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Original Article

Visual adaptation time to different ambient light conditions post-de-goggling of night vision goggle

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ABSTRACT

Objectives: The night vision goggles (NVGs) used for aviation can overcome the limitations of the human eye to see in the dark and augment the night vision well enough to enable safe flying and mission accomplishment. The technology, however, has some limitations that need to be defined so that safe flying envelopes can clearly be understood and operational possibilities can be optimally explored within that envelope. Further, the luminance level of NVG displays which operates in twilight to low photopic range affects dark adaptation of the eye post-de-goggling of NVG. Hence, the assessment of visual adaptation time through Gen-2++ NVG under different illumination conditions using contrast sensitivity (CS) and visual acuity (VA) as parameters was the desired objective of the study.

Material and Methods: In a prospective repetitive measure design, a total of 64 volunteered participants were examined for their visual adaptation time through Gen 2++ NVG post-de-goggling using Pelli-Robson CS chart and United States Air Force (USAF) 1951 tribar chart in the NVG Lab at two different locations. The visual adaptation time was measured under three different illuminations: Full moon (FM), half moon (HF), and quarter moon (QM). Furthermore, log CS values and VA of participants were measured under three ambient moonlight conditions with unaided eyes and using NVG.

Results: The average recovery time post-de-goggling of NVG for CS (i.e., CS value before wearing NVG) was 1 min 34 s for FM, 2 min 50 s for HF, and 4 min 01 s for QM conditions. The average recovery time for VA (i.e., VA value before wearing NVG) was 1 min 29 s for FM, 3 min 01 s for HF, and 5 min 32 s for QM conditions. The results of this study brought out that visual adaptation time post-de-goggling of Gen 2++ NVG increased significantly for both CS and VA with decreasing ambient moonlight illumination ($P < 0.001$). This study also brought out that the logarithm of the minimum angle of resolution value of CS and VA under three ambient light illuminations decreased significantly with a decrease in illumination both during unaided eye and NVG usage. *Post hoc* analysis revealed that there was a significant difference in visual adaptation time in both CS and VA between all three ambient light conditions ($P < 0.001$).

Conclusion: This study has estimated the time for dark adaptation required after de-goggling NVG use in different ambient moonlight levels for Gen 2++ NVG using CS and VA charts. The values based on CS can be considered in terms of time required for the detection of objects while that of VA can be attributed to the time for recognition of the object. The visual adaptation time post-de-goggling of NVG is very crucial and critical during approach, landing, and taxiing on the runway under dim light conditions for the accomplishment of mission safety. However, keeping in view the dynamic changes in night sky illuminations during flying operations, the findings of the study need to be validated in operational conditions.

Keywords: Contrast sensitivity, Dark adaptation, Night vision, Rhodopsin, Visual acuity

INTRODUCTION

The ability to conduct effective operations at night has been recognized as advantageous to Armed forces from past experiences. Image intensification technology has been widely used to increase visual capability at night. Image intensifiers amplify portions of the electromagnetic spectrum available in the ambient environment, usually 2000–7000 times greater than the actual scene.[1] The amplification depends upon the type of image intensifier and its response to ambient light conditions. The night vision goggles (NVGs) used for aviation can overcome the limitations of the human eye to see in the dark and augment the night vision well enough to enable safe flying and mission accomplishment. The technology, however, has some limitations that need to be defined so that safe flying envelope can clearly be understood and operational possibilities can be optimally explored within that envelope.[2] Aeromedical issues of NVG are reduced visual acuity (VA), poor contrast, field of view, less effective through rain, fog, and snow.[2,3] In addition to issues related to visual perception through NVGs, the effect of NVG on dark adaptation of eyes is a concern. Dark adaptation is an independent process during which eyes adjust from high luminance to low luminance which includes biochemical, physical, and neuronal aspects.[4] The use of NVG does not require scotopic vision because the output brightness of image intensifier tubes is in the low photopic to mesopic range (600–930 nm). This output brightness will affect the dark adaptation of human eye. The literature on visual adaptation of eye reveals that, as the eyepiece illumination of NVG would have been providing low photopic or mesopic vision, it would take some time to adapt to have good scotopic vision post-de-goggling of NVG.[4] Aircrew on night operations used to wear NVGs for a substantial period. Numerous studies examined the dark adaptation process after the removal of NVGs. However, the exposure to NVG was not more than 5 min in any of the previous experiments.[5-7] The evolution of NVGs through different generations has different display brightness levels which affect time to dark adaptation post-removal of NVGs. The display of recent NVG is slightly brighter than older NVGs. Hence, the relation between display brightness and dark adaptation time is a concern post-removal of NVG. Contrast sensitivity (CS) in actual night flying scenarios in different moon-light conditions is one of the visual parameters of enormous importance.[4] CS defines the threshold between the visible and invisible. Through the years, several different measurement techniques have been available to quantify an individual's CS as quickly and easily as VA is measured. Hence, it is an operational concern to estimate visual adaptation time in quarter moon (QM), half-moon (HF), and full moon (FM) light conditions post-de-goggling of Gen NVG 2++ using CS and VA as parameters.

