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Comparison of Visual Status of Iranian Military and Commercial Drivers

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Background: There is no legal requirement for Iranian military truck drivers to undergo regular visual checkups as compared to commercial truck drivers.

Objectives: This study aimed to evaluate the impact of drivers' visual checkups by comparing the visual function of Iranian military and commercial truck drivers.

Patients and Methods: In this comparative cross-sectional study, two hundred military and 200 commercial truck drivers were recruited and their Visual Acuity (VA), Visual Field (VF), color vision and Contrast Sensitivity (CS) were assessed and compared using the Snellen chart, confrontation screening method, D15 test and Pelli-Robson letter chart, respectively. A questionnaire regarding driving exposure and history of motor-vehicle crashes (MVCs) was also filled by drivers. Results were analyzed using an independent samples t-test, one-way ANOVA (assessing difference in number of MVCs across different age groups), chi-square test and Pearson correlation at statistical significance level of $P < 0.05$.

Results: Mean age was 41.6 ± 9.2 for the military truck drivers and 43.4 ± 10.9 for commercial truck drivers ($P > 0.05$). No significant difference between military and commercial drivers was found in terms of driving experience, number of MVCs, binocular VA, frequency of color vision defects and CS scores. In contrast, the last ocular examination was significantly earlier in military drivers than commercial drivers ($P < 0.001$). In addition, 4% of military drivers did not meet the national standards to drive as opposed to 2% of commercial drivers. There was a significant but weak correlation between binocular VA and age ($r = 0.175$, $P < 0.001$). However, CS showed a significantly moderate correlation with age ($r = -0.488$, $P < 0.001$).

Conclusions: The absence of legal requirement for regular eye examination in military drivers caused the incompetent drivers to be missed in contrast to commercial drivers. The need for scientific revision of VA standard for Iranian drivers is also discussed. The CS measurement in visual checkups of older drivers deserves to be investigated more thoroughly.

Keywords: Visual Acuity; Visual Fields; Color Vision; Contrast Sensitivity

1. Background

Driving is a complicated activity which is affected by different human sensory, mental, motor and compensatory abilities. Among these, visual system provides more than 90% of the information required for driving and thus driving has been considered a visually intensive task (1). As a result, different countries have proposed various visual standards for private and commercial vehicle drivers for driving licensure. In Iran, for instance, the mathematical summation of right and left eyes' Visual Acuities (VA) should be equal or more than 14/10 for the professional group 1 (heavy vehicle) drivers to be competent to drive, while VA of each eye is recorded as the number of lines seen out of 10 lines of the distant VA chart. Moreover, the uncorrected VA of the worse eye should not be less than 1/20 (2). This standard also requires the commercial group 1 drivers to have horizontal Visual Field (VF) of more than 120 degrees through the confrontation screening method and not to be total color blinded. In addition, one eye drivers do not have the right to hold driving license. Obviously, the result of these standards is disqualification of those who have not met the requirements for driving which might have adverse consequences on their health and social life (3). On the other hand, annually 1.2 million people are killed in Motor Vehicle Crashes (MVCs) each year and up to 50 million injured worldwide (4). In Iran, MVCs are considered to be the second highest cause of mortality (5). Many studies have been

conducted, therefore, to investigate the role of different visual measures and the effect of various visual impairments on driving performance and safety. To date, the importance of measuring VA, VF, color vision and also Contrast Sensitivity (CS) for initial and periodic driving relicensure has been acknowledged in various studies (3, 6). However, there have been conflicting findings on the relationship between these ocular parameters and MVCs (3, 7, 8). Other studies have also investigated the ocular status and prevalence of ocular diseases among vehicle drivers in Different country (9-11) and noted the importance of regular comprehensive visual screening examinations before issuing and renewing driving license. Considering the importance of visual system integrity for professional drivers, there have been more stringent visual standards and shorter relicensure intervals for professional public transport drivers in Iran, as against private drivers, in order to grant them the driving health card in addition to their driving license. However, there is not such a requirement for their counterparts in military forces who simply need to extend their driving license periodically like other private drivers without a need to hold the previously mentioned driving health card. Although several studies have investigated the ocular status of truck drivers in Iran, visual acuity was the only measured parameter in them (12-14). In contrast, no study has been conducted on military Iranian drivers, though the most noncombat fatalities in Iran's military forces are reportedly due to MVCs and military drivers are at fault in most of the crashes they have been involved (15).

