

# A New Objective Approach of Evaluating Breast Motion for Sports Bra Design

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**Abstract:** Traditional studies on evaluation of breast motion and bra performance included human subjects and maintain result consistency is restricted by biomechanical limitations. This study therefore proposes an objective and reliable approach to maintain consistent testing conditions for evaluating body motion by using a manikin with breast prostheses made by the Ecoflex silicone rubber. A medium-sized robotic arm, offering long reach, high payload, and high acceleration with six degrees of freedom, is integrated with the Vicon motion capture system. This allows the robotic arm to simulate the precise 3D motion of human body in a continuous repeatable motion, mirroring the movements of human subjects during running. In this paper, we illustrate the design and fabrication process of the hardware, the mathematical modelling of human motion and the generation of robotic trajectories and discuss our design considerations and quantitative results. This setup enables an objective assessment and comparison of body and breast displacements under different bra conditions. The influence of material properties used in the bra along with design factors such as the back design, bra cup and shoulder straps on the control of breast movement can then be objectively quantified and compared.

**Keywords:** body and breast motion, bra evaluation, sports bra design, silicone fabrication, robotics, motion capture, six degree-of-freedom motion simulation.

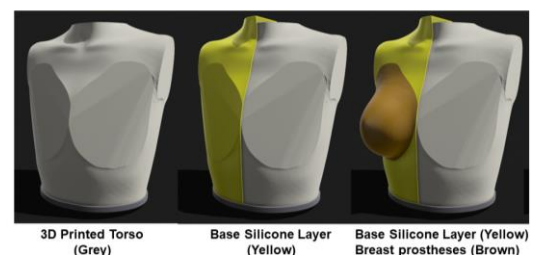


Figure 1 Illustration of manikin with breast prostheses

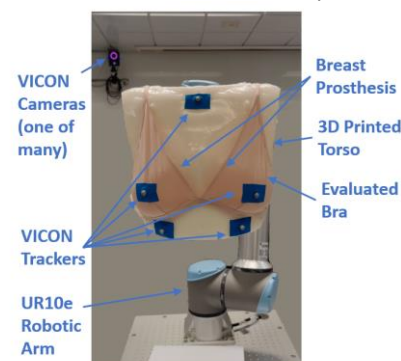


Figure 2 Robotic and motion tracking system for evaluating breast motion and bra performance

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