MATERIAL AND METHODS

Study design

This study was a prospective repeated measure experimental design, wherein visual adaptation time post-de-goggling of NVG Gen 2++ was measured for the same participants under different illumination conditions using CS and VA charts.

Study participants

There were a total of 64 healthy military volunteers from the Indian Armed forces (both male and female population), among which 32 were pilots from transport and helicopter stream and 32 were non-aircrew. The mean age of the participants was 30.56 ± 4.09 with a range of 24–38 years. The sample size was calculated using G-power version 3.1.9.7 with considerations of an α error probability of 0.05, power of the study (1-β) 0.80, and effect size f of 0.21. The inclusion criteria were well-rested healthy volunteers with age group of 20–40 years and corrected VA of 6/6. The exclusion criteria were visual abnormalities/ocular pathologies, any medication that affects vision and the presence of neurological disabilities, and any comorbidities. Since smoking is known to affect dark adaptation, the participants were advised to avoid smoking 02 h before the study.

Materials

The test article was the NL 93 Gen 2++ NVG (Israel) which is mounted on CGF Gallet Helmet. Various moonlight conditions were simulated using modified gooseneck lamp with rheostat. The illumination level for simulated conditions was 0.01 lux for QM, 0.05 lux for HF, and 0.1 lux for FM. Pelli-Robson CS Chart was used to record CS[8,9] and USAF 1951 Tri-Bar Chart was used to assess VA. A Yokogawa Make Lux Meter was used to assess the required illumination level at the level of charts.

Experimental protocol

This study was approved by the Institute Ethics Committee and a written informed consent was obtained from all study participants. This research was conducted at standard NVG Laboratory conditions at two different locations: Study of non-aircrew participants at the Institute of Aerospace Medicine, Bangalore, and for Aircrew participants at No 1 Aeromedical Training Centre, located at Airforce Station Hindon. The participants were familiar and well indoctrinated on the adjustment and focusing procedures of NVG. The participants were instructed to undergo 30 min of dark adaptation and made to sit at 3 m from the Pelli-Robson CS chart. The participants were asked to read the Pelli-Robson CS chart from the top left. The readings were in triplets in each line. The log CS value of the last triplet for which two letters (two of three) are named correctly was recorded as the log CS at QM light condition without NVG. All participants were initially asked to wear the NVG mounted helmet after proper adjustment and focussing. Then the participants were instructed to keep visualise through the NVG for 10 min without closing the eyes. During this 10-min period, log CS values with NVG were also recorded. After the completion of 10 min, the participants were instructed to flip up (de-googled) the NVG and asked to read the Pelli-Robson chart till the time they were able to read the same triplet letters as before wearing NVG. The time taken to read the baseline log CS value without NVG after de-goggling was recorded as visual adaptation time post-de-goggling of NVG Gen 2++. The above measurements were similarly repeated for HF (0.05 lux) and FM (0.1 lux) and time taken for visual adaptation time post-de-goggling of NVG was recorded [Figure 1]. Similar measurements of visual adaptation time were recorded from 6 m distance using USAF 1951 Tri-Bar Chart with VA as parameter in three moonlight conditions. During the study, Log CS values and logarithm of the minimum angle of resolution (log MAR) VA values were also measured with the naked eye and with NVG usage.

