Original Article

Accuracy of Night Shooting in Abnormal Contrast Sensitivity Infantry Force

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Objective: To compare the nighttime shooting performance with a group of normal and abnormal contrast sensitivity property.

Design: Descriptive cross-sectional study.

Materials and Methods: Seventy-three participants from Infantry Regiment were recruited and underwent through eye examination tests, including visual acuity, color vision, contrast sensitivity test, and slit-lamp examination. Personal data and shooting experience were recorded. Shooting test with M16A1 Rifle in daytime and nighttime were performed.

Results: All participants were male with a mean age of 24.14±7.04 years old. Best-corrected visual acuity [BCVA] was 0.04±0.09 LogMAR. Mean Log contrast sensitivity was 2.24±0.07. Two participants had abnormal contrast sensitivity (1.8 Log). Five participants had abnormal color vision. The mean shooting score in daytime and nighttime were 6.88±2.32 and 5.30±3.00, respectively (p<0.001). No associated factors between nighttime shooting performance and contrast sensitivity property was found.

Conclusion: The accuracy of nighttime shooting was significantly less than daylight shooting. The present study showed no associated factor between contrast sensitivity and nighttime shooting performance. Further study with a larger sample size is needed for subgroup analysis.

Keywords: Contrast sensitivity, Night shooting, Daylight shooting

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Visual acuity testing is an integral part of the clinical examinations performed for the diagnosis and treatment of eye conditions. Although visual acuity is very helpful in understanding the visual status, it cannot determine visual quality alone[(1)]. An assessment of visual function and visual quality is important, and they are measured objectively through contrast sensitivity testing. Contrast sensitivity reflects the ability to differentiate between light and dark in a series of bands with no clear boundary[(2,3)]. Many studies have demonstrated that impaired contrast sensitivity may exist in the presence of normal visual acuity[(4-6)]. Plainis et al[(6)] reported the value of contrast sensitivity testing in the diagnosis of central serous chorioretinopathy and suggested that contrast sensitivity testing can be a more useful tool than visual acuity in the diagnosis of this disease. Changes in contrast sensitivity in glaucoma have been demonstrated by McKendrick et al[(7)] and some other researchers[(8)]. Contrast sensitivity can be affected by a number of conditions, such as cataract, diabetes mellitus, and certain retinal and central nervous system conditions, and changes in such patients may be observed along with normal vision[(9-14)]. Irregular astigmatism and increased higher-order aberrations, especially coma aberration, can bring about changes in contrast sensitivity[(15,16)]. In addition, contrast sensitivity is a valuable test after cataract and refractive surgery and has been suggested as an indicator of surgical quality[(1,17,18)].

In situations of low light, fog, or glare, the contrast between objects and their background are often reduced. Driving at night is an example of an activity that requires good contrast sensitivity for safety. Poor contrast sensitivity can increase risk of a fall in an elderly population[(19)].

The present violence in three provinces Southernmost of Thailand is part of a longstanding conflict in the region. Several thousand people have been killed and many officers died on duty during the past ten years. From statistic, the most incident happen between 6.00 and 8.00, and 19.00 and 20.00[(20)]. Those reports could suggest that in low light or abnormal contrast condition, shooting performance may be reduced. This study is a first study to describe daytime

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and nighttime shooting performance with contrast sensitivity in the Infantry Company. The present study was conducted in the Infantry Battalion, Second Infantry Regiment of King's Guard in Prachinburi Province, Thailand.

Materials and Methods

Infantry Battalion in the Infantry Regiment in Prachinburi was selected by convenience. Seventy-three volunteers were recruited. Inclusion criteria were age 20 to 60 years and best-corrected visual acuity [BCVA] was 20/40 or better in aiming eye. Exclusion criteria were history of eye disease, previous eye surgery, or history of severe eye and head trauma. BCVA was assessed with an ETDRS chart and recorded in LogMAR unit. Contrast sensitivity was tested with Pelli-Robson Contrast Sensitivity Chart (Haag-Streit, UK) and values were recorded in Log unit. During examination participants sat directly one meter, or 40 inches in front of the chart. Color vision was tested by Ishihara color vision test (Kanehara Trading, Japan). The plate test was held 75 cm from the participants and tilted so that the plane of the paper is at right angle to the line of vision. Ophthalmic examinations continued with slit-lamp biomicroscopy. Any presence of ocular problems such as ocular media opacity, and optic disc abnormality were recorded. All participants underwent an interview for personal information, experience in the M16A1 rifle usage, aiming eye, and medical history.

