Effects of Postures and Wearing Night Vision Goggle on EMG Activities in Upper Neck and Trapezius

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Abstract— **The purpose of present study was to examine the effects of postures and wearing night vision goggle on EMG activities. The EMG activities were measured in muscle groups of upper neck and trapezius while wearing two types of night vision goggle with three postures (stand, sit, and prone). Twenty-nine male infantry soldiers participated in the experiments after providing informed consents with respect to the investigative procedures. Two types of night visual goggle for binocular eyepiece with single image intensifier have been evaluated. The weight of night visual goggles for Type A and Type B are 608g and 560g, respectively. The EMG activity was recorded over the right side of the upper neck (level C2) and trapezius muscles. Results of ANOVA showed that the EMG activities of upper neck muscles were lower significantly while wearing Type B NVG. The RVC of upper neck muscles for Type A and Type B are 31% and 27%, respectively. Further various operating positions were significant difference in both muscle groups. There was the heavy workload in neck muscle groups (42.5% RVC) while wearing night visual goggle in prone position particularly. In addition, head-worn equipment increases the mechanical load on the neck and alters the center of mass forward and upward in relation to the motion axis in the neck and cervical spine. Thus, suggestions of present study provided that soldiers should be avoided wearing NVG in prone posture. The weight arrangement of NVG could be evaluated in further research.**

Keywords— **Repetitive Stress Injuries; Occupational and Work Safety; head-mounted equipment.**

I. Introduction

Since the introduction of the first night vision devices in the 1930s, design improvements have decreased their size and weight, improved their resolution, and increased their reliability. These devices have become indispensable for a variety of night operations, both civil and military [1]. The early imaging devices were cumbersome and required use of powerful infrared lamps, hence making them "active" systems. However, those early devices were replaced in the 1960s by "passive" devices utilizing image-intensifying technology. In spite of the fact that development was driven by military requirements, civilian uses for these devices have greatly expanded in the last decade.

The modern military helmet is not just a piece of protective equipment but also a mounting platform for devices that enhance the pilot's performance. More and more pilots are required to fly in darkness using both a helmet and night vision goggles (NVG). Head-mounted display are a form of output device commonly used in aviation environments and head-mounted display consist of a display, which is attached to the wearer's head by means of ahead strap, spectacles frame, or hat [2]. The weight of commercially available head-mounted display varies considerably ranging from 30g up to 2280g. These are designed such that the display is positioned in front of the eyes. As the majority of the mass of the head-mounted display is housed in the display, most of the weight is located anteriorly of the head. Thus, increase helmet-mounted mass and specific neck postures have been found to be a cause of increase muscular activity and stress [3]. In addition, adding a weight to the head in the form of a head-mounted display may have significant effects on the musculoskeletal system of the head and neck complex. The head's center of gravity (COG) is located at the top of the clivus's center, a position that corresponds to a location that can be measured as 46.6% to the vertex of the head and 53.6% to the chin-neck intersect for a line drawn connecting the vertex of the head to the chin-neck intersect [4].

Although many studies have investigated the effects of NVG on physiological workload and muscle strain, these studies focused on pilots particularly. However, infantry soldiers need to carry out the tasks of search and detection in night for rescuing or military operation. Therefore, the purpose of present study was to evaluate the effect of postures and wearing night vision goggle on EMG activities in upper neck and trapezius on infantry.

II. Methods

A. Participants

The study was approved by the Research Ethics Committee of the researcher's institution. Twenty-nine male infantry soldiers participated in the experiments after providing

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informed consent to the investigative procedures. The mean age was 27.6 years (range 20-47 years), mean stature was 173.7 cm (range 165-190 cm), mean body mass 68.8 kg (range 52-115 kg), and mean head circumference was 55.8 cm (52.5-59.5 cm). All subjects were healthy and reported no musculoskeletal problems which might influence performance detrimentally. In addition, all subjects were instructed to avoid vigorous physical activity and drinking alcohol during the 12 hours prior to the experiment.

B. Apparatus and Materials

Two types of night visual goggle have been evaluated. The length and width of night visual goggle are about 150 mm and 130 mm respectively. Weights of both night visual goggle were presented in Table 1. Total weight of night visual goggles in Type A and Type B are 824 g and 794 g respectively.