2. Objectives

Unlike commercial truck drivers, there is no legal requirement for military truck drivers in Iran to undergo regular visual checkups. Moreover, there is limited information about the visual status of professional truck drivers in Iran. Therefore, this study was conducted to evaluate and compare the current visual status of professional truck drivers in military forces as well as commercial drivers in Iran. Regarding the limited data on visual status of professional drivers in Iran, this study was conducted to evaluate and compare the current visual status of professional truck drivers in military forces as well as commercial drivers, the former group is not legally required to undergo regular checkups but the latter is periodically checked to obtain the aforementioned driving health card as required by the national driving standards.

3. Patients and Methods

In this comparative cross-sectional study, professional military truck drivers were selected from one of the Iranian military forces in Tehran (the capital city of Iran) and their visual examination results were compared to findings of commercial truck drivers who came to Fardis occupational medicine center in Karaj, Iran, for their regular checkups. Drivers were included if they had age between 20 and 55 years and experience of at least two years of active professional driving (in commercial or military area). Subjects in both groups were randomly selected. At the first step, 235 and 245 commercial and military drivers were selected using simple randomization, respectively and after checking inclusion and exclusion criteria 200 drivers were included in each group (totally 400 participants). After completing a written informed consent, all drivers were asked to fill out a questionnaire about their demographic data, driving experience, their ocular history and any history of involvement in MVCs. The visual system of all the participants was assessed by one optometrist to gain information on how their visual system had been functioning before the time of this visit. In fact, this study did not aim to see how vision could be improved by glasses or other visual corrections, but to understand the current status of professional drivers' visual system while driving. The study was approved by the ethics committee of Baqiyatallah University of Medical Sciences in Tehran, Iran, and conformed to the provisions of the Declaration of Helsinki. Monocular and binocular VA were measured with a Snellen chart at distance of 6 meters and in sufficient indoor lighting while the driver used his habitual glasses at driving if he had any. The score was considered as driving VA. The results were recorded both in Snellen fraction and also as a fraction showing the number of successive lines seen by the driver out of 10 lines of the chart to conform to the national driving standard. It was considered legally abnormal if the sum of VA for right and left eyes was less than 14/10. For statistical purposes, however, we had to convert Snellen fraction to Logarithm of Minimum Angle of Resolution (Log MAR). The visual field was tested binocularly using the confrontation method and values less than 120 degrees were recorded as abnormal according to the standards for commercial drivers in Iran. Color vision was assessed with the D-15 test. A failure, as specified by Farnsworth, was two or more crossings of the D-15 score sheet which were parallel to one of the protan, deutan or tritan axes marked on the score sheets (16). Contrast sensitivity was also measured binocularly at 1 meter using the Pelli-Robson chart and expressed as logarithmic CS (Figure 1). Each letter was scored as 0.05 log units (17). Scores greater than 1.95 and 1.80 log units were considered normal for individuals with the age between 20 and 50 years and more than 50, respectively (16). Results from this study were analyzed with SPSS 16 software (SPSS, Inc., Chicago, IL, USA). As our data had normal distribution, we used independent samples t-test, one-way ANOVA (assessing difference in number of MVCs across different age groups), chi-square test and Pearson correlation to statistically compare them at statistical significance level of $P < 0.05$.

Figure 1. Pelli-Robson Contrast Sensitivity Chart

The numbers give the log CS corresponding to the neighboring group of three letters. For example, the number 2.00 appears next to a group of letters with a contrast of 1/100 (i.e. 1%) indicating a log CS of 2.00.

