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Description

Introduction: Body Mass Index (BMI) is of increasing interest to eye care practitioners. Associations have recently been proven between high BMI and several diseases of are affecting the eyes, including AMD, intracranial hypertension, optic disc cupping and glaucoma. The symptoms of dizziness and vertigo have also been associated with high BMI. However, to these authors' knowledge, there has been no study performed comparing BMI to binocular function.

Methods: In this analytical-descriptive study, 119 randomly-selected young subjects had their BMI measured, along with refractive error, dissociated phoria, NPC, vergence ranges and facility, and stereopsis.

Results: In most situations, the subjects with the normal and overweight had better performance than other two groups. Also the worst performance was related to underweight subjects. The one-way ANOVA showed only statistically significant difference between mean of near point of convergence and vergence facility in different states of BMI.

Conclusion: Unlike most ocular diseases that are adversely affected by higher BMI values, most binocular vision skills are adversely affected by lower BMI values. The possible reasons for this are discussed.

Disciplines

Optometry

Comments

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Body Mass Index and Binocular Vision Skill

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Abstract

Introduction: Body Mass Index (BMI) is of increasing interest to eye care practitioners. Associations have recently been proven between high BMI and several diseases of are affecting the eyes, including AMD, intracranial hypertension, optic disc cupping and glaucoma. The symptoms of dizziness and vertigo have also been associated with high BMI. However, to these authors' knowledge, there has been no study performed comparing BMI to binocular function.

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Keywords: Stereopsis, Binocular vision, Heterophoria

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Introduction

As a single value to measure of overall health, Body Mass Index (BMI) has generated growing interest worldwide. In its usefulness as both a measure of patient symptoms are well as overall health, BMI might be to systemic health as visual acuity is to ocular health. In fact, increasingly elevated BMI has been associated with ocular disease as well.

BMI reduces weight and height to a single number. As such, it does not take into account body fat percentage, waist circumference, or other important factors. Although details like these are lost when BMI is used, it remains a straightforward if simplified way to compare large numbers of research participants – much like spherical equivalent refractive error does.

Recall that the formula for BMI is = weight (kg) / height ^{2}(m^2) $\frac{Mass\ (kg)}{(height\ (m))^2}$

Definition of different states of BMI has presented in Table 1.

Table 1: Definitions based on BMI

Definition	BMI
Underweight	Under 18.5
Normal	18.5 -24.9
Overweight	25-29.9
Obese	>30

The original AREDS study found that subjects with obese (>30) compared to non-obese BMI had a 1.93 higher odds ratio of having AMD.[1] Patients with idiopathic intercranial hypertension (IIH) and a normal-range BMI, while uncommon, have better outcomes than the more commonly obese IIH participants who were at high risk for pseudotumor cerebri.[2] A 2010 study found that "persons who are taller or have lower BMI have a smaller neuroretinal rim area and a larger optic cup-to-disc area ratio."[3]

What has not been investigated to these authors' knowledge is the effect of BMI on binocular function. That is the aim of this study.

Materials and Methods

In this analytical-descriptive study, students at Zahedan University of Medical Sciences were randomly selected from the list of students. 119 students, who met inclusion criteria and were consented, were entered into the study. Inclusion criteria were best-corrected visual acuity 20/25 or better in each eye at 6m and 40cm, absence of manifest deviation at 6m and 40cm with cover test, no history of eye and head trauma and normal eye health. The Horizontal Lang Two-Pencil Test was used to screen for stereopsis and binocularity.[4] Refractive errors were determined by retinoscopy (Heine ß-200 retinoscope) and the results of retinoscopy were refined by subjective refraction and finally dissociated red-green balance test was performed.

