DEVELOPMENT OF A SPORTS BRA TESTER

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Introduction

Today's sports bras fall short of women's expectations for performance and comfort. Only a limited amount of research has been conducted on breast dynamics and the interaction between bras and the female body during high performance activities such as marathons. [1,2,3] To address this issue, an instrumented silicone model of a woman's torso is developed and mounted on a vertical actuation system to provide a platform for studying attenuation of breast movement by sports bras during activities such as running.

Objectives & Methodology

The objective of this research is to determine the extent to which the Knixwear Evolution bra attenuates vertical movement of the breast during running. To this end, a mechanical model of a female torso was developed to test the Knixwear Evolution sports bra, size 4 (designed for 36C / 38C / 34 D / 34 DD). A Femini Just Fit vest model ST4 silicone vest was mounted to a standard rigid commercial torso mannequin and Kollmorgen servo-driven Lintech linear stage. The Kollmorgen AKD-controlled AKM41E-ANCNC-00 motor, rated at 1.73 kW, drives the mannequin in an oscillatory pattern through the Lintech linear stage with a peak vertical amplitude of 70 mm at 1 Hz, similar to the vertical motion exhibited in the torso by runners. The Femini vest's foam breast inserts have been replaced with silicone breast forms to mimic the weight and compliance characteristics of breast tissue. The system is shown in Figures 1 and 2.