4. Results

All the military and commercial truck drivers examined in this study were male with the mean (SD) ages of 41.6 (9.2) and 43.4 (10.9), respectively (P = 0.070). The mean years of driving among military and commercial drivers were 15 ± 2.23 and 16 ± 3.73, respectively. Twenty-three (%11.50) and 19 (%9.50) military and commercial drivers reported a history of MVC, respectively. There was no significant difference between military and commercial drivers in terms of years of driving experience, educational status, and number of MVCs (P > 0.05). However, military drivers have had their visual system examined 2.3 years ago on average which was significantly more than that for commercial drivers (1.3 years on average) (P < 0.001). Indeed, the last eye visit in 28.5% of military drivers, in comparison with only 2% of commercial drivers, was equal or more than 3 years ago. Mean driving VA values in the better eye of military and commercial drivers were 0.019 and 0.032 Log MAR, respectively while the difference reached a significant level (P = 0.047). However, the mean binocular driving VA values of the two groups were 0.009 and 0.014 Log MAR, respectively which did not show a significant difference (P = 0.061) (Table 1). By adding VA of right and left eyes, results showed that 4% of military drivers and 2% of commercial drivers had scores less than 14/10 and thus couldn't meet the national visual standard for driving. Table 2 shows that in military truck drivers as the time interval to the last ocular examination gets longer, the frequency of drivers with VA of less than 20/30 in better eye rise as well. Nevertheless, no significant differences were observed in chi-square test results between These frequencies (P = 0.748). Furthermore, chi-square test did not show a significant difference in the frequency of drivers with less than 20/30 VA in the better eye (P = 0.260) and also binocular driving VA (P = 0.213) between military and commercial truck drivers. All the drivers from both groups had normal binocular peripheral visual field in horizontal line. Abnormal color vision was found in 1% of military drivers and 3% of commercial drivers with deuteranopia being the most prevalent color vision defect in both groups. None of the drivers had total color blindness. The chi-square test did not show a significant difference between the two frequencies in military and commercial drivers (P = 0.080). Contrast sensitivity of both military and commercial drivers was 2.00 log units on average with no significant difference between the two groups (P = 0.121). According to normal values (16), none of the military drivers with the age over 50 years had CS scores below 1.80 log units while this was the case for 2.5% of commercial drivers. In contrast, none of the commercial drivers with the age under 50 years had CS scores below 1.95 log units while 5.9% of military drivers were so. Additionally, by considering military and commercial drivers as a whole, we also tried to investigate the possible significant correlations between different parameters of the study as well as the effect of age on these parameters. ANOVA analysis showed a statistically insignificant difference in number of MVCs across different age groups (P = 0.171) (Tables 3 and 4). In contrast, regarding monocular and binocular VA, there was a significant difference between their scores across different age groups (p < 0.001). The Least Significant Difference LSD Post Hoc analysis showed that binocular VA in drivers older than 58 years was significantly reduced compared to younger groups of drivers (P < 0.001). Contrast sensitivity was also reduced significantly across different age groups and this reduction was significant between each two age groups using the LSD Post Hoc test. Results of Pearson correlation test showed an insignificant correlation between the number of MVCs and age (r = -0.003, P = 0.066), binocular VA (r = -0.003, P = 0.071) and CS scores (r = 0.001, P = 0.061). There was a moderately significant correlation between Log MAR VA and CS of the drivers (r = -0.361, P < 0.001). The correlation between Log MAR binocular VA and age was significant but relatively weak (r = 0.175, P < 0.001) (Figure 2). However, CS showed a significantly moderate correlation with age (r = -0.488, P < 0.001) (Figure 3).

Table 1. Visual Status of Military and Commercial Drivers [a]

Variable	Better eye VA, (Log MAR)	Better eye VA < 20/30, %	Binocular VA, < 20/30, %	Binocular VA, (Log MAR)	Binocular CS, (Log Unit)	Color vision defects, %	Abnormal VF, %	Last ocular examination, y
Drivers								
Military	0.019	4	1.5	0.010	2.00	1	0	2.3
Commercial	0.032	4.5	2	0.014	2.00	3	0	1.3
P Value	< 0.05	NS	NS	NS	NS	NS	-	< 0.001

[a] Abbreviations: CS, Contrast Sensitivity; VA, Visual Acuity; VF, Visual Field.

Table 2. Frequency of Better Eye Visual Acuity Impairment as a Function of Last Ocular Examination Time in Military Drivers [a, b]

Variable	Time of Last Ocular Examination, y			Asymptomatic
	Less Than 2 Years	2 - 4 Years	More Than 4 Years	Significance
Better Eye VA				0.748
< 20/30	3.5	4	6.5	
≥ 20/30	96.5	96	93.5	

[a] Abbreviations: VA, Visual Acuity.
[b] Data are presented as (%).

