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Skin deformation behavior during hand movements and their impact on functional sports glove design

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Abstract

In this study a three-dimensional (3D) INFOOT scanner was used to scan the hand in different postures and Geomagic Studio 12 was used to measure and analyzes the skin deformation behavior (skin relaxed-strain ratio) during various sport activities. Thirteen female participants between the ages of 40-65 years with hand size medium (M) performed a relaxed hand posture and two dynamic postures which were relevant to key sport activities. There were significant differences in the skin relaxed-strain ratio between the experimental postures, especially in phalangeal and metacarpal regions with exception in (third finger-metacarpal region). The results of this study suggest that the metacarpal region had significantly larger skin relaxed-strain ratio than the phalangeal region and metacarpal-carpal region. This study has contributed to enhancing the knowledge of the skin deformation behavior during various sports activities which could be incorporated into sports and functional glove pattern design and engineering for improving the fit, comfort, and functionality of a sport glove.

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Keywords: Skin deformation; strain distribution; functional gloves; sports

1. Introduction

Functional sporting gloves are commonly used and required in numerous sports such as hockey, baseball, lacrosse golf and cycling. The role of sports gloves is primarily functional, such as providing wearers with protection from impact and abrasion, or enhancing performance by allowing greater grip or dexterity. In spite of their protective and enhancing purpose, the gloves should not restrict the wearer's hand function such as grip and

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dexterity. Design factors such as the fit of a glove should enable dynamic freedom of movement while avoiding undesired pressure that could impede the grip strength; range of motion; performance of task; and physiological comfort of users [1].

The effects of gloves on hand performance have been investigated by number of researchers and many suggest that poorly designed or fitted gloves are likely to reduce hand dexterity, tactile sensitivity, hand strength and increase hand fatigue [2, 3]. The performance of the gloved hands is substantially affected by the properties of the glove's material and most importantly by the fit of the gloves [4]. Gompers [5], stated that a functional glove that does not fit or is uncomfortable to wear is a glove that would not be used, no matter how technically superior it may be. An accurate and efficient measurement of hand dimensions is crucial for the optimization of the effectiveness and practical use of the gloves.

Previous researchers have focused on hand anthropometry data for development of an improved glove sizing system and on designing a better glove pattern. Robinette and Annis [6], investigated the size variability of Air Force men and women and developed a nine-size system for chemical protective gloves which included a combination of three hand lengths and four hand circumference measurements. In 1988, a US Army hand anthropometric survey report [7] provided comprehensive statistical information of 86 hand dimensions from 2307 samples. However, for development and engineering of a functional sports glove, it is insufficient to only measure the hand dimensions in a static relaxed posture since the significant changes in the hand shape, size and skin surface are present during hand movements. Therefore, databases for hand anthropometry in static relaxed posture cannot be easily used since the glove could restrains hand movements and discomfort may arise due to undesired pressure on the hand.

William [8], revealed that up to an additional of 16% of the total length of material at the back of the hand is required to accommodate the change in skin strain when a fist is made. For example, on a size 9 hand, an increase of 31 mm from an original length of 191 mm can be observed during relaxed hand posture and a power grip posture. To date, only a small number of researches in ergonomic hand tool design and military handwear design have considered the anatomical shape of the hand during different hand movements in the design process [1, 8, 9]. A study specifically focusing on functional sports glove design does not currently exist.

The present study explored the skin relaxed-strain ratio at the back of the hand (dorsal side) as a preliminary investigation for determining the quantitative values of the skin deformation behavior during various sports activities. Data and results obtained from the study will provide valuable preliminary information to be incorporated into sports and functional glove pattern design and engineering for improving the fit, comfort, performance and functionality of a sport glove.

2. Experimental and methodology

2.1. Subjects

A total of thirteen healthy female subjects between the ages of 40-65 years with hand size M were recruited to participate in this study. The subjects chosen had no major injury or trauma to their right hand. The study was approved by RMIT University Human Research Ethics committee. The ranges of hand length and hand circumference of the right hand of the subjects were:

- Hand length: 190 mm – 220 mm
- Hand circumference: 200 mm – 225 mm

These two key dimensions (hand length and hand circumference) were selected based on the literature and industry practice of a glove design sizing system which uses one or two of these key dimensions to define their size categories. The key dimensions selected for this study were consistent with literature [10] which was size M.

Before the hand measurement process, each subject was informed of the whole test procedure, action they should take during the process and the pose for taking measurement. Each subject was also informed about the purpose of the study and the method of maintaining confidentiality.