Statistical analysis

Data were compiled and analyzed using Microsoft® Excel 2019 Professional Edition and IBM Statistical Package for the Social Sciences version 29 for statistical analysis. The dependent variable was visual adaptation time under different illumination levels and the independent variables were log CS value and log MAR VA, without and with NVG. The data were checked for normalcy. Since the data of visual adaptation time were normally distributed, parametric tests were applied to make statistical analysis. Analysis of variance (ANOVA) was used to compare the visual adaptation time post-de-goggling of NVG in all three ambient light conditions. Bonferroni *post hoc* tests were executed to ascertain the statistical significance of visual adaptation time in between the different illumination conditions. Results with a $P < 0.05$ were considered statistically significant.

RESULTS

Visual adaptation time

The visual adaptation time post-de-goggling of Gen 2++ NVG under FM, HF, and QM conditions is depicted in Tables 1 and 2. It was observed that the visual adaptation time showed an increasing trend with the decrease in illumination [Figures 2 and 3]. This increment in visual adaptation time was statistically significant using ANOVA test (for CS: ANOVA, $F [2,126] = 412.72$, $\eta^2 = 0.87$, $P \leq 0.001$) and (for VA: ANOVA, $F [2,126] = 1010.49$, $\eta^2 = 0.94$, $P \leq 0.001$).

CS

It was observed that the contrast discrimination (in log CS values) obtained from Pelli-Robson Chart with Gen 2++ NVG was significantly better than the scores without wearing NVG in all three ambient moonlight conditions ($P < 0.001$). This is depicted in line diagram [Figure 4] and values are depicted in Table 3.

VA

It was observed that the VA (in log MAR values) obtained from USAF 1951 Tri-Bar chart with Gen 2++ NVG was significantly better than the scores without wearing NVG in all three ambient moonlight conditions ($P < 0.001$). This is depicted in line diagram [Figure 5] and values are depicted in Table 4.

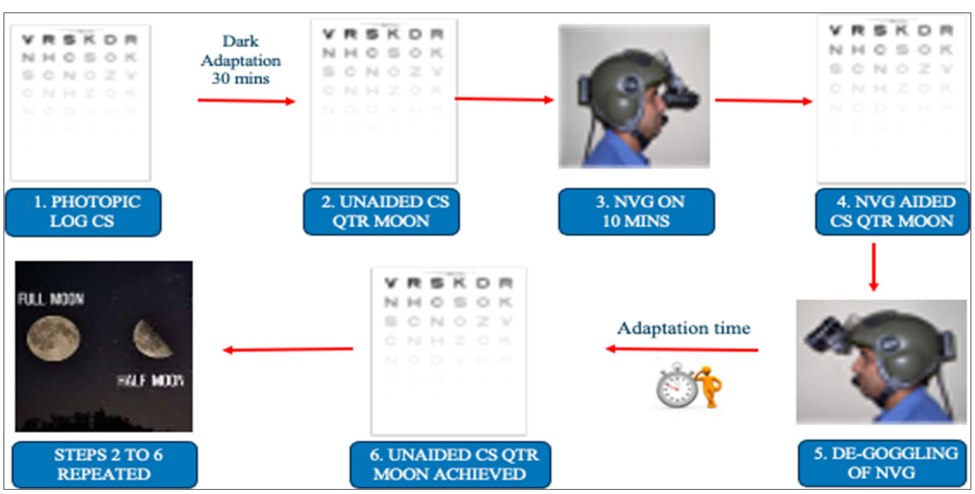

Figure 1: Schematic representation of experimental protocol. CS: Contrast sensitivity, QTR: Quarter moon, NVG: Night vision goggle

Table 1: Assessment of difference in visual adaptation time (in seconds) for post-de-goggling of Gen 2++ NVG using CS (*n*=64).

Visual adaptation time post-de-goggling of NVG using CS			
Ambient light	**QM**	**HM**	**FM**
Mean	248.25 (4'01")	170.19 (2'50")	93.66 (1'34")
SD	67.44 (1'07")	48.4 (48")	38.03 (38")
Repeated measures ANOVA F (2,126)=412.72	$p<0.001$		

Minutes are denoted as' and Seconds as". NVG: Night vision goggles, CS: Contrast sensitivity, QM: Quarter moon, HM: Half moon, FM: Full moon, ANOVA: Analysis of variance, SD: Standard deviation

Table 2: Assessment of difference in visual adaptation time (in seconds) for post-de-goggling of Gen 2++ NVG using VA (*n*=64).