Near dissociated heterophoria was determined with alternate cover test method with best correction, and with subjects fixating on an accommodative target which was a small isolated letter "E" of approximately 20/30 (6/9) size on the fixation bar. Measurement of the deviation was carried out with prism neutralization. The lowest power of prism that neutralizes the recovery movement was

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taken as a measure of the deviation in prism diopters. For confirmation of the end point, the subjects were asked to observe an apparent jump of the fixation target when the cover test was repeated.[5] (Subjective cover test or Phi test)

For determination of NPC, a push-up test was carried out. A small isolated letter "E" of approximately 20/30 (6/9) size from a reduced Snellen chart target was slowly brought from 40 cm toward the subject along the subject's midline at a rate of approximately 3-5cm/sec. The subjects were instructed to keep the target single during the test and report when it appeared double (break point). The distance between break point to the plane of the lateral canthus was measured with a millimeter ruler. In cases in which subjects did not report diplopia, the examiner measured the distance at which one eye lost its fixation on the target.[6]

For assessment of the jump convergence, the subjects were asked to alternate their fixation between two pencils placed at two different distances along the subject's midline, one at 50 cm and another at 15cm. The subject's eyes were seen during change of fixation from the more distant target to the nearer one and the quality of the convergence movement was evaluated. Only a rapid and simultaneous convergence movement was recorded as normal and other movements were considered abnormal.[5]

For measurement of stereopsis, the TNO test was used. With the best correction in trial frame, the subject was worn the red and green anaglyphic filters and the booklet was held at distance of 40 cm so that it was perpendicular to the subject's visual axis. At first the screening plates (plates of I, II, III, IV) were presented, and if the subjects was able to successfully completed these pages, the graded plates from 480 to 15 seconds of arc was showed until the subject was unable to identify three-dimensional shape (Pac-man shapes) correctly. The lowest discriminated disparity by each subject was recorded as his/her stereopsis in seconds of arc.[7]

Vergence facility was tested at near by flipper prism. The selected power for flipper was 3 prism diopters (Δ) base-in (BI) and 12 prism diopters (Δ) base-out (BO). A vertical column of small letters "E" of approximately 20/30 (6/9) size was used as an accommodative target at 40 cm. The subjects were asked to observe the fixation target through the habitual correction. The flipper prism was changed from the base-in to the base-out and back again to the base-in; this constitutes one cycle. The target should be clear and single with each prism flip. The number of cycles that subject was able to completed at one minute were recorded as vergence facility in cycles per minute. We also noted any difference between the BI and BO responses and any evidence of fatigue. In checking for suppression, we used physiological diplopia. [5, 8]

A prism bar was used for measurement of fusional reserves at near. The target was same as one for vergence facility. The subject was asked to look at the target and the prism with base-in was introduced over the habitual correction and prism power slowly increased step-by-step until the subject reported sustained blur, break, and recovery The above procedure was repeated with base-out prism and the blur, break and recovery points were determined. The determined prism powers recorded in prism diopters. We observed the subject's eyes during the measurement for detection of possible suppression. [5,,9]

For calculation of body mass index (BMI), at first the subject's height (meters) and weight (kilograms) was measured with tape measure and scales, respectively and then BMI was determined from the following standard formula: [10]

After data collection, data were analyzed in SPSS.17 software using descriptive and analytical (Independent-Samples T, Chi-square and One-Way ANOVA tests) statistics. In all tests, the significance level was considered to be 0.05.

Results

From the 119 students under study, 72 (60.5 %) were female and 47 (39.5 %) male. The mean of age, height and weight in all subjects and separately in males and females are presented in Table 2.

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Table 2: Mean and SD of age (years), height (centimeters) and weight (kilograms) in all subjects and separately in two sexes.

Sex / Variables	Males	Females	All subjects	P-value
	Mean ± SD	Mean ± SD	Mean ± SD	
Age	20.9 ± 1.0	21.2 ± 1.5	21.1 ± 1.3	0.2
Height	172.0± 9.4	163.2± 8.0	166.7±9.5	< 0.001
Weight	69.1± 8.8	60.0± 7.0	63.6± 8.9	< 0.001

The Independent-Samples T test showed significant differences in the mean of height and weight between two groups (P < 0.001) but not in the mean of age. (P= 0. 2)

The mean of BMI in all subjects and separately in females and males were 22.97±3.1, 22.67 ± 3.3, 23.4 ± 2.9, respectively. There was not considerable difference in the mean of BMI between two sexes using the Independent-Samples T test. (P= 0. 2)

Table 3 displays the distribution of different conditions of BMI in subjects of under study.

Table 3: The frequency of different conditions of BMI in all subjects and separately in two sexes.

