.2%) were emmetropic. Thirty-seven point eight percent of the participants had BMI > 25. A significant relationship between refractive errors and all BMI groups was found ($p < 0.025$). Compared to normal weight group, overweight and obese groups, only the underweight group showed a significant relationship with refractive errors, $p < 0.006$.

Conclusion. Myopia is associated with being underweight, hence the link between the two is statistically significant. The severity of this condition, however, is unaffected by body mass index. Myopia was not a concern among students with normal or high body mass index (BMI).

Keywords: BMI, refractive errors, obesity, underweight, E learning

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INTRODUCTION

Body mass index (BMI) is a person's weight in kilograms (or pounds) divided by the square of height in meters (or feet) (1). Obesity is defined as the accumulation of excess fat in the body to the extent that it may damage health, according to WHO (2). In daily practice, doctors use BMI > 30 to define obesity. Studies have shown that over time, the development of obesity is mainly the result of over-feeding rather than a defect in basic energy expenditure (3).

The prevalence of overweight and obese people varies from region to region, with higher prevalence rates in the Middle East, Central and Eastern Europe, and North America. The prevalence of obesity in the United States was 49.1% in 2017 (4). Iraq 2015 obesity rate was 33.9% (5). Women show greater BMI distribution and higher obesity rates than men. Over the past two decades, the prevalence of being overweight has risen sharply. It is estimated that by 2030, 86.3% of adults will be overweight, 51.1% of adults will be obese, and by 2048, all American adults will be overweight or obese (6).

A large number of studies have shown that obesity has an important negative impact on health. The relationship between obesity and hypertension has been well-established in both adults and children (7). Also, obesity can cause major changes in the mechanics of the lung and chest wall (8). Obesity has a significant impact on the reproductive system (7, 9), moreover, it raises the risk of cancer in multiple organ sites (10). Obesity is considered a strong risk factor for diabetes mellitus which can lead to several eye diseases; in this way, obesity affects the eye indirectly.

Being underweight is considered a risk factor for many health problems, such as osteoporosis and anemia (11). Children and adolescents' underweight status enhances the risk of several infections, especially in developing countries (12).

Obesity has a negative impact on vision and eye health. There is increasing evidence that obese people are at greater risk of serious, vision-threatening eye diseases (13).

Refractive errors (RE) are a type of vision problem when the light cannot be focused accurately on the retina. Refractive errors are the most common type of vision problem (14). Uncorrected refractive errors are the second leading cause of blindness after cataracts worldwide (15). The incidence of refractive

errors is affected by genetic factors and environmental factors (16).

There is a very limited number of studies about the relationship between refractive errors and BMI. In this study, we attempted to find an association between BMI and refractive errors. Consequently, if there is a positive relationship, it could be added to preventive strategies of RE.

SUBJECTS AND METHODS

Study design: We conducted a statistical cross-sectional study to assess the relationship between BMI and refractive errors among medical students at Al-Kindy College of Medicine.

Study population: We posted an announcement on Al-Kindy College social media that explained the study design and we accepted volunteers from each study year with a total sample size of 400 students out of the overall number in the college, in the period from December 8, 2021 to January 10, 2022. We excluded students that underwent vision correction surgeries.

Ethical issues: Informed consent was obtained from all participants to be involved in the study and for their data to be published. The study was approved by the scientific committee of Al-Kindy College of Medicine.

Data collection involved three stages:

- The first station was a questionnaire containing 8 questions: the first three items assessed personal data (age, gender, and educational level) and the remaining five items referred to wearing and duration of eyeglasses, study hours, method of study (papers or digital studying), screen time and sleep hours.

- The second station included measuring weight in kilograms and height in centimeters by using a stadiometer to calculate BMI.

- The third station included an assessment of uncorrected visual acuity (UCVA) first by using an E Snellen chart at the distance of 6 meters. Those with 6/6 VA were excluded from the next step.

Finally, for students with subnormal UCVA refractive error, assessments were performed by auto-refractometer. An auto ref-keratometer (PKR-9000) was used to determine SPH, CYL and the axis of the cylinder.

Statistical analyses

According to BMI, data were divided into four groups (17): underweight < 18.5, normal weight (18.5 - 24.9), overweight (24.9 - 29.9), and obese > 29.9.