Visual adaptation time post-de-goggling of NVG using VA			
Ambient light	**QM**	**HM**	**FM**
Mean	332.12 (5'32")	186.34 (3'01")	88.84 (1'29")
SD	48.63 (49")	62.41 (62")	28.39 (28")
Repeated measures ANOVA F (2,126)=1010.49	$p<0.001$		

Minutes are denoted as' and Seconds as". NVG: Night vision goggles, CS: Contrast sensitivity, QM: Quarter moon, HM: Half moon, FM: Full moon, ANOVA: Analysis of variance, SD: Standard deviation

Table 3: Comparison of contrast sensitivity values among different moonlight conditions.

Comparison of CS (log values) among different illumination conditions			
Ambient light	**Without NVG (Mean±SD)**	**With NVG (Mean±SD)**	**Wilcoxon test**
QM	0.49±0.09	0.82±0.10	$p<0.001$
HM	0.72±0.10	0.99±0.11	$p<0.001$
FM	0.92±0.10	1.13±0.12	$p<0.001$
Friedman test	$p<0.001$	$p<0.001$	

NVG: Night vision goggles, CS: Contrast sensitivity, SD: Standard deviation, QM: Quarter moon, HM: Half moon, FM: Full moon

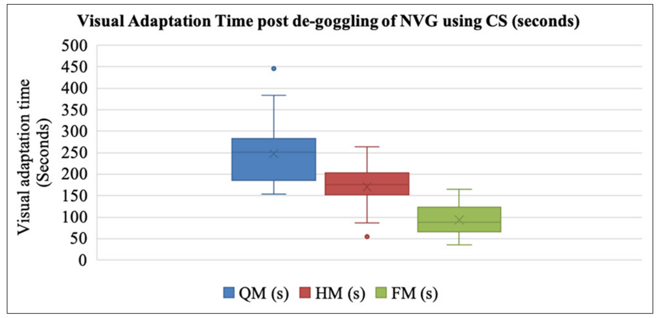

Figure 2: Box-and-Whisker plot (visual adaptation time post-de-goggling of Gen 2++ night vision goggles using contrast sensitivity). CS: Contrast sensitivity, QM: Quarter moon, NVG: Night vision goggle, HM: Half moon, FM: Full moon.

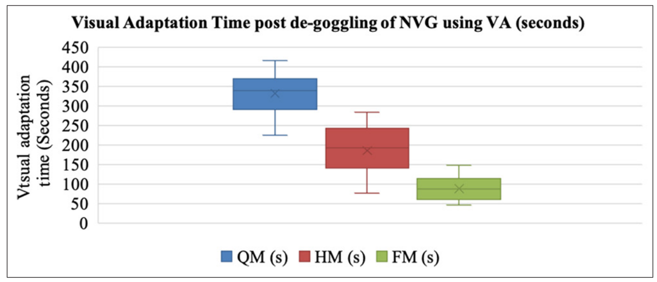

Figure 3: Box-and-Whisker plot (visual adaptation time post-de-goggling of Gen 2++ night vision goggles using visual acuity). VA: Visual acuity, QM: Quarter moon, NVG: Night vision goggle, HM: Half moon, FM: Full moon.

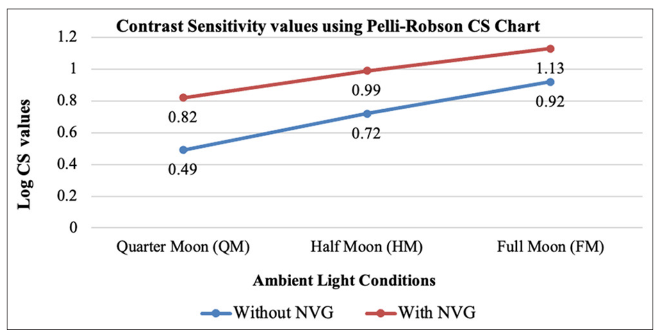

Figure 4: Line diagram depicting the contrast sensitivity under different illumination conditions for Gen 2++ night vision goggle. CS: Contrast sensitivity, NVG: Night vision goggle.