Sex / BMI	Females		Males		All subjects	
	Number	Percent	Number	Percent	Number	Percent
<18.5	4	3.4	4	3.3	8	6.7
18.5-249	30	25.2	49	41.2	79	66.4
25-29.9	12	10.1	15	12.6	27	22.7
>30.0	1	0.8	4	3.4	5	4.2
Total	47	39.5	72	60.5	119	100.0

Most subjects (79) had BMI in the range of 18.5-24.9, or normal. Comparing all subjects as well as males only, the most prevalent condition of BMI was in the normal range, followed by overweight, underweight and obese conditions. In females the trend was same with except of that the prevalence of obese condition was higher than underweight. The X^2 test does not show statistically significant difference in the distribution of BMI states in two sexes. (Pearson X^2 = 1.518, df= 3, P= 0.6)

The mean of refractive errors in two eyes are showed in Table 4.

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Table 4: Mean and SD of Sphere, Cylinder, Axis of astigmatism and Spherical equivalent (SE) in two eyes of subjects.

Refraction / Eye	Sphere	Cylinder	Axis	SE
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Right	-0.69 ± 1.6	-0.11 ± 0.2	39.1 ± 69.0	-0.63 ± 1.5
Left	-0.72 ± 1.6	-0.10 ± 0.2	37.0 ± 69.4	-0.67 ± 1.5

There was considerable correlation between SE of right and left eye. (r= 0.98, P < 0.001)

Table 5 shows the mean of near point of convergence (NPC), vergence facility with flipper prism 12BO/3BI, stereopsis with TNO stereo- test, fusional reserves with base-out (BO) and base-in (BI) prisms (blur, break and recovery) and dissociated phoria in all subjects and according to different states of BMI.

Table 5: Mean and SD of some of binocular vision tests according to different states of BMI.

BMI / Variables	<18.5	18.5-24.9	25-29.9	>30.0	Total	P-value
	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	
NPC	12.0± 2.5	6.0 ± 1.4	6.5 ± 0.7	6.5 ± 1.1	6.6± 1.3	<0.001
Vergence Facility	5.0±2.4	15.0± 2.0	12.7±1.7	12.3±2.0	12.3±2.2	0.003
Stereopsis	120.9±106.1	95.97±54.4	60.0±30.5	107.5±86.0	100.9±65.0	0.1
BO Blur	10.0± 3.4	11.4± 5.9	12.0± 3.5	10.3±3.3	11.1±5.3	0.09
BO Break	20.3± 8.4	35.0 ± 6.2	40.0±5.0	22.2± 8.7	22.4± 9.0	0.2
BO Recovery	15.6± 5.8	25.0± 4.2	25.0 ± 6.0	16.6±6.5	16.7±6.4	0.3
BI Blur	10.0± 3.3	12.0 ± 2.0	8.3± 2.6	12.0 ± 4.3	9.6± 3.2	0.3
BI Break	14.0± 2.3	17.7± 5.3	18.0± 3.2	17.2 ± 5.3	17.3± 2.7	0.9
BI Recovery	6.0 ± 2.1	14.0± 4.3	14.3± 3.3	12.9± 4.1	13.1± 4.0	0.2
Dissociated Phoria at near (negative = exophoria)	-12.0 ± 2.7	-5.0± 5.6	-3.8± 3.2	-8.0±1.9	-4.9±5.1	0.4

According to Table 5, we can see that in most situations, the subjects with the normal and overweight had better performance than other two groups. Also the worst performance was related to underweight subjects. The One-Way ANOVA showed only statistically significant difference between mean of near point of convergence and vergence facility in different states of BMI.

For determination of that these differences were between which states of BMI, the Tukey's Post Hoc test was used. (Table 6)

Table 6: The results of Tukey's Post Hoc test for NPC and VF.

Variable	BMI	Mean ± SD	Tukey's Results
NPC	<18.5 (group1)	12.0± 2.5	P<0.05 with all groups
	18.5-24.9 (group2)	6.0 ± 1.4	P<0.05 only with group 1
	25-29.9 (group3)	6.5 ± 0.7	P<0.05 only with group 1
	>30.0 (group4)	6.5 ± 1.1	P<0.05 only with group 1
Vergence Facility	<18.5 (group1)	5.0±2.4	P<0.05 with all groups
	18.5-24.9 (group2)	15.0± 2.0	P<0.05 only with group 1
	25-29.9 (group3)	12.7±1.7	P<0.05 only with group 1
	>30.0 (group4)	12.3±2.0	P<0.05 only with group 1

Another test of binocular vision evaluation is the jump convergence test. Table 7 illustrates the distribution of states of jump convergence with attention to BMI status.