The spherical equivalent of refraction (SE) of the right eye for each subject was included in the current study and SE was calculated mathematically by algebraic summation of SPH with half of the CYL (spherical equivalent = SPH + 1/2CYL). Refractive error was regarded as myopia (SE > -0.5 D) or hyperopia (SE > 0.5 D). Myopia was further categorized as mild (≥ -0.50 D and < -3.00 D), moderate (≥ -3.00 D and < -6.00 D), and high (≥ -6.00 D). Classification for hyperopia: it is mild if less than 2.0 D, moderate if 2.25 to 5.0D, and high if > 5.0 D. Data analyses were performed using SPSS version 26, tables, Pearson correlation and Chi-square test. P-value < 0.05 was considered significant. Continuous variables are expressed by mean \pm standard deviation and categorical variables are expressed by numbers (percentages).

RESULTS

Out of 400 participants from all six study years of Al-Kindy College of Medicine, there were 188 (47%) males and 212 (53%) females. The participants' data were expressed as mean \pm SD: the age of students was 20.1 \pm 2 years old (range 18 -24 years), the weight was 67.7 kg \pm 13.6, the height was 167.0 \pm 9.0 cm, the right eye spherical equivalent was 1.133D \pm 1.75, and BMI was 24.16 \pm 3.97. The characteristics of the sample by BMI categories were shown in detail in Table 1.

Of all participants (400 students), 191 had refractive errors (47.8%), whereas 209 (52.2%) were free of refractive errors (emmetropic). There was a statistically significant correlation between BMI and refractive errors (p-value = 0.025).

Among 191 students with refractive errors, 181 (94.8%) were myopic and only ten (5.2%) were hyperopic.

Table 1. Characteristics of sample by BMI categories

	Underweight (n = 21; 5.3%)	Normal (n = 229; 57.3%)	Overweight (n = 119; 29.8%)	Obese (n = 31; 7.8%)
Age	19 \pm 1	20.1 \pm 2	20 \pm 2	21 \pm 2
BMI	17.49 \pm 0.89	22.14 \pm 1.73	27.04 \pm 1.36	33.47 \pm 6.79
RSE	-2.28 \pm 2.41	-1.00 \pm 1.59	-1.08 \pm 1.83	-1.54 \pm 1.83
Height	164 \pm 9	167 \pm 10	168 \pm 8	167 \pm 11

BMI- body mass index, RSE - right eye spherical equivalent

Table 2. Percentages of BMI groups by refractive error categories

			BMI				P value
			Underweight (n = 21; 5.3%)	Normal (n = 229; 57.3%)	Overweight (n = 119; 29.8%)	Obese (n = 31; 7.8%)	
RE (n = 191; 47.8%)	Myopia	(n = 181; 94.8%)	15 (8.3)	97 (53.6)	51 (28.2)	18 (9.9)	0.025
		Mean (-2.625)	-3.23	-2.49	-2.69	-2.66	
Hyperopia	(n = 10; 5.2%)	1 (10.0)	4 (40.0)	5 (50.0)	0 (0.0)		
	Mean (2.175)	0.63	3.16	1.70	0		
Emmetropic (n = 209; 52.3%)			5 (2.4)	128 (61.2)	63 (30.1)	13 (6.2)	

BMI - body mass index, RE - refractive error

Regarding the correlation of refractive errors with different BMI subgroups, the results are as follows: a total of twenty-one (5.3%) students were underweight, fifteen (71.4%) were myopic, one (4.8%) was hyperopic, and five (23.8%) were free of refractive errors.

Of students with the normal BMI, 128 (56%) were free of refractive errors, 97 (42.3%) were myopic, and four (1.7%) were hyperopic. Among the overweight group, 63 (52.9%) were free of refractive errors, 51 (42.8%) were myopic, and five (4.2%) were hyperopic. Regarding the obese group, thirteen (42.0%) were free of refractive errors, eighteen (58.0%) were myopic and there were no detected cases with hyperopia. Table 2 demonstrates the pro-

portion of each BMI group according to the refractive errors category.

In comparison with the normal BMI group, the prevalence of refractive errors in the underweight group was 76.2%, with a statistically significant difference from the normal (44.1%), with $p = 0.006$; myopia was the most prevalent refractive error in this group. Furthermore, there were no statistically significant differences for the prevalence of refractive errors in overweight and obese BMI subgroups when compared with the normal weight group (47.1%, 58.1% and, 44.1%, respectively; p -value = 0.006, 0.645 and 0.309 respectively), as shown in Table 3.