The M16A1 rifle was used for shooting at 25 meters away from target, first, nine shots were fired to adjust the alignment of rifle. In the first shooting session, the participants fired 10 shots in two minutes by single shooting session in daytime in normal light condition between 11.00 and 12.00 (Lux meter = 3,200 to 4,400 lx). In the second shooting session, the participants fired 10 shots in nighttime between 19.00 and 20.00 (Lux meter = 10 to 25 lx) using the same technique and the same rifle. The standard shooting target plates from the Royal Thai Army in black and white color (100% contrast sensitivity) were used in the present study. There were 10 small targets in one plate (Figure 1). One shot that hit the target would be counted for 1 point, with a maximum of 10 points for 10 targets. If the shot did not hit the target then zero point would be recorded. In the nighttime shooting, spotlight was used to shine the target plate only and the shooter was kept in the dark.

The primary outcome of the present study was to compare night-shooting score of abnormal contrast sensitivity group and normal contrast sensitivity group. Secondary outcomes of this study included (i) average score of daytime shooting and nighttime shooting, (ii) eye disease, visual acuity, and color vision status of sample group, and (iii) factors that affect the accuracy of shooting.

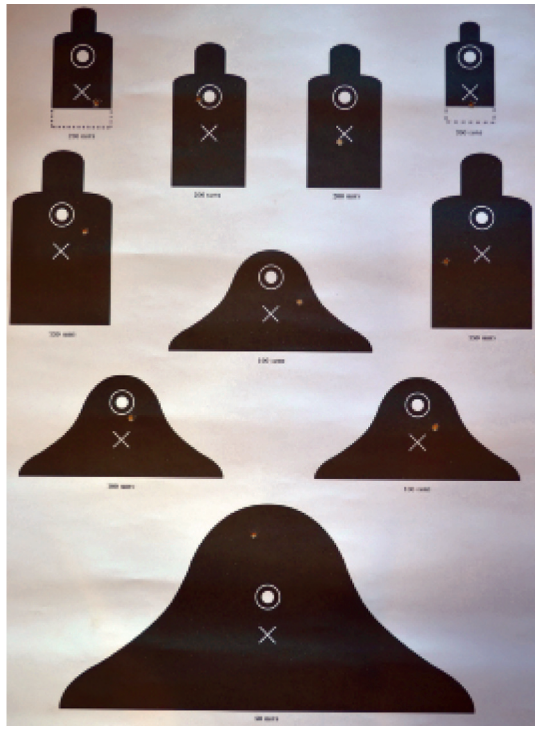

Figure 1. Shooting target.

Statistical analysis was carried out using SPSS for Windows (version 23.0, SPSS Inc., Chicago, IL, USA). Descriptive data were reported as percentage, mean ± standard deviation and ranged minimum to maximum. Continuous data were compared with the Mann-Whitney U test and paired t-test, whereas the Fisher's exact test was used to compare the categorical data between groups. The *p*-value smaller than 0.05 was considered statistically significant.

The Institutional Review Board of the Royal Thai Army Medical Department approved the study protocol, which was conducted in accordance with the tenets of the Declaration of Helsinki. All participants signed written informed consents.

Results

The 73 participants were all male. The mean age was 24.14±7.04 years with a range of 20 to 55 years. Mean best-corrected visual acuity was 0.04±0.09

LogMAR, range 0 to 0.4. Mean Log contrast sensitivity was 2.24±0.07, range 1.8 to 2.25. Two (2.7%) had abnormal contrast sensitivity (1.8 Log). Five (6.9%) had abnormal color vision. Forty-eight (65.8%) were in the present position less than one year. Sixty-one (83.6%) worked in the Combat Company and twelves (16.4%) worked in the Combat Support Company.

