Journal of Fiber Bioengineering and Informatics 6:4 (2013) 441–451
doi:10.3993/jfbi12201308

A Study on Biomechanical Models of Sports Bra's Shoulder Straps

Jie Zhou [a,*], Winnie Yu [b]

[a] *Apparel and Art Design College, Xi'an Polytechnic University, People's Republic of China*

[b] *Institute of Textiles and Clothing, The Hong Kong Polytechnic University, Hong Kong SAR People's Republic of China*

Abstract

Excessive breast movement causes breast discomfort, pain and sagging. Previous research has shown that sports bras can support the breasts and reduce breast movement during different activities especially running. However, so far, no published research has studied the design of shoulder straps from a biomechanical modeling perspective, for improving the performance of sports bras. In this study, biomechanical models of shoulder straps with different widths and in different positions on the shoulder have been built, based on the assumptions that the behavior of shoulder straps is similar to that of springs and the front shoulder strap is aligned with the body. The results show that wider shoulder straps are more effective in reducing the breast forces, and the location of the shoulder straps on the shoulder affects their performance in controlling breast movement. This provides a theoretical basis for optimizing the design of shoulder straps to produce more effective sports bras.

Keywords: Shoulder Strap; Sports Bra; Biomechanical Model

1 Introduction

The female breast contains limited anatomical support due to a lack of muscles and bones. Excessive movement during activities produces large forces on the breasts and results in stretching of the Cooper's ligaments, discomfort, pain, and/or sagging. Excessive movement causes the breasts to lose their natural perkiness, fullness and cleavage after a certain period of time, and affects health and breast aesthetics.

To decrease excessive breast movements and associated breast discomfort, pain and/or sagging, sports bra designers have solved the issues by using stiff fabric materials around the breasts and tight shoulder straps with different designs to minimize breast movement and forces on the breasts.

Previous experimental studies [1-18] have focused on evaluating breast movement under different wearing conditions and compared the effectiveness of sports bras, manufactured in different

*Corresponding author.
Email address: xianzj99@163.com (Jie Zhou).

styles and material properties, in controlling breast movement. These studies have verified that sports bras are more effective in limiting breast motion and reducing breast pain, compared to normal bras [1, 2, 6, 12, 19]. Further more, the previous model studies have focused on predicting the interactions between the body and the bra [20] and the internal forces acting on a breast in static and different postures [21]. In the medical field, model studies have been used to predict breast deformations in static conditions. Applications include breast plastic surgery [22], clinical biopsy [23], modelling of breast compression, similar to X-ray mammography [24], registering X-ray and MRI mammography, validation of non-rigid registration algorithms [25], and to test reconstruction algorithms for elastography [26]. However, no studies have been done to investigate the effects of shoulder strap properties and analyse the biomechanical properties of shoulder straps in controlling breast movement.

In this study, biomechanical models of sports bras' shoulder straps will be developed and used to analyze the function of the shoulder strap with different widths and in different positions in order to optimise their design and improve the performance of sports bras.

2 Designs of Shoulder Straps

The shoulder straps of bras are essential to support the breast mass and hold the breast in place with limited breast movement. Most shoulder straps of sports bras are wider than those used for normal wear, so as to distribute the breast mass across a greater area in the back panel and reduce pressure on the shoulders. Current sports bras tend to use padded straps to dissipate the energy produced by the breast mass and velocity during movement.

There are five main back designs of sports bras: cross-over, racer back, vertical centre [27], straight back and U-back (Fig. 1). The styles of cross-over, racer back and vertical centre design can prevent the straps from slipping off the shoulders during activities [27]. The sports bras with straight back or U-back are anticipated to be more effective than the other three types of back designs in reducing vertical breast movements because the force direction acting on these shoulder straps is more aligned with the direction of breast gravity.

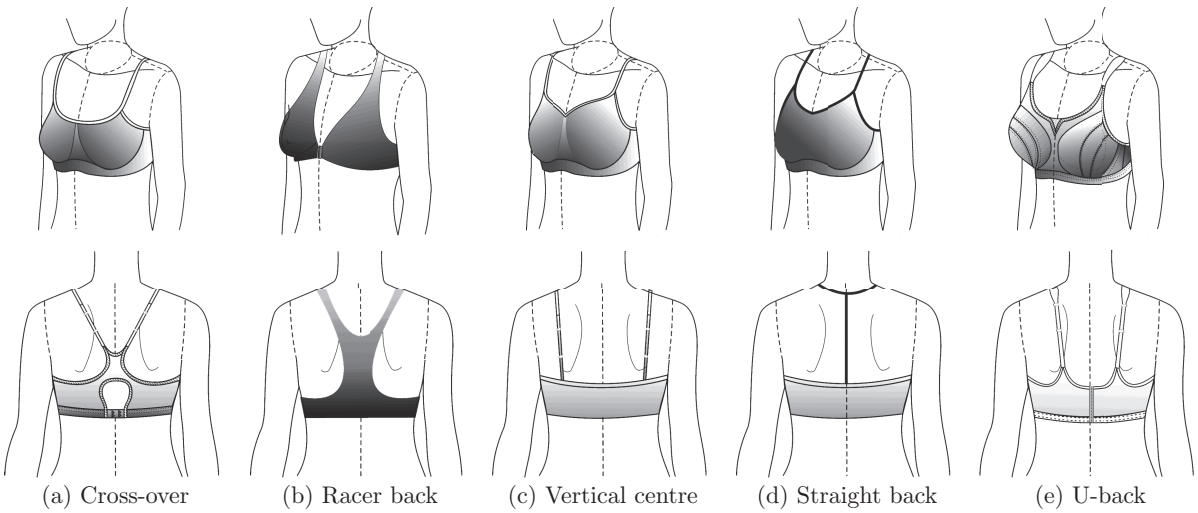

Fig. 1: Sports bras with five back designs