Table 3. Relation between BMI and refractive errors compared to the normal weight group

		Total	Refractive errors (n, %)	Non-refractive errors (n, %)	P-Value
Underweight	Underweight	21	16(76.2%)	5 (23.8%)	0.006
	Normal	229	101 (44.1%)	128 (55.9%)	
Overweight	Overweight	119	56 (47.1%)	63 (52.9%)	0.645
	Normal	229	101 (44.1%)	128 (55.9%)	
Obese	Obese	31	18 (58.1%)	13 (41.9%)	0.309
	Normal	229	101 (44.1%)	128 (55.9%)	

Table 4. Degrees of myopia severity among BMI groups

		Mild (n = 127; 31.8%)	Moderate (n = 47; 11.8%)	Severe (n = 7, 1.8%)	P- Value
BMI	Underweight	10 (7.6)	3 (7.1)	2 (28.6)	0.567
	Normal	73 (55.3)	22 (52.4)	2 (28.6)	
	Overweight	36 (27.3)	13 (31.0)	2 (28.6)	
	Obese	13 (9.8)	4 (9.5)	1 (14.3)	

Among 181 myopic students, myopia was mild (-0.5 to -3.0 D) in 127 students, moderate ($> -3.0 < -6.0$ D) in 47 students, and high (> -6.0 D) in seven students. No statistically significant correlation between BMI and the severity of myopia was found ($p = 0.56$).

Out of a total of ten students with hyperopia, five (50%) of them were obese, four (40%) had normal BMI, and one (10%) was underweight. No high hyperopia was detected in all groups, six had mild hyperopia and four had moderate hyperopia. Being the least frequent refractive errors within the study

sample, no further analysis for hyperopia was done. The frequency of myopic errors according to the severity in each BMI subgroup was shown in detail in Table 4.

The prevalence of refractive errors in the underweight group was positively correlated compared to normal weight, overweight and obese groups ($r(248) = 0.163$, $P = 0.011$), when compared to the students that are free of refractive errors, as it is shown in Table 5. If correlated with height, a statistically significant correlation between the right spherical equivalent and the height was found, r

(398) = 0.125, p-value = 0.013. Furthermore, it is correlated negatively (inversely) with the time of exposure to digital screens, $r(398) = -0.141$, p-value = 0.005 as shown in Table 6.

Table 5. Correlation between underweight group and RSE compared to the normal weight

		BMI	RSE
Underweight	Pearson's correlation	1	0.163
	P-Value		0.011

Table 6. Correlation between right spherical equivalent and height / Correlation between right spherical equivalent and screening time

		Height	RSE
Height	Pearson's correlation	1	0.125
	P-value		0.013
		RSE	ST
RSE	Pearson's correlation	1	0.141
	P-value		0.005

DISCUSSION

Among 400 students of Al-Kindy College of Medicine/University of Baghdad, 47.8% of the students were found to have refractive errors, and myopia was the most frequent type of refractive error constituting 94.8% of cases, whereas hyperopia affected 5.2%. Thirty-seven point five percent of the students were overweight and obese, which indicates a potential risk for future diseases.

Our study found that there was a statistically significant correlation between BMI and refractive errors ($p = 0.025$) as in Table 2. The previous cross-sectional study included 3,771 Chinese students in 2016 and showed a nonlinear relationship between BMI and refractive errors, that the risk for refractive errors increases as BMI rises above 19.81 kg/m² (18). A different age group study sample (6 - 21 years) may be the reason for the discrepancy in results.

Regarding the correlation of refractive errors with each BMI subgroup, 56.0% of students with normal BMI were free of refractive errors, 42.3% were myopic and 1.7% were hyperopic. Out of twenty-one underweight students, 71.4% were myopic, 4.8% were hyperopic, and 23.8% were free of

refractive errors. There was a statistically significant correlation between the underweight BMI group and refractive errors in comparison with the normal BMI group, with p-value = 0.006 and myopia being the most prevalent refractive errors in the underweight group (Table 3). For the overweight and obese groups, there was no statistically significant correlation with all types of refractive errors in comparison with the normal BMI group, p-value = 0.6, p-value = 0.3, respectively (Table 3)

The current study reported that the state of myopia (mild, moderate and high) was not statistically correlated with BMI groups and p-value = 0.56, as shown in Table 4. In contrast, another study reported that the prevalence of high myopia (spherical equivalent > -6.0D) was higher in individuals with BMI < 18.5 kg/m² (19). The discrepancy between the results may be explained by the genetic difference and difference among age groups of the study population (school children/adolescents) as well as the difference in sample size. We assume that the positive association between myopia and underweight students could be attributed to nutritional factors. However, many studies found that it is an inconsiderable factor (20, 21).

There was a weak positive correlation between being underweight and refractive errors as demonstrated in Table 5, which was demonstrated in a previous report about myopia risk factors among Korean adults in 2009. They discovered that decreased BMI was associated with an increased prevalence of myopia and high myopia ($SE > -0.5$, $SE > -6$, respectively) (19). A study of medical students at the University of Sriwijaya, Palembang (Indonesia), found that there was a very weak and non-significant positive correlation between BMI and myopia (16). A study in Austria (22) reported a similar observation to the study that the relation of being underweight with myopia is significant. Another study in the Department of Ophthalmology of Johannes Gutenberg University demonstrated that low birth weight is linked to VA and refractive long-term outcomes long after childhood (23).