Table 3. Frequency Distribution of Binocular Contrast Sensitivity of Drivers Across Different Age Groups

Age Groups	Binocular Contrast Sensitivity (Log Unit)											Total
	1.20	1.70	1.80	1.85	1.90	1.95	1.95	2.00	2.05	2.10	2.15	
≤ 30						1		29	3	2	22	57
31 - 39					3	5	2	63	6	8	15	102
40 - 48					9	16		64	3		9	101
49 - 57			3	6	14	15		77	2	1		118
< 58	1	1	3	3	6			8				22
Total	1	1	6	9	32	37	2	241	14	11	46	400

Table 4. Frequency Distribution of Binocular Driving Visual Acuity of Drivers Across Different Age Groups

Age Groups	Binocular Driving Visual Acuity						Total
	0.4	0.6	0.7	0.8	0.9	1	
≤ 30				3		54	57
31 - 39		1		2		99	102
40 - 48				1	4	96	101
49 - 57			4	1	8	105	118
< 58	2				6	14	22
Total	2	1	4	7	18	368	400

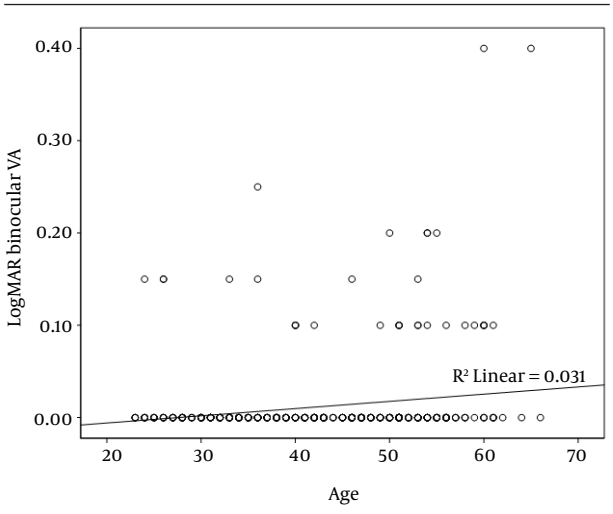

Figure 2. Relationship Between Age of Drivers and Their Log MAR Binocular Visual Acuity

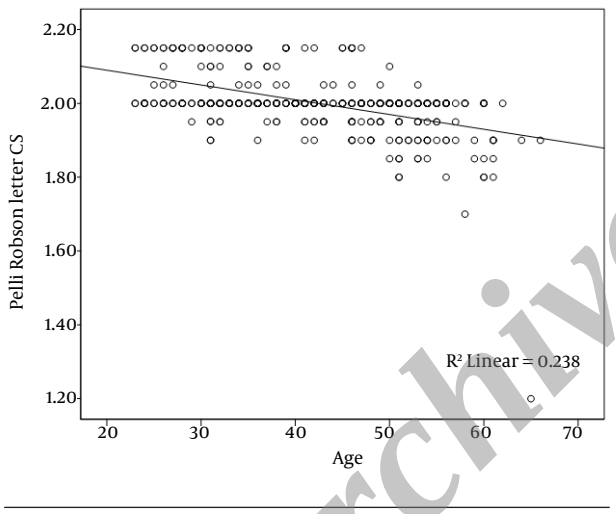

Figure 3. Relationship Between Age of Drivers and Their Pelli-Robson Contrast Sensitivity Scores