The EMG activity was recorded over the right side of the upper neck (level C2) and trapezius muscles. The skin area of current interest was shaved and cleaned with 70% alcohol solution. Disposable pre-gelled surface electrodes (Blue Sensor M-00-S, Medicotest A/S, Denmark, Ag/AgCl) were attached over the muscle of concern, parallel to the muscle fibers, with an inter-electrode center distance of 30 mm, impedance <20 kΩ. Reference electrodes were placed over bone. The signals were amplified, band-pass filtered 20-500 Hz, A/D converted and sampled at 1000 Hz (Biopac Systems Inc, USA). Reference EMG values for normalization (RVC) were obtained during maximum isometric voluntary contraction (MVC) of the specific muscle group for two trials of about 5 sec; the RVC value was calculated as the mean of the two trials.

C. Experimental Procedures

The participants were dressed in tracksuit during the trials, which were performed in a temperature-controlled laboratory (23 ^{o}C). Before commencement of the actual experiment, participants were given an opportunity to warm-up and asked to perform known all experimental tasks until they were able to produce steady manipulation. A total of six trials were performed at types of night visual goggle (Fig. 1), and three postures (sit, stand and prone). The order of these trials was randomly assigned for each subject. In addition, each trial involved wearing for at least 5 min or more (if required) until measurements stabilized. A minimum rest period of 10 min (more if required) was provided between trials. During the rest periods, participants were asked to stay seated, relax and remain silent.

Fig. 1 Wearing two types of night visual goggle

D. Data Analysis

A randomized complete block design (blocks as individual subjects) with two within-subject factors (NVG and postures) was used for this study. All trial data files were exported in Microsoft Excel format, with the mean values for dependent variables then calculated over the final 1 min of each trial. Further, multivariate analysis of variance (ANOVA) was utilized to identify significant differences between conditions for dependent variables. Statistical significance was set at a probability level of 0.05.

Table 1 Two types of night visual goggle have been evaluated

NVG	Weight (g)	Head-mounted strap (g)	Total (g)
Type A	608	216	824
Type B	560	234	794
Difference	48	-18	30

III. Results

Results of ANOVA showed that the EMG activities of upper neck muscles were lower significantly in Type B model. The RVC of upper neck muscles for Type A and Type B are 31% and 27%, respectively. By contrast, the EMG activities of trapezius muscles were not significant difference between NVG. The mean RVC was about 20% (Fig 3). In addition, EMG activities were significant difference among various operating positions in both muscle groups ($p < 0.05$). There was heavier workload in neck muscle groups (42.5% RVC) while wearing night visual goggle in prone position particularly. In addition, the EMG activities of trapezius muscles were increase while participant wearing NVG in stand and prone posture.

The interesting result from the viewpoint of neck muscle activities was the significant interaction between NVG types and postures (Fig. 4). The effect of NVG types on neck muscle was significant for sit and stand postures. The EMG activities of neck muscle were lower in sit and stand posture while wearing type A and type B, respectively. By contrast, the highest loads occurred in both NVG types while wearing NVG in prone posture.

