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An Ergonomic Study of a Conventional Ballistic Helmet

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Abstract

Ballistic helmet is a standard infantry equipment that provides ballistic protection from fragmenting to the head, temples, ear and neck of the wearer. This paper presents the study of the design of a locally used ballistic helmet, i.e. Personnel Armor System for Ground Troop (PASGT) type helmet, from ergonomic perspectives and the identification of potential risk areas of injury based on the current ballistic helmet design. Two quantitative assessment techniques are employed in the investigation. First, a set of questionnaires were distributed to the current users of the PASGT helmet. The result showed that the 54.8% of respondents experienced pain on the parietal (top) area of their head, which is a potential risk area of head injury. Second, an experiment with 10-mm thick sponge layer added to the interior part of the helmet was conducted to test its effect on the contact pressure between the head of the wearer and the medium size PASGT helmet while jogging on a treadmill at 8 km/h for 180 seconds. Mean of peak contact pressure with and without wearing the sponge of 2.5 kPa and 2.6 kPa, respectively, are obtained from the practical test. The maximum of peak contact pressure is found to be 3.6 kPa with the sponge and 4.2 kPa without the sponge. The results obtained in this study indicate that there are areas of discomfort interior to the PASGT helmet in contact with the wearer and that the discomfort can be minimized by appending a sponge layer to the frontal of the helmet.

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1. Introduction

Ballistic military helmets are intended to protect the head of the wearer whilst providing ‘sufficient amount’ of comfort. Head and neck represent just 12% of the body area that is typically exposed in a battle field. However, they receive up to 25% of all hits and almost half of all combat deaths are caused by head injuries [1]. Among others, the reason might arise from the fact that the helmet is not being worn as often as it should be by the troops. This paper presents two quantitative methods to measure the level of comfort as experienced by wearers of a locally used ballistic helmet, i.e. Personnel Armor System for Ground Troop (PASGT) type helmet, from ergonomic perspectives and the identification of potential risk areas of injury based on the current ballistic helmet design.

2. Background

Ballistic helmet materials and designs have been improved from time to time mainly to counter prevailing threats and the invention of new or improved ballistic materials. Figure 1 shows the evolution of different helmet designs and materials used by the United States Army (U.S. Army) since World War I. Weight, comfort, and protection level influenced the eventual redesign of the fragmentation helmet to become the famous M1 helmet of WW II. The steel outer shell used a molded inner shell to attach the suspension made of cotton webbing and leather. The composite inner liner placed into the

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ballistic steel shell. The inner liner, introduced in 1941, was made of cotton fabric-reinforced phenolic laminate. An improved ballistic version of the liner, fielded in 1961, used nylon fabric to replace the cotton. The one-size M1 helmet weighed 1.55 kg, had 0.12 square meter of surface coverage, and protected against the 0.45 caliber round at 244 m/s with a 50% ballistic limit of 396 m/s against the standard North Atlantic Treaty Organization 1.1 gram fragment simulator [3].

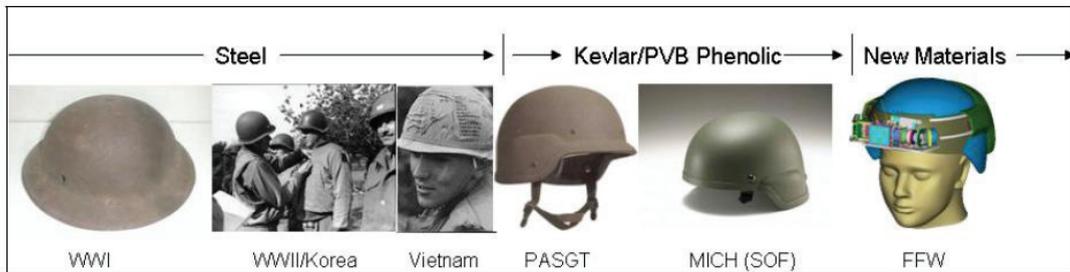


Fig. 1. Historical perspective of U.S. Army helmet design and materials (after [2]).

With the invention of Kevlar¹ in 1965, it became immediately obvious that what could be done with nylon would be done better with this high strength polymer. With considerable development effort, the steel pot which is the M1 helmet was gradually eliminated from the U.S. inventory in the late 1970s and replaced with the improved Kevlar design called the Personal Armor System for Ground Troops (PASGT) in 1976 [4]. The PASGT helmet that is made of Kevlar 29 and weight between 1.4 kg for extra small and 1.9 kg for extra large [5]. This development is next being implemented by Malaysian Army locally. Currently there are only three sizes available fabricated by Rohas Composite Sdn. Bhd., which are small (S), medium (M) and large (L) that have weight of 1.1 kg [6]. This type of PASGT helmet is classified as a conventional ballistic helmet. Throughout the development, improvements in protection level which is 50% ballistic limit now at 610 m/s, area of coverage with 0.14 square meter and better fit with 1st to 99th percentile of the U.S. military population were achieved while the same weight was maintained as for the M1 [2]. The retention-suspension system, fixed on the shell, was made of nylon webbing in the form of basket to provide a stable helmet-head interface. The standoff distance between the head and the helmet was 12.3 mm, thus it allowed for ventilation and heat transfer as well as transient deformation due to ballistic impact [1]. Figure 2 shows the PASGT helmet in different side of view.



Fig. 2. The main design features of a PASGT helmet.

Although the PASGT helmet has found much praise from the troop which has saved many lives, the material of PASGT from laminated material is not ideal structurally, however. There are still lacks of design and human factor exist in PASGT helmet including balance, maintainability, weight distribution and size [7-10].

3. Methodology

Two quantitative assessment techniques are employed in the investigation. First, a set of questionnaires were distributed to the current users of the PASGT helmet. As this study is selected on an ergonomic field, a questionnaire survey is a common method performed by other researchers in order to get an apparent view regarding what the respondent want and

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