# The Influence of Sports Bra Support, Running Speed, and Footwear on Breast Motion

**Ine Mylle**[1], Jessica Yeoman[1], Jack Williams[1], Christopher Napier[1]
[1]SFU Run Lab, Department of Biomedical Physiology and Kinesiology, Simon Fraser University, Vancouver, BC, Canada
Email: ine_mylle@sfu.ca

## Summary

Excessive breast movement during running can cause discomfort, making adequate sports bra support essential. We investigated the effects of sports bra support, running speed, and footwear on breast accelerations using inertial measurement units (IMUs) in nine female runners. Higher running speeds significantly increased breast accelerations, while high-support bras effectively reduced accelerations, and influenced mediolateral asymmetry. Footwear had no significant effect. These findings emphasize the importance of optimized sports bra support, especially at higher running speeds, while suggesting that footwear does not meaningfully impact breast movement.

## Introduction

Excessive breast movement due to inadequate support can lead to discomfort and reduced participation in sports. Sports bras help mitigate this motion, but their effectiveness varies with activity intensity (or at higher running speeds) [1]. While breast movements have been studied in laboratory settings, fewer studies have used wearable inertial measurement units (IMUs), which enable real-world breast dynamics during various physical activities. Additionally, the influence of advanced footwear technology (AFT) on breast movement remains unclear despite studies demonstrating higher impact forces in more cushioned shoes [2]. This study investigated how sports bra support, running speed, and footwear influence breast accelerations, movement variability, and symmetry using IMUs to improve sportswear design.

## Methods

We examined breast accelerations in nine well-trained female runners (30.56 ± 4.65 years; 168.22 ± 5.51 cm; 60.67 ± 5.14 kg; cup size range: B-DD) across two sports bras (low and high support), two shoe types (daily trainer and AFT), and two running speeds (2.7 m/s and 5.0 m/s). Participants completed eight 45-second treadmill running trials in a blocked randomized order (according to the sports bra) with IMUs just above each nipple, on the sternum, and on the sacrum. Running steps were segmented based on the zero-crossing of the vertical acceleration signal of the sacral IMU [3], with the middle 20 steps of each trial used to calculate breast accelerations. Sternal accelerations were subtracted to isolate breast motion and three-dimensional peak accelerations were calculated for each breast separately. Symmetry between the left and right breast was quantified using the normalized symmetry index [4] while movement variability was determined using the coefficient of variance. We tested the effects of bra support, speed, and footwear using a linear mixed model, with a significance level set at $p<0.05$.

## Results and Discussion

Peak breast accelerations were significantly higher at faster running speeds across all axes ($p<0.001$) and with lower support bras in the anteroposterior and vertical directions ($p<0.001$), consistent with previous research [5]. Lower support bras led to significantly greater mediolateral symmetry between the left and right breast ($p<0.001$). Footwear type had no effect on breast acceleration or symmetry, suggesting breast motion is primarily influenced by upper-body support, though lower-body mechanics may adjust to attenuate greater impact forces in AFT [6]. Additionally, no interaction effects between bra support, and/or speed, and/or footwear were found. These findings reinforce the critical role of sports bra support and running speed in breast motion dynamics, highlighting the necessity of optimized support for high-intensity activities.

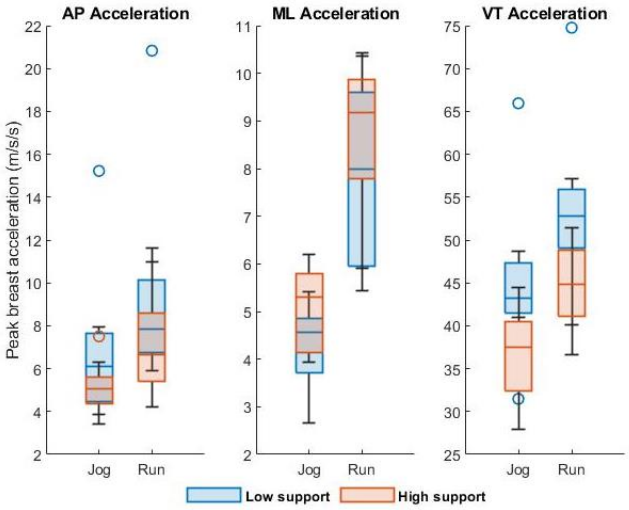


**Figure 1**: Peak breast acceleration for the anteroposterior (AP), mediolateral (ML) and vertical (VT) directions.

## Conclusions

This study highlights the critical role of sports bra support in reducing breast accelerations, particularly at higher running speeds, while finding no significant influence of footwear. Using IMUs, this research provides valuable insight into breast dynamics during real-world physical activities.

## Acknowledgments

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## References

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