5. Discussion

In this study, we didn't find any significant difference in visual parameters between Iranian military and commercial truck drivers even though military drivers were not required to pass regular visual checkups. However, 4% of the military drivers did not meet the national visual requirements for driving as opposed to only 2% of commercial drivers. This becomes an important issue when it is realized that military drivers were not obliged to go under regular visual checkups as commercial drivers were. In fact, military drivers who failed in our visual tests were not legally required to undergo more advanced examinations. This highlights the risk imposed to road safety by military drivers with inadequate VA and the need for regular examinations. Both military and commercial drivers had sufficient VA for driving on average. Although statistical analysis hardly showed a significant difference in VA of the better eye between the two groups, it was not clinically important. Furthermore, this difference did not reach to a significant level as far as binocular VA was concerned. Many studies have considered 20/30 as the minimum VA required for driving. In this regard, we found 4% of military drivers and 4.5% of commercial drivers had driving VA less than 20/30 in their better eye ($P > 0.05$). Regarding binocular VA, this percentage reduced to 2% and 1.5%, respectively, likely because of the binocular summation phenomenon ($P > 0.05$) (18). These frequencies are much lower than those reported in previous studies. Sharifi et al. (13) investigated visual status of 1500 professional drivers in Iran and found that 7.7% of drivers had binocular VA less than 8/10. In Malaysia nearly 7% of the drivers showed VA of less than 0.3 Log MAR in the better eye (19). Also, as another Iranian study among 4003 public drivers 9% of them had insufficient vision for driving before correction of refractive errors (20). In Malaysia 6.7% of new drivers failed to reach legal requirements in this regard (19). At the time of this study, professional drivers in Iran were required to have eye checkups once every 10 years. In a study on the prevalence of visual impairment in European drivers, van Rijn et al. (21) reported that 14% had VA less than 8/10. Other than Spanish drivers who required having periodical tests for their visual function, the remaining drivers didn't need to pass regular testing according to their country's legislations. Adekoya et al. (22) also found that 11.5% of Nigerian professional drivers had less than 20/30 VA in their better eye noting that 93% of them had not been tested at least once during renewals.

In our study, lack of a significant difference between military and commercial drivers in terms of frequency of drivers with unacceptable VA for driving, despite the regular and periodic visual exams for the latter (every 2 years for age ≤ 40 and annually for age > 40), indicates the importance and necessity of these periodic checkups. In other words, regular vision examinations could not even decrease the frequency of drivers with inadequate VA for driving, let alone longer intervals between visual system examinations. Three major drawbacks of VA standard for driving in Iran deserve to be discussed here. As mentioned earlier, the mathematical summation of VA in right and left eye should be equal or more than 14/10 for the professional group 1 drivers according to this standard. Firstly, the distance at which VA should be taken is not indicated in this standard. Secondly, it should be noted that the standard and acceptable way to record VA is in Log MAR units or more clinically, as a Snellen fraction to reduce the interexaminer and intraexaminer differences in VA measurements. In this standard, however, VA should be recorded as the number of successive lines read by the subject out of 10 lines of the VA chart. In practice, this can leads to differences in measured VA with different charts; since 6th line, for example, might be equivalent to 20/35 in one chart and