Table 1. Demographic data (n = 73)

	n (%)
Age (year)	
20 to 29	68 (93.2)
30 to 39	1 (1.4)
40 to 49	1 (1.4)
≥50	3 (4.1)
Mean ± SD (min-max)	24.14±7.04 (20 to 55)
Position	
Combat company	61 (83.6)
Combat support company	12 (16.4)
Working time	
<1 year	48 (65.8)
1 to 5 year	16 (21.9)
>5 year	9 (12.3)
Underlying disease	
No	72 (98.6)
Yes	1 (1.4)
Experience with M16A1	
<1 year	59 (80.8)
1 to 5 year	7 (9.6)
6 to 10 year	3 (4.1)
>10 year	4 (5.5)
Personal weapon	
M16A1	53 (72.6)
Others	20 (27.4)
Aiming eye	
Right eye	65 (89.0)
Left eye	8 (11.0)
Correction	
Without glasses	73 (100)
With glasses/contact lens	0 (0.0)
BCVA, mean ± SD (min-max)	
Right eye	0.04±0.09 (0 to 0.4)
Left eye	0.04±0.09 (0 to 0.4)
Color vision	
Normal	68 (93.2)
Abnormal	5 (6.8)
Contrast sensitivity (Log unit), mean ±SD (min-max)	2.24±0.07 (1.8 to 2.25)
Shooting scores, mean ±SD (min-max)	
Daytime	6.88±2.32 (1 to 10)
Nighttime	5.30±3.00 (0 to 10)
Result	
Fail	13 (17.8)
Pass	60 (82.2)

BCVA = best-corrected visual acuity

Most participants (80.8%) had experience of M16A1 shooting of less than one year. Fifty-three (72.6%) had daily use of M16A1 rifle, while twenty (27.4%) used another weapon in daily duty. Right eye was found to be an aiming eye in 89%. None of the participants used eyeglasses or contact lens. The demographic data is summarized in Table 1.

The mean score in daytime and nighttime shooting were 6.88±2.32 and 5.30±3.00, respectively (Table 2). Nighttime shooting score worsened significantly ($p<0.001$). Two participants had abnormal contrast sensitivity, one was 24 years in the Combat Support Company with no underlying disease, a visual acuity of 20/20 (LogMAR = 0), and normal color vision in both eyes. His contrast sensitivity was 1.8 Log units, defined as abnormal in aiming eye (right eye) and 2.25 Log units, defined as normal in left eye. His score was 7 points in daylight shooting and 1 point in nighttime shooting. Another was 25 years in the Combat Company with no underlying disease, a visual acuity of 20/20 (LogMAR = 0), and normal color vision test in both eyes. His contrast sensitivity was 1.8 Log units, defined as abnormal in aiming eye (right eye) and 2.25 Log units, defined as normal in left eye. His score was 1 point in daylight shooting and 2 points in nighttime shooting. From the mean score of nighttime shooting, we used a military standard cut-off score 3 points or less (mean -1SD) to define pass and fail category. All factors that could affect nighttime shooting score were analyzed. None of the factors was found to be associated with fail shooting performance in nighttime, as summarized in Table 3.

Discussion

The main rule of the ophthalmic capability for young male recruitment into military service are the visual acuity test and the refractive error measurement. Contrast sensitivity is not being tested. The present study is the first to describe the contrast sensitivity value in the Royal Thai Army. Contrast sensitivity can be tested by using chart, light box, view-in tester, and computer/video systems. The most common printed plates include the Arden, Vistech, Regan, Cambridge, and the Pelli-Robson grating charts. The Pelli-Robson

Table 2. Comparison of daytime and nighttime shooting score

	Mean ± SD	*p*-value*
Daytime shooting score (n = 73)	6.88±2.32	<0.001#
Nighttime shooting score (n = 73)	5.30±3.00	