DISCUSSION

Night vision equipment for military aircraft significantly improves the ability to operate in low light. After using NVG, most pilots are apprehensive about doing night flying on their own again. At present, available night vision imaging technologies enable pilots to fly in ambient light, an exceedingly risky, if not impossible, situation without assistance. However, the visual information provided by these devices is not nearly as good as what can be seen with the unhindered, unaided eye during daylight hours. The use of night vision devices compromises a number of visual parameters, including depth perception, sharpness, and field-of-view. The intrinsic properties of image intensification-based sensors create additional challenges for the processing of visual data because their spatial and spectral contents differ from those of unassisted vision.[10]

When an individual is suddenly exposed to a dark environment from daytime or fully illuminated conditions,

Table 4: Comparison of VA among different ambient moonlight conditions.

Comparison of VA (log MAR values) among different illumination conditions					
Ambient light	**Without NVG**		**With NVG**		**Wilcoxon test**
	Log value (Mean±SD)	**Snellen's equivalent**	**Log value (Mean±SD)**	**Snellen's equivalent**	
QM	1.04±0.03	20/219.2	0.43±0.05	20/53.8	p<0.001
HM	0.74±0.07	20/109.9	0.36±0.04	20/45.8	p<0.001
FM	0.58±0.07	20/76	0.30±0.04	20/39.9	p<0.001
Friedman test	p<0.001		p<0.001		

VA: Visual acuity, log MAR: Logarithm of the minimum angle of resolution, NVG: Night vision goggles, SD: Standard deviation, QM: Quarter moon, HM: Half moon, FM: Full moon

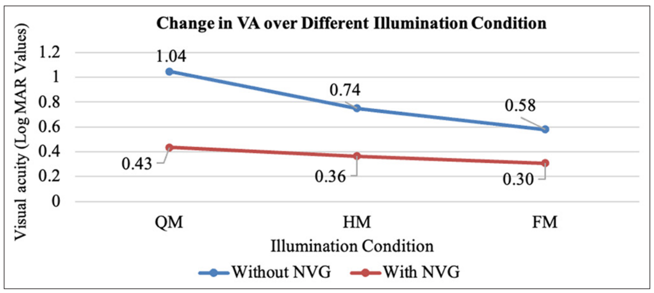

Figure 5: Line diagram depicting the visual acuity (VA) under different illumination conditions for Gen 2++ night vision goggle. CS: Contrast sensitivity, Log MAR: Logarithm of the minimum angle of resolution, NVG: Night vision goggles, QM: Quarter moon, HM: Half moon, FM: Full moon.

he/she takes some time before visualizing optimally in the dark. This phenomenon is known as dark adaptation. The ability of visual system to achieve good visibility in low light conditions is because of dark adaptation. The dark adaptation occurs in two stages: The initial stage is commensurate with lowering of stimulus threshold in cone cells and the second stage is a function of the sensitivity of rod cells. On exposure to bright light conditions, the pigment in the rods, i.e., rhodopsin gets completely degenerated. The time taken for cone adaptation is approximately 6–8 min while it takes 20–30 min for rhodopsin to regenerate and optimally function. Although the "Dark adaptation time," in laboratory conditions varies from 30 to 40 min, in nature, these levels of illuminance do not usually occur, and so, the time to adapt is much shorter.[2,11] The NVG image is monochromatic in the green spectrum. After an extended period of NVG use, some aircrew complained of an orange or brown after-image. This is called brown-eye syndrome which is a transient physiological effect and occurs due to green photoreceptor fatigue. This phenomenon affects people differently and usually lasts for a few minutes depending upon how long the NVGs were worn. However, this is not likely to affect the VA once the eye is fully dark adapted.

Numerous studies examined the dark adaptation process after the removal of NVGs. However, the exposure to NVG was not more than 5 min in any of the previous experiments.[5-7] Multiple studies have been extensively used VA to evaluate and describe through night vision image intensification devices. The resolution limit of night vision systems under varying ambient illumination and contrast levels was found by multiple investigations. The use of image intensifiers to test CS has been less common. Such data would be helpful because CS can offer a more complete estimate of visual function across a variety of stimulus sizes, whereas acuity merely indicates the limit of resolution.