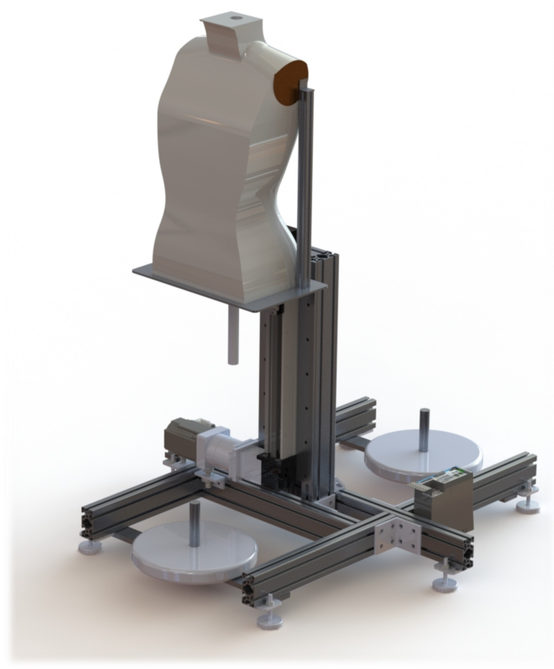

Figure 1: CAD Render of preliminary design

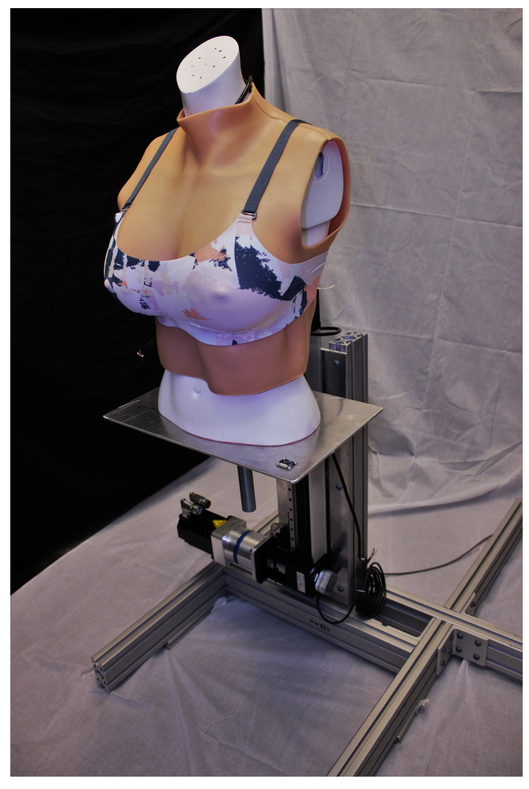

Figure 2: Manufactured design

Three Tinkerforge accelerometer modules (with ST LIS3DSH accelerometers) were mounted to the platform, one in each silicone breast and one on the rigid platform at the based of the mannequin. These accelerometers were set to +/-2 g and 50Hz filtering and transmitted data at 100Hz to a desktop PC via a Tinkerforge Master Brick. These accelerometers provided relative amplitudes of the two silicone breast forms and were compared the rigid (but moving) frame of reference. The data from the accelerometers was collected using the default Tinkerforge data acquisition software operating at a sampling frequency of 100Hz. The data was then post-processed in Excel with a 10-point moving average filter.

Two trials were conducted: one with no bra and one with a Knixwear Evolution bra, size 4. Data for four oscillations is shown in Fig. 3.

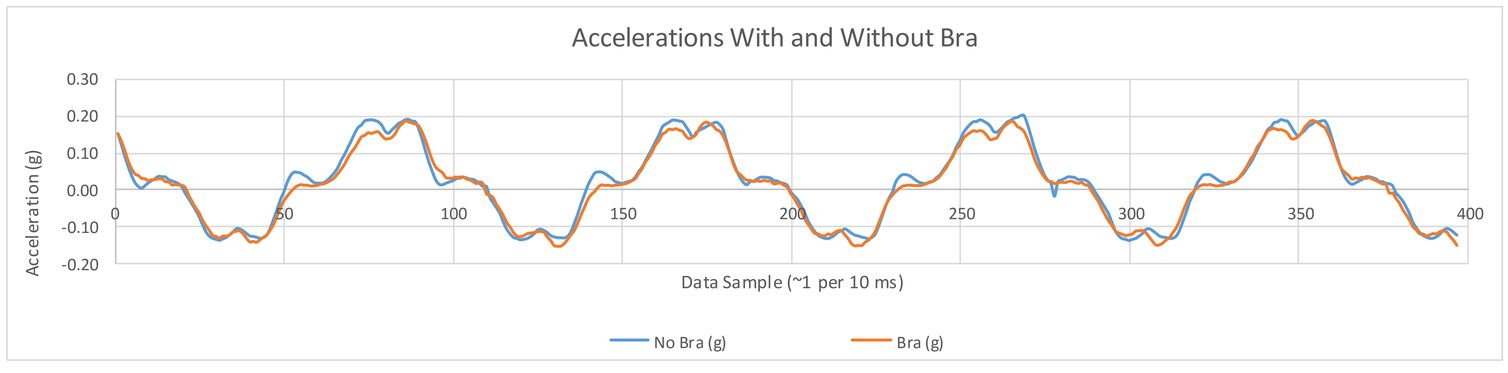

Figure 3: Plot showing superimposed acceleration magnitude curves of model fitted with and without the Knixwear Evolution bra.

Results & Discussion

The mannequin was driven with vertical, approximately sinusoidal trajectory at 1 Hz, with an amplitude of 70 mm, peak-to-peak. The accelerometer data graph compares the accelerations in the silicone breast of the mannequin, with and without the Knixwear Evolution bra. While the accelerations are similar in both cases, a double-humped pattern is seen during peak upwards movement and the with-bra results show approximately 14% attenuation in the first of the two humps. In contrast, we see a slight increase in peak accelerations in the with-bra results during the most negative accelerations.

This work demonstrates the feasibility of doing accelerometer-based sports-bra testing on an automated platform. Future work will examine attenuation characteristics at higher and lower frequencies, as well as other amplitudes and with other sports bra designs. Finally, validation of the results with human subjects will also be undertaken.

Conclusion

The initial results of this automated sports bra testing system have successfully shown the feasibility of automated testing of movement attenuation in a commercial sports bra. The Knixwear Evolution sports bra was shown to reduce acceleration in a simulated breast by approximately 14% during peak positive accelerations, with a torso movement of 70 mm at 1 Hz. Future work will examine testing at different frequencies and amplitudes, as well as with other bra designs.

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