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RESEARCH ARTICLE **OPEN ACCESS**

The Prevalence of Color Vision Deficiency in Medical Students at King Saud bin Abdulaziz University for Health Sciences

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Abstract:

Objective: This study aimed to identify the prevalence of Color Vision Deficiency (CVD) and its contributing factors among medical students enrolled at King Saud bin Abdulaziz University for Health Sciences in Riyadh, Saudi Arabia.

Methods: In this cross-sectional study, 522 students from King Saud bin Abdulaziz University for Health Sciences in Riyadh, Saudi Arabia, participated. The student filled out the questionnaire immediately after completing the Ishihara test. Data analyses were conducted in SPSS.

Results: Of 522 students, 29.9% were females, and 70.1% were males. The prevalence of CVD in medical students was 1.5%, with 98.3% of students having normal vision while 0.2% had small changes or misdiagnosed CVD. All eight students with a definitive diagnosis of CVD were males, with a significant association (p=0.04) between sex and CVD status. There was a significant association of CVD status with the familial history of CVD (p=0.002) and history of congenital color vision abnormality (p=0.0342). No significant associations were found for the knowledge of CVD, history of vision problems, eye surgery, eye or head trauma, any exposure to chemicals, current health status, and vitamin A intake.

Conclusion: The CVD prevalence reported by our study is the lowest compared to all other studies in medical students worldwide. A considerable number of medical students were unaware of their vision problems. Therefore, preliminary screening of all school-going students is recommended to ensure they are aware of their medical condition and minimize the potential difficulties faced during studies and clinical work.

Keywords: Color vision deficiency, Medical students, Prevalence, Vision problem health, Saudi Arabia.

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1. INTRODUCTION

Color Vision Deficiency (CVD) is a condition marked by disruptions in color perception, resulting from a decrease in the quantity of visual pigment per cone or the absence of one or more of the three cone systems [1]. Congenital color vision deficiency can manifest as an X chromosome-linked recessive trait, an autosomal dominant trait, and, in extremely rare cases, an autosomal recessive trait [2]. It is among the most prevalent vision disorders, and the occurrence of CVD differs among various races and geographical areas. Nevertheless, a significant number of cases of color blindness go unnoticed due to the lack of adequate screening [3]. The role of color vision is crucial in healthcare, as certain medical indications rely on color variations. Medical practitioners must be able to differentiate colors so they can assess the differences in colors during clinical examination. Therefore, medical practitioners with color vision deficiency may encounter challenges in their professional careers [4]. There are numerous CVD forms that might be congenital or acquired. Reduced sensitivity to a specific color due to an irregularity in one of the three cones' alignment is known as anomalous trichromacy [5]. Reductions in sensitivity to red are referred to as protanomaly, reductions in sensitivity to green as deuteranomaly, and reductions in sensitivity to blue as tritanomaly. Dichromacy is a condition in which one type of retinal cone is absent, and only two cones are able to see color. Tritanopia, deuteranopia, and protanopia are the three forms of dichromacy. Lastly, monochromacy is the lack of color perception caused by either an absence of cones or a single type of cone [6]. During their clinical rotations, medical students may come across a variety of colored symptoms, including cyanosis, icterus, and pallor. Individuals suffering from Color Vision Deficiencies (CVD) could find it challenging to interpret these colored indicators. On the other hand, these symptoms could go unnoticed, resulting in incorrect diagnoses and improper patient care [7]. For instance, the occurrence of CVD was identified as 1.77% among preparatory students for medical universities in Makkah, Saudi Arabia. Additionally, the prevalence was higher in male students, reaching up to 3.5% [8]. In the latest findings, a prevalence of 2.1% was documented among medical students at Imam Abdulrahman bin Faisal University in Saudi Arabia. Notably, there was a significant correlation between CVD as well as a history of vision problems, and 87% of the students were incognisant of their color vision issue [9]. Moreover, a 3.9% prevalence of CVD was found in dental students at King Khalid University, Saudi Arabia [10]. Careful analysis of subtle color might be important to dermatologists and other specialists scoping tissues (gastroenterologists). The typical ophthalmology resident would be concerned about underperformance in recognizing subtle pigment changes if their color deficiency were known during a training or occupational interview [6]. It is critical for medical students to be aware of their potential CVD, as the absence of this awareness could pose a significant risk to patients' lives due to deficiencies in a lack of proper clinical examination [11]. Further, medical institutions were not providing advice or screening, and the medical community failed to recognize the issue or implement education as there is no data available for CVD prevalence in medical students in Riyadh. This study aimed to assess the prevalence of CVD and identify the factors contributing to it among medical students enrolled at King Saud bin Abdulaziz University for Health Sciences in Riyadh, Saudi Arabia.

