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Development of High Performance Firefighting Gloves Prototype applied to Ergonomic Design

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Introduction In the complexity of a modern industrialized society, firefighters are exposed to great risks like burning or collapsing buildings and even industrial chemical accidents. High performance protection combined with comfort has become one of the greatest technical challenges (Boorady, et al. 2013, Coca, et al. 2010). A firefighter's personal protective equipment (PPE) has been regulated according to performance and design requirements that are standardized to protect body parts from potential dangerous elements in various situations. Though some ergonomic requirements exist in a few EN qualification standards, PPE regulation for design require a consideration of firefighters' views on ergonomic design properties of their PPE. Last year, the National Research Foundation of Korea conducted a research project on firefighters' protective PPE. Part of this project aims to design structural firefighting gloves that meet the demands of firefighters' comfort satisfaction. The aim of this paper is to clarify firefighters' design needs for their firefighting gloves and to determine ergonomic design elements which could provide the best compromise between protection and comfort.

Methods The study manages a living lab, which is a research concept of a user-centred, innovative co-operating system, often conducting wear trials and in-depth interviews with advisory group. The study selects 18 types of popular firefighting gloves from six nations (USA, England, Japan, Australia, South Korea, and Germany) which met stringent industry specifications. In order to examine differences between firefighting gloves in more detail, wearer trials were conducted with 12 firefighters drawn from South Korean based fire stations. A standardized set of hand activities (e.g. turning the thumb, gripping and releasing, pivoting wrist back and forth and side to side) were undertaken to examine the wearability of gloves. Also, In depth interviews following these activities were conducted to identify any discomfort, restriction of movement, or other problems they may have experienced with the firefighting gloves. Through analyzing firefighters' design needs for their gloves, ergonomic designing specifications were extracted. Finally, firefighting gloves prototypes was developed by partnership with high performance fabric manufacture company and glove production company in South Korea.

Finding & Discussion In general, fit issues were identified as a major concern regarding firefighting gloves, resulting in limited dexterity that negatively affected firefighters' work efficiency and safety. Firefighters indicated that most of gloves used in the trials the form of finger are too fat and too much protective materials which made gloves thick and stiff. Whereas,

Japanese and Australian gloves were reported better-fitting due to light weight and technical fit by most firefighters. Ergonomic design issues while wearing gloves were identified through firefighters' responses about their limited dexterity, the weightiness of the gloves, the lack of grip, and the greater negative impact on wearability when wet. Weight lightening and improvement in hand grip are required for fire suppression duty while holding a fire hose; When designing the gloves of first type we focused on the improvement of main problems in current firefighter gloves. The gloves of first type have Silicon coated Para-aramid palm panels with anatomic cutouts which offer superior grip and flexibility and makes them easy to don and doff. Also, the gloves of first type have multi-layered structure which makes them lightweight and comfortable. The gloves sufficiently meets all the protection and performance requirements of KFI, Korean Fire Institute. Whereas, protective design elements were required for fire rescue duty to absorb heat and impact. The design prototype 2 is to develop a new fire rescue glove, which provides greater dexterity and flexibility compared to the commercially available gloves. 3 dimensional glove patterns are to follow the natural curve of human hand to provide greater dexterity, fingertip, grip and overall comfort. Additionally the wrinkles in each finger joint are to expect to provide activity enhancement. This design prototype 2 has added protection with the carbon fiber knuckle and thumb, which needs the high impact protection. The combination of cut resistant, high heat resistant and chemical resistant layers provides firefighter's hand with the protection they need in any heavy industrial environments.

Conclusions and Further Research This study identified ergonomic design concepts and development of prototype, related to firefighting gloves. The major issues that firefighters' response indicated are technical fit, proper use of materials, and consideration in a specific firefighting task. Recommendations are made to enhance ergonomic design solutions for firefighting gloves. In particular, appropriate 3D curve patterns would be advantageous, particularly where gloves have some problems obtaining correct finger sizes. The provision of design solutions such as cutting out thick patterns from finger joints may also help enhance dexterity. As the present study was limited to firefighting gloves, further studies on large scale assessments for firefighters' PPE are needed.

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