Table 7: The distribution of normal or abnormal states of jump convergence with attention to BMI status.

Jump convergence / BMI	Normal		Abnormal		Total	
	Number	Percent	Number	Percent	Number	Percent
<18.5	8	6.7	0	0.0	8	6.7
18.5-24.9	74	62.2	5	4.2	79	66.4
25-29.9	27	22.7	0	0.0	27	22.7
>30.0	5	4.2	0	0.0	4	4.4
Total	114	95.8	5	4.2	119	100.0

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Most subjects (114) had normal jump convergence and only 4 cases of abnormal state of jump convergence were seen. The abnormal ones were related to normal BMI status. The X^2 test did not display considerable difference in the distribution of the jump convergence status in different states of BMI. (Pearson $X^2 = 2.64$, df= 3, P= 0.4)

Discussion

The results of this study show that, like so many other biological functions, body mass index does have an affect on binocular function. However, in this case, it was lower BMI, not higher, that adversely affected function -- much to the surprise of the authors.

Very few published studies have examined the visual effects of lower BMI. One of the few uncovered in the recent literature only discovered and inverse relationship between visual attention to food and BMI.[11]

In the current study, the eight subjects with the lowest BMI (about 7% of the 119 in the study) showed the weakest performace on most binocular vision tests. For example, the near point of convergence (NPC) was about 12 cm with the lowest BMI subjects, and between 6-7 cm in the rest of the sample. Vergence facility was only 5 cpm in the lowest BMI group, and between 12-15 cpm in the others. Stereopsis threshold was the worst of the cohort, at over 120 arc seconds.

Other visual performance measures were similar. Positive and negative relative vergence ranges (blur, break, and recovery) at near were not always significantly worse, but generally lagged behind the higher BMI cohorts. This may have been because the mean dissociated phoria was approximately 12 prism diopters exophoric in those with the lowest BMI group.

If this results are repeatable, this study may demonstrate one of the rare occasions that having a lower than average body mass index is worse than having a higher than average, or even obese, BMI. All the visual performance measures may have been weak in the low BMI group simply due to their high exophoria at near. This leads one to question if there is any connection between high exophroia and low BMI. The connection, if any, is far from obvious.

If the authors can be permitted to speculate, it may be that lower exophoria (or even esophoria) allows for a more sedentary lifestyle than does high exophoria. If double-digit exophoria at near makes it more difficult to complete near tasks, patients with this kind of phoric posture may not spend as much time doing deskwork, a known risk factor for obesity. The flaw in this logic is that these exophoric patients would be expected to have no trouble watching television for hours on end, which is an even stronger risk factor for obesity.

Whatever the cause, there are two differential diagnoses for these lowest BMI patients. One is false convergence insufficiency (FCI), as the high exophoria at near combined with a low NPC and normal convergence ability fits the diagnosis. Measuring accommodative amplitudes would allow the clinician to discover if these patients have FCI. Treatment would then be with a multifocal lens, or accommodative vision therapy if the patient opts for an active treatment.

A less likely diagnosis is high basic exophoria. Testing phoric posture at far would determine if these patients have this condition. The treatment of choice is generally base in prism.

Conclusion

Further studies are certainly needed to see if these surprising results can be replicated with a larger sample. If so, an explanation as to why the lowest body mass index patients have the poorest binocular ability is certainly wanting.

Perhaps if nothing else can be gleaned from this study, the take-home message should be that when it comes to binocular function, intuition and common sense may not always serve the clinician to predict patient ability. In this case, common sense would predict that just has that patient with a higher BMI is at risk for ocular disease, so too should these patients be at risk for binocular dysfunction. However, this prediction is exactly the opposite of what we observed in this study.

If repeatable, this study may warrant screening patients with the lowest BMI for binocular vision problems, which may then be treated with a near add or prism.

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