2. MATERIALS AND METHODS

A quantitative cross-sectional study was completed within one year at the College of Medicine, King Saud bin Abdulaziz University for Health Sciences in Riyadh province. Ethical approval was obtained from King Abdullah International Medical Research Center. After assuring the students that their data would be kept confidential, a written consent form was provided and signed by them. The sample size was sufficient to achieve adequate statistical power and was calculated using Open-Source Epidemiologic Statistics for Public Health (OpenEpi) Version 3.01 with a 95% confidence level and a 5% margin of error. According to recent literature, the prevalence of CVD in dental students was 3.8% [10]. The calculated sample size was 58 at 95% CI. However, the maximum number of students were invited and recruited for the study. Recruitment of participants was through a convenience snowball sampling technique. Medical students (male and female) from the 2nd to 6th year and medical interns were contacted through text messages and emails. A total of 526 students were responded to the questionnaire. Along with the consent form, students were provided with an anonymous questionnaire (Google Forms) to fill out. The questionnaire contained 3 sections: the first section contained personal data (gender, age, academic year, nationality, and marital status), the second section contained medical history (previous vision problems, familial vision problems, congenital color vision abnormalities, eye surgery, trauma, health problems and history of vitamin A intake), and the third section was the Ishihara plates. All students were instructed to not spend more than 5 seconds on each color vision plate and to keep a distance of at least 75 cm between the device and their eye. The student filled out the questionnaire immediately after completing the Ishihara test. After completing this procedure, the participants submitted their individual Google forms. The data from the questionnaire (google form) were automatically collected in a Google sheet from where all data were used for further analysis. The Ishihara plates results were divided into 3 categories: students scoring 13 or above were categorized as normal, students scoring 11-12 as having small changes or misdiagnosed, and students scoring ≤10 as deficient [9]. The data was analyzed for descriptive outcomes *via* the Statistical Package of Social Sciences (SPSS Inc. Version 29.0). The Fisher's exact test was applied by using the R package “exact2x2” for the determination of potential associations. The level of significance was kept at 95% (p = 0.05).

3. RESULTS

All eight students with a definitive diagnosis of CVD were male and in their pre-clinical academic years. A significant association (p = 0.04) was found between sex and CVD status, while the association between academic year and CVD status was non-significant (p = 0.66). The students with CVD were aged less than 23 years, and there was a non-significant association between CVD status and the age of these students. The demographic characteristics of the medical students involved in this study are summarized in Table **1**.

The history of medical students and its association with their CVD status is summarized in Table **2**. Of the total 8 students with CVD, 87.5% (7) students reported that they had previous knowledge of CVD, while 12.5% (1) students were unaware of CVD, and there was no statistically significant association between knowledge of CVD and the CVD status of students. Of the students having CVD, 25% (2) reported a previous history of vision problems, while 75% (7) students did not report any previous vision problems. Of the normal 513 students, 53% (272) students did not have any previous vision problems, while 47% (241) of the students reported having previous vision problems, and of these, 90% (218) reported that they had refractive errors. There was no statistically significant (p = 0.48) association between the history of vision problems with CVD status.

The results of the current study showed a statistically significant (p = 0.002) association between familial history of CVD and CVD status, with 50% (4) of the deficit students reporting a familial CVD history and 50% (4) report-

Table 1. Demographic characteristics and CVD status of medical students (n=522).