In a prospective repetitive measure design, in the present study, a simpler approach was used to measure CS and VA using NVG Gen 2++ and expressed as log values. The time taken to dark adaptation after the removal of NVGs was measured for all three moonlight conditions. The results obtained were analyzed to find the changes in dark adaptation time and log values of CS and VA under different illumination conditions. The average recovery time (i.e., CS value before wearing NVG) was 1 min 34 s for FM, 2 min 50 s for HF, and 4 min 01 s for QM conditions [Table 1]. The average recovery time for VA (i.e., VA value before wearing NVG) was 1 min 29 s for FM, 3 min 01 s for HF, and 5 min 32 s for QM conditions [Table 2].

The results of this study brought out that visual adaptation time post-de-goggling of Gen 2++ NVG increased substantially with decreasing ambient moonlight illumination ($P < 0.001$). This study also brought out that log value of CS [Table 3] and log MAR values of VA [Table 4] under three ambient light conditions decreased significantly with decrease in illumination both during with NVG and without NVG usage ($P < 0.001$).

These findings of visual adaptation time, log CS, and log MAR VA values are consistent with the results of other studies.[5-7,12-15] *Post hoc* analysis revealed that there was a significant difference in visual adaptation time using both VA and CS and other parameters such as log CS and log MAR VA with and without NVG between all three ambient light conditions ($P < 0.001$). This finding was also considered an important finding in the present study. Furthermore, the estimated dark adaptation time falls within the cone adaptation threshold curve limits.[10]

The evolution of NVGs through different generations has different display brightness levels which affects the time-to-dark adaptation post-removal of NVGs. The display of recent NVGs is slightly brighter than older NVGs. In this study, the average display brightness level of Gen 2++ NVG was 1.06 lux for QM, 1.25 lux for HF, and 1.47 lux for FM conditions [Table 5]. The increase in display brightness with increased illumination is attributed to increasing gain properties of I^2 tubes. In addition to ambient illumination, the display brightness of NVG affects the time required for dark adaptation after the removal of NVG. Hence, the relation between display brightness and dark adaptation time is a concern post-removal of NVG.

These findings in this study have operational implications in night flying with the usage of NVG, where a particular level of light would be required to get differentiate contrast between the objects seen through NVG and CS function is essential for target recognition by pilot. Furthermore, visual adaptation from unaided dark night or NVG light to bright light conditions was almost instantaneous, due to photopic light conditions. However, adaptation from NVG vision (mesopic) to ambient moonlight conditions requires few minutes which is a serious concern for aerospace safety during approach/landing and taxiing the aircraft in night flying operations. Hence, the aircrew flying with NVG needs to be cautioned about the period for dark adaptation required for optimum detection and recognition of any objects or obstacles post-degoggling of NVG.

Limitations of the study

This study determined the visual adaptation time post-de-goggling of Gen 2++ NVG. However, military pilots in the Indian Air Force (IAF) (Transport and Helicopter streams) are using newer generation NVGs such as Gen 3 (F4949 and Geo - over the nose vision [ONV]) are operationally capable up to starlight conditions (0.001 lux). The Gen 3 NVGs provide greater display illuminance and lower noise levels than Gen 2++. Hence, the higher display brightness of Gen 3 NVG is expected to affect visual adaptation time more than Gen 2++. In this study, trained aircrew in NVG usage about adjustment and focusing procedure of NVG are expected to prevent learning effects compared to non-aircrew population. However, no difference was found between aircrew and non-aircrew participants. This study was conducted in a controlled laboratory setting environment located at the heights of 2900 ft and 700 ft above mean sea level. Since scotopic vision gets reduced at exposure to higher altitudes (from 5000 ft above mean sea level), future studies on different simulated (normobaric and hypobaric hypoxia) altitudes will be beneficial.

Table 5: Display brightness level of Gen 2++ NVG among different ambient moonlight conditions.