The current study has taken into consideration the screening time which is defined as the time that students spent using screens per day and according to the results, it can be a risk factor for myopia (p value = 0.005, Table 6). The screen time is negatively related to the spherical equivalent. This result is comparable with a prospective cross-sectional study conducted in Qatar that confirmed a positive asso-

ciation between obesity and low vision in school children aged 6 - 18 years old as a result of the long time spent on watching TV and internet use (24).

It is worth mentioning that many previous reviews re-analyzed multiple research devoted to investigating the association of digital screen time as a risk factor to increase the prevalence of myopia, and they obtained almost similar outcomes. They revealed mixed results as some studies (25) prove the relation and others deny it. Nearly, most of them recommend conducting further research with more subjective measures of digital screening exposure time and defects associated with eyes to confirm or exclude it as an independent risk factor.

Another finding demonstrated that the height of subjects was significantly related to the refractive errors, and taller people were more susceptible to becoming myopic. A previous study conducted among schoolchildren in China in 2016 to assess the prevalence and risk factors related to myopia and high myopia revealed that taller students were more prone to become myopic (26).

This study has limitations: it was conducted only among medical students and was applied to a single college with a small sample size which is acceptable if compared to the total number of students. The study is focused on myopia, which may be one of the limitations. However, according to our

results, it is the most frequent refractive error among the study sample.

CONCLUSION

Myopia is associated with being underweight, hence the link between the two is statistically significant. The severity of this condition, however, is unaffected by body mass index. Myopia was not a concern among students with normal or high body mass index (BMI).

Recommendation

Forty-seven point eight percent of students had different degrees of RE, which seems to be high, however, we need further studies to compare medical students with students from other colleges.

We also recommend the follow-up of students from the first to the final academic years. Further studies are needed to compare the study methods, BMI and RE.

The occurrence of overweight and obesity was 37.5% and it is relatively high, therefore, we recommend adhering to nutritional and physical programs to maintain a healthy weight, to control and prevent future illnesses.

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Korelacija indeksa telesne mase sa refraktivnim greškama

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SAŽETAK

Uvod. Indeks telesne mase predstavlja težinu osobe izraženu u kilogramima (ili funtama) koja je podeljena kvadratom visine izražene u metrima (ili stopama). Gojaznost pogađa širok spektar starosnih grupa od mladih do starije populacije. Postoji više očnih bolesti koje su povezane sa gojaznošću, poput dijabetičke retinopatije, sindroma spuštenog kapka, okluzije vene retine, gubitka vida izazvanog moždanim udarom, makularne degeneracije izazvane starenjem i, moguće, refraktivnih grešaka. Refraktivne greške su optički nedostaci koji se odnose na sposobnost fokusiranja oka i predstavljaju osnovni uzrok oštećenja vida, što može dovesti do poteškoća u obrazovanju, propuštanja mogućnosti zapošljavanja, niže produktivnosti i smanjenog kvaliteta života.

Cilj. Cilj studije bilo je utvrđivanje povezanosti između indeksa telesne mase i refraktivnih grešaka.

Metodologija. Studija preseka dizajnirana je tako da uključi reprezentativni uzorak studenata Medicinskog fakulteta Al-Kindy, u periodu od 8. decembra 2021. do 10. januara 2022. godine. Izmerena je visina i težina studenata. Procenjen je indeks telesne mase, kao i refraktivne greške.

Rezultati. U studiji je ukupno učestvovalo 400 studenata; od njih je 191 (47,8%) student imao refraktivne greške, dok je kod 209 (52,2%) studenata zabeležena emetropija. Indeks telesne mase > 25 utvrđen je kod 37,8% ispitanika. Zabeležen je značajan odnos između refraktivnih grešaka i svih grupa indeksa telesne mase ($p < 0,025$). Za razliku od grupa u kojima su ispitanici imali normalnu telesnu težinu, prekomernu težinu ili su bili gojazni, grupa ispitanika sa nedovoljnom težinom jedina je u kojoj je zabeležen značajan odnos sa refraktivnim greškama ($p < 0,006$).

Zaključak. Miopija je povezana sa nedovoljnom težinom i stoga je veza između ovih pojava statistički značajna. Međutim, na ozbiljnost ovog stanja ne utiče indeks telesne mase. Miopija se nije javljala kod studenata sa normalnim ili povišenim indeksom telesne mase.

Ključne reči: indeks telesne mase, refraktivne greške, gojaznost