20/50 in another chart. Thus, the actual standard VA of the driver is neglected in this way. Thirdly, it is the mathematical summation of monocular visual acuities that this standard is based upon. This means that two drivers with monocular visual acuities of (4/10 - 9/10) and (6/10 - 7/10) are failed as the sum of monocular VA is equal to 13/10. Even so, the first driver would have binocular VA about 9/10, which is clinically much better than the other one who would have binocular VA about 7/10. This doesn't sound scientific since it is the neural interactions in visual cortex, named binocular summation or binocular inhibitions, that determine binocular VA and in clinical practice binocular VA is equal or more than the VA in better eye (18). In most of other countries, notably in US, UK and Australia, binocular VA of 20/40 or VA more than 20/30 in the better eye is considered as the cut-off value for commercial drivers' fitness to drive (6-8). The need for scientific revision of VA standard for drivers in Iran is thus imperative. All the drivers in our study had more than 120 degree horizontal binocular peripheral vision by confrontation VF test. This is in line with Maentyjarvi et al study in which VF was interpreted as normal in all drivers (10). Asghari et al. (14) also found that only 0.6% of professional drivers had VF less than 120 degree. In the large sample size study of Haliza et al. (19) 1.72% of drivers had less than 120 degree peripheral vision with average range of 56 to 176 degree. Confrontation VF test, however, has low sensitivity due to high false-positive and false-negative rates; and with lack of reproducibility, confirmation, and validation of findings (6). Therefore, its usefulness in assessing drivers' fitness to drive is quite debatable. In other studies in which more complicated or automated techniques were used to assess VF, higher frequency of drivers with reduced VF was reported (9, 21). Additionally in a low sample size study, it has stated that people with hemianopia and quadrantanopia may be fit for driving (23). Visual field testing is believed to clarify certain ocular disorders (19). In this study, 2% of all drivers (1% of military drivers and 3% of commercial drivers) were found to have color deficiency while none of the drivers had total color blindness. Deutanopia was the most prevalent color deficiency in both groups. To date, this is the first study that has assessed color vision of professional drivers in Iran. Frequency of color vision defects among professional drivers have been reported to be 0% to 7% in other studies with deutanopia being the most frequent defect (9, 10, 24, 25). In naturalistic driving, the critical cues on the road can be obtained through multiple sources of information like luminance, position, and pattern. Nevertheless, in some circumstances in which theses cues might not be informative, color deficiency may impact the performance of interpreting traffic control devices and other color coded signals. Both military and commercial drivers were found to have mean CS of 2.00 log units with no significant difference. Several studies reported considerable greater risk of involvement in road crashes for older drivers with Pelli-Robson CS below 1.25 to 1.35 log units (26, 27). In this regard, none of the drivers under 58 years had CS of 1.25 log units or below in our study; however, 4.5% of all drivers older than 58 had this low amount of CS. This is in line with van Rijn et al. (21) study in which 6.5% of European drivers older than 75 years had less than 1.25 log units Pelli-Robson CS. However, CS assessment is not included in visual standard for drivers in Iran as well as many other countries. Although VA is very helpful in understanding the visual status of an individual, it cannot determine visual quality alone (28). A subject with impaired CS may, for example, have difficulty in detecting a dark-coated pedestrian at night. Many studies have thus indicated the importance of CS measurement for competency to drive (3, 6, 17, 29). Regarding the effect of age on visual status, drivers older than 58 were found to have significantly poorer binocular VA compared to younger groups. Moreover, CS of drivers was also reduced significantly across different age groups in a way that it was significant between each two age groups. Previous studies have also found the greater prevalence of VA and CS impairments in older groups of drivers (17, 19, 28). Additionally, we found a stronger correlation between CS and age relative to that of VA and age. Based on previous investigations, it seems that the prevalence of CS impairments is much higher than the prevalence of impairments of VA in older drivers (21). The CS as measured with letters starts to fall off nearly 12 years before high contrast VA (30). Moreover, we found only a moderate correlation between VA and CS; drivers with better VA had better CS. Consequently, relatively coarse predictions of CS are possible on an individual basis from VA measurements. Furthermore, there are specific ocular diseases, such as cataract and age-related macular degeneration, in which CS may be more affected than VA (31, 32). Therefore, it seems that adding CS measurement to standard visual examinations of drivers older than 40 could provide eye care professionals more information on their visual function while driving especially at night. We could not find any significant correlation between CS or VA reduction and history of MVCs. This confirms findings of previous studies (21, 27). Two reasons could possibly lead to this finding. At first, frequency of drivers with VA or CS impairment was low in our study. Secondly, we used self-reported crash involvement in computing crash rates which has several limitations like social desirability, and unwillingness to share this type of potentially embarrassing information (3). As there is no access to an integrated system of police reports on driving accidents in Iran, we could not use this gold standard for measuring driving safety. As an advantage we assessed the visual status of military truck drivers and compared it with relevant data extracted from commercial drivers for the first time in Iran. Furthermore, as mentioned, color vision in professional drivers was evaluated for the first time in Iran. On the other hand, the main weak point of the study was probably the impact of locality of the sampling, which makes the popularization a little hard. In this study, there was not a statistically or clinically significant difference in visual status between military and commercial drivers. Nevertheless, the absence of legal

requirement for military drivers to undergo regular standard eye examinations made their last eye visit to be considerably earlier than that of commercial drivers. Therefore, military drivers with inadequate visual function for driving could easily be missed, which makes the need for regular eye checkups more prominent. However, this issue did not make their number of MVCs to be considerably different from commercial drivers with regular eye visits. Their driving performance, however, might negatively be influenced which could be the subject of future studies. In addition, there is a need for VA standard of drivers in Iran to be scientifically revised. Including CS measurement in visual checkups of older drivers deserves to be investigated more thoroughly. The authors also believe that the results from the present study should be generalized to the whole Iranian drivers with caution due to relatively low sample size.

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