* Paired t-test

\# Statistical significant $p<0.05$

Table 2. Factors associated shooting performance in nighttime

	Fail (n = 13) n (%)	Pass (n = 60) n (%)	*p*-value*
Age (year)			0.636
20 to 29	12 (17.6)	56 (82.4)	
30 to 39	-	1 (100)	
40 to 49	-	1 (100)	
≥50	1 (33.3)	2 (66.7)	
Mean (min-max)	22 (21 to 54)	22 (20 to 55)	0.274
Position			1.000
Combat unit	11 (18.0)	50 (82.0)	
Combat support unit	2 (16.7)	10 (83.3)	
Working time			0.520
≤1 year	8 (16.7)	40 (83.3)	
1 to 5 year	2 (12.5)	14 (87.5)	
>5 year	3 (33.3)	6 (66.7)	
Underlying disease			0.178
No	12 (16.7)	60 (83.3)	
Yes	1 (100)	-	
Experience in M16A1			0.560
<1 year	12 (20.3)	47 (79.7)	
1 to 5 year	-	7 (100)	
6 to 10 year	-	3 (100)	
>10 year	1 (25.0)	3 (75.0)	
Personal weapon			1.000
M16A1	10 (18.9)	43 (81.1)	
Others	3 (15.0)	17 (85.0)	
Aiming eye			1.000
Right eye	12 (18.5)	53 (81.5)	
Left eye	1 (12.5)	7 (87.5)	
Previous eye surgery			N/A
No	13 (17.8)	60 (82.2)	
Yes	-	-	
Correction			N/A
Without glasses	13 (17.8)	60 (82.2)	
Glasses/contact lens	-	-	
Mean BCVA (min-max)			
Right eye	0 (0 to 0.3)	0 (0 to 0.4)	0.330
Left eye	0 (0 to 0.1)	0 (0 to 0.4)	0.265
Color vision			0.578
Normal	13 (19.1)	55 (80.9)	
Abnormal	-	5 (100)	
Contrast sensitivity (Log unit), mean (min-max)	2.25 (1.8 to 2.25)	2.25 (1.8 to 2.25)	0.231
Shooting score, mean (min-max)			
Daytime	9 (7 to 9)	7 (1 to 10)	0.013#
Nighttime	2 (0 to 3)	7 (0 to 10)	<0.001#

BCVA = best-corrected visual acuity; N/A = not available

* Fisher's exact test or Mann-Whitney U test

Statistical significant $p<0.05$

falls in the printed plates category of tests that is used in clinics and is easy to use. From previous study, O'Neal and Miller, contrast sensitivity has been reported to be strongly related to pilots' aircraft detection performance, suggesting that contrast sensitivity should be assessed in pilots[21]. Therefore, contrast sensitivity test might be necessary for military personnel working in special combat unit such as in the Rifle Company or as an aviator.

Bhee et al[22] presented correlation between different contrast levels of target and effectiveness of shooting performance with M16 rifle, in the Second ICMM Pan Asia Pacific Congress on Military Medicine in 2012. Their work concluded shooting performance with M16 rifle correlated with contrast level of target. Similar to our study, they found mean nighttime shooting score was significantly less than daytime shooting score. However, we found no associated factor between contrast sensitivity property and nighttime shooting performance. This could be due to the small number of participants, two in seventy-three that had abnormal contrast sensitivity.

Other possible factors included excitement, under pressured situation, limited time, and panic. Those could be explanations of failed nighttime shooting performance in normal contrast sensitivity participants. Our shooting target plate was black on white (100% contrast), which in real situation, the target might have lower contrast level. Moreover, color target might be questioned for shooting performance in abnormal color vision shooter. Further study with a larger sample size is needed for subgroup analysis such as differences in level of contrast sensitivity, contrast level of target plate, and contrast in color target.

The present study may draw attention to a process of recruitment of military personnel that might have responsibility and duty in special circumstance such as during violence or in a war area.

What is already known on this topic?

Visual acuity test was generally used as an assessment of visual function and visual capability. A specific test such as contrast sensitivity test will be requested upon special circumstances or ocular diseases. Being under abnormal contrast sensitivity situation will affect working performance for everyone, including normal visual acuity individuals.

What this study adds?

This study confirmed an important awareness of visual function testing. Therefore, testing for visual acuity is important but testing for contrast sensitivity is also important in some special type of work such as military personnel. This study supported previous evidence that impairment of contrast sensitivity function will affect working performance.

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Potential conflicts of interest

The authors declare no conflict of interest.

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