Ambient light	Average display brightness level (lux)
QM	1.06 lux
HM	1.25 lux
FM	1.47 lux

NVG: Night vision goggles, QM: Quarter moon, HM: Half moon, FM: Full moon

Recommendations

Based on the results of this study, the following are recommended: The approach and taxiing to a well-lit runway would not be affected by post de-goggling of NVGs since the visual adaptation is instantaneous. The presence of sufficient landing lights also would address the issue adequately. However, in those situations, where the approach or taxiing needs to be undertaken only with ambient light conditions at night, the aircrew need to be cautioned about period of dark adaptation which would vary as per the intensity of ambient light conditions. Furthermore, awareness of dark adaptation for aircrew should be incorporated as part of operational training in aerospace medicine.

CONCLUSION

This study was undertaken at standard NVG labs to estimate the duration of visual adaptation time for various light conditions during night operations using CS and VA as parameters. It was observed that the adaptation time to ambient moonlight conditions after de-goggling of NVG was found to be statistically significant. Furthermore, the visual adaptation time was found to increase with decreasing moonlight intensities. The visual adaptation post-de-goggling of NVG Gen 2++ based on CS can be considered in terms of the time required for the detection of objects while that of VA can be attributed as time for recognition of the objects. Notwithstanding the above, the aircrew undertaking an NVG mission should be aware of the occurrence of this phenomenon.

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Use of artificial intelligence (AI)-assisted technology for manuscript preparation: The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

REFERENCES

1. Dyer JL, Young KM. Night vision goggle research and training issues for ground forces: A literature review. Technical report no. 1082. Georgia: U.S. Army Research Institute for the Behavioural and Social Sciences, Infantry Forces Research Unit; 1998.
2. Verona RW, Rash CE. Human factors and safety considerations of night vision systems flight. Technical report no. 89-12. Fort Rucker, AL: U.S. Army Aeromedical Research Laboratory; 1989.
3. Parush A, Gauthier MS, Arseneau L, Tang D. The human factors of night vision goggles: Perceptual, cognitive, and physical factors. Rev Hum Factors Ergon 2011;7:238-79.
4. Miller RE, Tredici TJ. Night vision manual for the flight surgeon. Ophthalmology Branch Armstrong Laboratory Human Systems Center, Brooks Air Force Base Texas. Special Report; 1985.
5. Glick DD. Dark adaptation changes associated with use of the AN/PVS-5 night vision goggle. Usaarl Report no. 72-2-72-2. U.S. Army Aero medical Research Laboratory, Fort Rucker, Alabama; 1974.
6. Glick DD. A visual comparison of standard and experimental maps using the AN/PVS-5 night vision goggle. Usaarl Report no. 75-26-7-6. FortRucker, AL: U. S. Army Aeromedical Research Laboratory; 1975.
7. Thomas RS, Wright ST, Clark PJ, Thompson WT, Gooch JM. Optical filter effects on night vision goggle acuity and preservation of dark adaptation. Aviat Space Environ Med 2010;81:869-72.
8. Pelli DG, Bex P. Measuring contrast sensitivity. Vision Res 2013;90:10-4.
9. Pelli DG, Robson JG, Wilkins AJ. The design of a new letter chart for measuring contrast sensitivity. Clin Vis Sci 1988;2:187-99.
10. Thomas J. Chapter 14 ophthalmology in aerospace medicine. In: Davis JR, Johnson R, Stepanek J, Fogarty JA editors. Fundamentals of aerospace medicine. 5th ed. Philadelphia, PA: Lippincot Williams and Wilkins; 2008. p. 349-79.
11. Hecht S, Mandelbaum J. The relation between vitamin A and dark adaptation. JAMA 1939;112:1910-6.
12. Rabin JC. Image contrast and visual acuity through night vision goggles [Technical Report No. USAARL-96-26]; 1996.
13. Rabin J. Spatial contrast sensitivity through aviator's night vision imaging system. Report no. AD-A279 338 [Reprint]; 1994.
14. Raghunandan V, Sekhar MB, Tripathy NK, Joshi VV. Study of performance characteristics of ANVIS MK-III night-vision goggle and comparison with other NVG for aviation usage. Indian J Aerosp Med 2022;66:21-6.
15. Sharma D, Tripathy NK, Raghunandan V, Sekhar BM. Visual acuity through night vision goggles (NVGs): A comparative assessment between Gen 2++ and Gen 3 NVGs under different illumination conditions. Indian J Aerosp Med 2021;65:17-22.

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