Characteristics	-	CVD Status			*p*-value
		Deficient	Small Change /misdiagnosed	Normal	
Knowledge about CVD	Yes	7 (87.5)	1 (100)	370 (72.1)	0.605
	No	1 (12.5)	0	143 (27.9)	
Problem with vision	Yes	2 (25)	0	241 (47)	0.482
	No	6 (75)	1 (100)	272 (53)	
Familial CVD history	Yes	4 (50)	0	34 (6.7)	0.002
	No	4 (50)	1 (100)	479 (93.3)	
Congenital color vision abnormalities	Yes	1 (12.5)	0	1 (0.2)	0.0342
	No	7 (87.5)	1 (100)	512 (99.8)	
Eye surgery	Yes	0	0	36 (7)	1
	No	8 (100)	1 (100)	477 (93)	
Eye or head trauma	Yes	0	0	21 (4.1)	1
	No	8 (100)	1 (100)	492 (95.9)	
Chemical Exposure	Yes	0	0	4 (0.8)	1
	No	8 (100)	1 (100)	509 (99.2)	
Current health problem	Yes	1 (12.5)	0	38 (7.4)	0.506
	No	7 (87.5)	1 (100)	475 (92.6)	
Vitamin A intake	Yes	5 (62.5)	0	279 (54.4)	0.595
	No	3 (37.5)	1 (100)	234 (45.6)	

Abbreviation: CVD: Color Vision Deficiency.

Table 2. CVD status of medical students according to their history (n=522).

Characteristics		CVD Status			*p*-value
		Deficient N (%)	Small Change /misdiagnosed N (%)	Normal N (%)	
Sex	Males	8 (100)	0	358 (69.8)	0.0411
	Females	0	1 (100)	155 (30.2)	
Age	> 20	3 (37.5)	1 (100)	122 (23.8)	0.3493
	21-23	5 (62.5)	0	364 (71)	
	24-27	0	0	24 (4.6)	
	28-31	0	0	3 (0.6)	
Academic Year	Pre-Clinical	8 (100)	1 (100)	449 (87.5)	0.6637
	Clinical	0	0	62 (12.1)	
	Intern	0	0	2 (0.4)	

Abbreviation: CVD: Color Vision Deficiency.

ing no familial CVD history. Only 6.7% (34) of the normal students reported that they had a familial CVD history, and 93.3% (479) of the normal students did not report any familial CVD history.

Of the eight students with CVD in this study, 87.5% (7) did not have any congenital color vision abnormality, and 12.5% (1) had congenital color vision abnormality. Of the total 513 normal students in this study, 99.8% (512) students did not have any congenital color vision abnormality. The association between CVD status and history of congenital color vision abnormality was significant (p = 0.0342) in this study.

No student with CVD reported any eye surgery, eye or head trauma, or any exposure to chemicals, while their association with CVD status was also non-significant (p = 1). In this study, only 12.5% (1) of the students with CVD had current health issues, and 7.4% of the students with normal color vision had current health issues. Of the participants of this study, 62.5% (5) of students with CVD and 54.4% (279) of students with normal color vision were taking vitamin A in their diet. The association of CVD status with current health issues and vitamin A intake was not statistically significant (p>0.05).

4. DISCUSSION

The current study investigated the prevalence of CVD at the College of Medicine, King Saud bin Abdulaziz University for Health Sciences in Riyadh, and the results indicated the prevalence of CVD was found to be 1.5%. This result is in accordance with some of the previously published studies conducted in Nigeria, Cameroon, and India, reporting the CVD prevalence of 1.7%, 1.7%, and 1.8%, respectively, in medical students [12-14].

The prevalence of CVD in our study was slightly lower than reported by four studies from Pakistan (2%, 3.4%, 3.7%, and 3.75%), three studies from Saudi Arabia (2.1%, 3.7%, and 3.9%), one study from Ethiopia (2.85%), one study from Malaysia (3.2%) and one study from Bangladesh (3.35%) [9, 10, 15-23]. However, some other studies reported a much higher CVD prevalence than our study. These studies include three studies from Nepal (4%, 5.58%, and 5.83%), two studies from Egypt (4.5% and 6.9%), one study from Iran (6%), one study from Pakistan (6%), and one from India (4.69%) [24-31].

