

Evaluation of Shock Absorbing Performance of Sports Bras

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Abstract: A scientific understanding on the reduction of breast displacements during activities will be necessary for the future development of optimal sports bras in order to prevent breast injury. This study aims to evaluate the shock absorbing performance of different sports bras, and to analyze the factors involved. Three healthy women were invited to participate in the experiments. They wore four types of sports bras of two different support levels and performed three different activities. Breast movements were recorded by a 6-camera Vicon motion capturing system. The breast displacement and the reduced percentage of controlled breast displacement (RBD) are proposed as the main parameters for evaluating the shock absorbing performance of sports bras. The naked breast displacement ranged from 1.01 to 4.37 cm. The breast displacement was the largest during stepping at the nipple. However, the RBD was larger at outer breast when wearing sports bras. The magnitude of shock absorption did not agree with the support levels claimed by the manufacturers. The encapsulation bras were more effective than compression bras in controlling breast displacement. The encapsulation bra EP-2 was the most effective shock absorber due to its higher content of polyamide, wider shoulder strap and higher neckline.

Keywords: Sports bra, shock absorption, displacement, breast.

1. Introduction

Breast pain is common among women and varies markedly in severity and clinical significance [1]. The reported prevalence of breast pain ranges from 41% to 79% [2-6]. A considerable percentage of the women worldwide have suffered from breast pain during activities. In 1998, the American Council on Exercise (ACE) reported that a majority of women experienced breast discomfort while exercising [7]. Lorentz and Lawson found that 56% of 59 female volunteers experienced sports-related breast pain or discomfort [8]. Correlative report by Haycock in 1977 also concluded that 72% of the respondents indicated breast sore or tender after exercise [9]. In Shangold's study, 52% reported specific minor breast injuries [10]. Therefore, the prevention of breast pain and maintenance of breast health during women's daily life and exercise has become an important and urgent research topic.

Clinical experiments have shown that sports bras could provide good external support and relieve breast pain [11] as the bra absorbed the vibration energy and helped to reduce breast displacement and discomfort.

Although sports bras have been invented for more than 30 years, the factors influencing the bra performance in shock absorption still remains unclear.

Therefore, this paper aims to propose a new and unique performance indicator for evaluating the shock absorbing performance of various sports bras, to compare the effectiveness of different shock absorbing bras and to validate the manufacturers' claimed levels of bra support.

2. Methodology

2.1 Subjects

All recruited subjects were healthy, active, premenopausal adult females of breast sizes 34B, 34C or 36B. They were not breast feeding nor pregnant during the testing period. Those with a history of previous breast surgery, musculoskeletal disorder or pain were also excluded. The exclusive criteria were set to avoid the confounding factors such as variety of sex hormones and physical disability.

In this study, three healthy female volunteers with ages of 29 ± 5 years, height 159.67 ± 2.82 cm, weight 52.56 ± 4.98 kg, body mass index 20.46 ± 1.89 kg/m² were recruited to participate. Ethical approval was obtained from The Hong Kong Polytechnic University Human Ethics Committee prior to commencing the wear trial. Each participant was fully informed of all procedures and protocols prior to giving their written consents.









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JFBI Vol. 2 No. 2 2009 doi:10.3993/jfbi09200906

2.2 Garment samples

Four sports bra styles (two compression type bras and two encapsulation type bras) of support levels 2

and 3 were sponsored by a major bra brand in France and tested in this study. The diagrams, fibre contents and design features are shown in Table 1.

Table 1 Sports bra samples

Bra code and type	Front view	Back view	Claimed Support level	Fiber content (%)				Design features
				Polyamide	Polyester	Elastane	Cotton	
CP-2 Compression sports bra			2	55	16	29	2-layer princess line top vest, racer back, adjustable hooks & eyes at the back	
EP-2 Encapsulation sports bra			2	67	28	10	5	2-layer princess line top vest, racer back, adjustable hooks & eyes at both sides with removable pad in the inner cup
CP-3 Compression sports bra			3	42	53	5	2-layer princess line top vest, racer back, adjustable hooks & eyes at both sides	
EP-3 Encapsulation sports bra			3	56	27	15	2	Moulded cups, titanium memory underwire, adjustable hooks & eyes at both sides

2.3 Activities

The experiments were carried out in the Human Locomotion Lab in the Hong Kong Polytechnic University with controlled temperature of $23 \pm 0.5^{\circ}\text{C}$ and $65 \pm 3\%$ relative humidity.

The subjects were instructed to perform walking and running on a treadmill under two experimental conditions - bare breasted and wearing sports bra. Unlike other research, this work also studied the stepping motion on a 24 cm high platform.

The stride rate of exercise can influence breast motion [9]. Therefore, each subject first tried to walk, run and step at her own velocity deemed replicable.

During this pilot test, the stride rate was timed and the norm was set as the standard velocity to be controlled. A metronome was then set to ensure that the subjects walk, run and step for two minutes at the same stride rate in each experiment. The subjects were allowed to rest for five minutes between subsequent experiments.

2.4 Motion Analysis

The 3D body kinematics was recorded using a six-camera Vicon motion capturing system (Model: Pulnix 6701AN, Oxford Metrics, UK). The motion signals in terms of 3D coordinates of specified breast positions were recorded with 60 Hz sampling frequency. Both