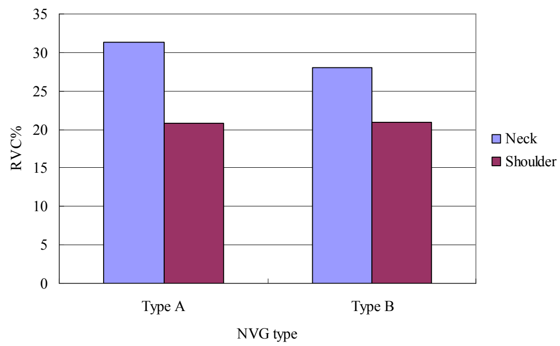

Fig. 2 Comparison of RVC between NVG types

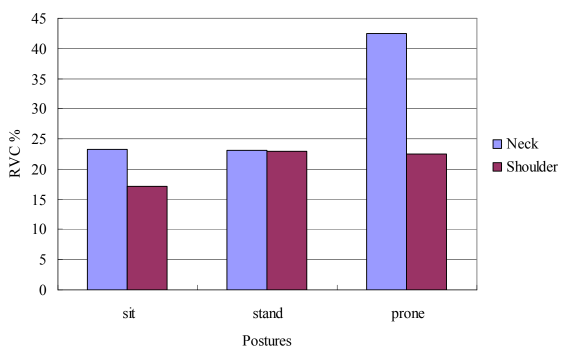

Fig. 3 Comparison of RVC between wearing postures

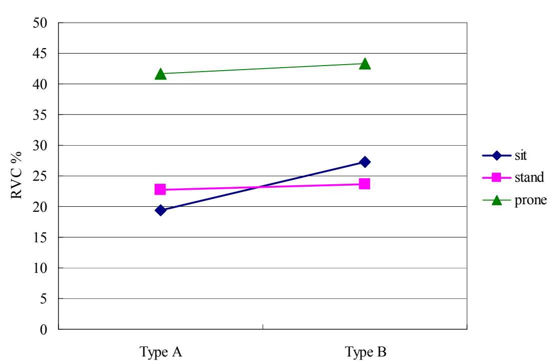

Fig. 4 Interaction between NVGs and postures on neck muscle

IV. Conclusions

Some human factors issues relevant to NVG design and use include: image field of view; field of regard; system resolution and aided visual acuity; image peculiarities resulting from the optics and the image intensification process; increased operator workload; and the integration of the NVG mounting system. Present study focused on workload increased with NVG mount and wearing postures. Although new technologies have been added to the head-mounted with the aim of improving task performance in areas of military and aviation, researchers have been found to considerably reduce the risk of injuries to the head and neck. Previous study aimed to quantify musculoskeletal stress as weight was added to the front of the head in different head positions and determine the effectiveness of a counterbalance in reducing stress. Changes in head position from neutral resulted in significant increases of EMG amplitude in the neck extensors of up to 18% and due to head load by 46% with a frontal load of 2 kg [2]. Sternocleidomastoid EMG showed little change due to increases in load but increased significantly by up to 265% of the neutral position when the head was rotated [5-7]. Thuresson et al. [5] reported that higher muscle activity occurred during the ipsilateral rotated positions plus neck flexion and trunk inclination. Results of present study also revealed that postures effect was the most contributors in neck muscle. During air combat sorties, the measured mean muscle strain is 5-20% of maximal voluntary contraction level (MVC), and it is the highest in the cervical flexors [10]. Present study also revealed that the EMG of trapezius muscles is about 25% of maximal voluntary contraction level (MVC) while wearing the NVG.

Helmet/mount/NVG integration: The fit of the helmet ultimately has an effect on correct NVG image placement, stability during operations, and comfort during extended NVG use. Counterweights, integrated nape/chin straps, flexible tubing, and tightly fitting oxygen masks have all been used to help stabilize the NVG and provide a comfortable system during operations. However, some of these will not be available (e.g., oxygen mask) or should not be considered for use (e.g., flexible tubing strapped to the helmet and affixed to the overhead). A counterweight system will help offset the forward center of gravity effects of having the NVG attached to the front of the helmet, but at the cost of added weight. A helmet designed with an integrated nape/chin strap will provide added helmet stability, especially given the lack of excessive Gs expected in the expected civilian operating profile. However, the most critical consideration in stability and comfort is helmet fit. The helmet must be fitted to the individual operator. Once that is accomplished, a properly designed mount can be effectively located in order to ensure the NVG image can be correctly positioned. If a helmet is not used, these critical stability and positioning issues should be taken into consideration in the design of a head mount system.

Head-worn equipment increases the mechanical load on the neck and alters the center of mass forward and upward in relation to the motion axis in the neck and cervical spine [8]. Any equipment applied anywhere on the helmet except at the normal center of mass of the head may cause additional stress on the neck muscles [9]. Sovelius et al. [11] also reported that helmet weight alone had a large effect on muscular workload. The additional frontal weight of the NVG caused a further increase in the activity of cervical muscles that were already subjected to high strain. Thus, suggestions of present study provided that soldiers should be avoided wearing NVG in prone posture. The weight arrangement of NVG could be evaluated in further research.

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