In our study, all the deficient students were males, and none of the females reported CVD, which can be attributed to the X chromosome-linked recessive nature of congenital red-green CVD (most common type) and blue cone monochromacy [32]. Similar results were previously reported in Pakistan, India, and Cameron, where none of the females had CVD [14, 22, 30]. However, some studies from Ethiopia, India, Malaysia, Nepal, and Pakistan reported only a few cases of CVD in females in their respective medical student cohorts. However, the percentage was lower than in males in those studies [15, 17-19, 31]. Contrary to these studies reporting no to little prevalence of CVD in females, a study from Pakistan reported a higher prevalence rate of 4.48% among females compared to 2.4% among males [21]. These differences maybe due to the fact that the percentage of females in the study population of these studies was high. However, there is a need to explore this problem by conducting large-scale research involving larger sample size.

About half of the affected participants (50%) reported a familial history of CVD, and the association between familial history and the occurrence of CVD was also significant. Two previously published studies in Iran and Egypt reported a lower percentage (25% and 17.6%, respectively) of participants having a familial history of CVD with a significant association between the occurrence of CVD and family history of CVD [25, 26]. In contrast, a study from Saudi Arabia reported a non-significant association between familial history of CVD and occurrence of CVD, with a percentage of 21.7% reporting a family history of CVD [9]. A study also reported that there was a clear link between parent’s consanguinity and CVD [33]. A notable prevalence of consanguinity in the Saudi population has been documented, including elevated incidences of congenital disabilities and genetic disorders, necessitating genetic screening and premarital genetic counseling [34].

Given that color recognition is vital in daily life, the significance of screening should be applied to school-age children, as Color Vision Deficiency (CVD) has been documented in numerous studies, including this demographic. Early detection enables parents to provide appropriate support to their children, while teachers can modify their instructional strategies to enhance student benefit. Despite the technique employed being a screening instrument for protan and deutan deficiencies with elevated sensitivity and specificity [9], it is advisable to utilize an additional confirmatory tool (Richmond HRR test) to identify tritan deficiencies. It is advisable to distinguish between protan and deutan abnormalities in affected participants utilizing the Medmont C100 Test and the Farnsworth–Munsell 100 Hue Test to evaluate the severity and various patterns. Moreover, the cross-sectional design of this study and the selected sample restrict the generalisability to a comparable age cohort. We advocate for a comprehensive elucidation of several age demographics, namely children, adolescents, adults, and geriatrics, to facilitate an in-depth examination of the disease's nature, whether acquired or hereditary, and its ramifications on their lives.

CONCLUSION

The CVD prevalence reported by our study is the lowest compared to all other studies in medical students worldwide. All the definitive CVD students were male, with a significant association between CVD and sex. Many medical students do not know about their vision problems; ultimately, they may face problems during their studies in medical universities and later in their professional lives. Therefore, preliminary screening of all school-going students is recommended to ensure awareness of their medical condition, enabling them to make informed decisions regarding their academic pursuits.

LIMITATIONS

The lowest prevalence in our study may be due to a small sample size compared to other studies. The small sample size in this study might have created sample bias, which may have not adequately represented the broader population, leading to challenges in generalizing findings. Therefore, we recommend a larger sample size for future studies.

AUTHORS' CONTRIBUTION

It is hereby acknowledged that all authors have accepted responsibility for the manuscript's content and consented to its submission. They have meticulously reviewed all results and unanimously approved the final version of the manuscript.

LIST OF ABBREVIATIONS

CVD = Cardiovascular Diseases

SPSS = Statistical Package for the Social Sciences

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The study was approved by the Institutional Review Board of King Abdullah International Medical Research Center (KAIMRC), Saudi Arabia (protocol code IRB/2655/22).

HUMAN AND ANIMAL RIGHTS

All human research procedures followed were in accordance with the ethical standards of the committee responsible for human experimentation (institutional and national), and with the Helsinki Declaration of 1975, as revised in 2013.

CONSENT FOR PUBLICATION

All the information was kept anonymous. Written informed consent was taken after the study was thoroughly explained.

STANDARDS OF REPORTING

STROBE guidelines were followed.

AVAILABILITY OF DATA AND MATERIALS

The data supporting the study results are present within the study.

FUNDING

None.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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