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Three-dimensional Movements of Pert and Ptotic Breasts

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Abstract

This paper applies a new Breast Coordinate System to measure three-dimensional breast movements, relative to the thorax by eliminating the effects of body rotation, translation, bending and tilting during activities. Two-dimensional and three-dimensional breast movement trajectories of pert breasts and ptotic breasts are presented and compared from four different perspectives in both the global and local coordinate systems. The scatter plot of breast displacements against time in x, y and z coordinates were fitted by polynomial functions. The movement amplitude of the ptotic breast is larger than that of the pert breast in all directions. In a vertical direction, the ptotic breast velocity is greater than that of the pert breast one.

Keywords: Breast Motion; Movement Trajectories; Local Coordinate System

1 Introduction

The breast has no bone and muscle for internal support and attaches on the pectoralis major, which is situated at the anterior thorax of the body. During activities relative movements occur between the breast and the thorax which cause the breasts to bounce repeatedly, leading to breast discomfort, pain, and/or breast sagging. Sports bras are designed to support breasts, reduce movement and enhance comfort. To improve the design of sports bras, it is necessary to scientifically measure and analyze the relative breast movements. To study the relative movements of breasts; researchers must define a reference object and determine the number of reference point and their positions to describe the reference object.

Previous studies used, one [1-9], two [10], three [11-14] or four [15-16] positions to define a reference object for measuring breast relative movements [17]. Only one paper [11] presented the Breast Movement Trajectories (BMTs) and compared different stiffness of breasts. However, their selected reference positions [11] belong to different segments of the body and these positions had relative movements during activities, so these positions cannot describe a rigid object and build reliable and stable reference systems [17]. It is, therefore, very difficult to accurately measure breast movements relative to a stable reference system.

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Breast movements can be described by Breast Movement Trajectory (BMT), displacement, velocity or acceleration. Several studies have shown BMTs in walking [4, 18] and running [2, 4, 11, 12, 18, 19] with and/or without a bra. Okabe and Kurokwa [11] used BMTs to describe the breast movements of different stiffness breasts relative to the body when the subjects walked or ran. However, multi-trajectories overlapped with each other under an unstable reference system, so it was difficult to retrieve breast movement data from their studies [17].

Previous studies collected the data of breast displacements [2-9, 11-13, 15, 18, 20], velocities [2, 9] and accelerations [3] and have contributed to the study of breast movements, suggesting ways to improve the designs of sports bras. However, the studies did not have a stable reference system to evaluate breast movements [17], and only one previous study [11] collected the data of BMTs of different stiffness breasts.

In this study, the thorax is chosen as a reference object and a new Breast Coordinate System (BCS) is applied for measuring breast movements [14]. It was found that there was [9] finds no significant difference between the movements of the left and right breasts when subjects run on a treadmill, so in this study the left breast was chosen for measuring breast movements. The BMTs of two breast types with different properties are presented and discussed in a Global Coordinate System (GCS) and the BCS. The polynomial curves of breast displacement, velocity and acceleration during a single jogging stride are fitted by equations for three axis directions. This study will be useful for studying the breast dynamic behaviors and improving the sports bra design.

2 Methods

2.1 Participants

Two subjects with the same breast size but different breast properties participated in this study. They were healthy with no history of previous breast surgery, any musculoskeletal disorder or pain. Prior ethical approval was obtained from the Human Ethics Committee of The Hong Kong Polytechnic University. The two subjects were fully informed of all the procedures and protocols before signing their written consents. Their details are shown in Table 1.

Table 1: Physical characteristics of the two subjects

Subject	Race	Age (year)	Height (cm)	Weight (kg)	BMI (kg/m^2)	Breast fed	Breast size	Breast stiffness (N/m)	Breast shape
1	Chinese	25	158	56.7	22.7	No	36B	248	
2	Chinese	40	160	57.8	22.6	yes	36B	186	

The bare-breasted subjects were asked to jog slowly at 7 km/h on a treadmill for three repeats, with 30 seconds rest after each test.