Portuguese Journal of Sport Sciences
11 (Suppl. 2), 2011

VERTICAL BREAST EXTENSION DURING TREADMILL RUNNING

Joanna Scurr, Jennifer White, Alexandra Milligan, Debbie Risius and Wendy Hedger

University of Portsmouth, Portsmouth, UK

The aim was to quantify vertical movement of the breast beyond the anatomical position (breast extension) in various support conditions and to investigate the relationship of breast extension to breast pain, breast mass, and breast kinematics during running. The breast and trunk motion of 23 females of varying breast mass was recorded in a static no bra condition and during running in different support conditions. Static breast position was subtracted from dynamic position to calculate extension. In no bra, everyday and sports bra, the breast extended 21 mm, 9 mm, and 4 mm beyond the anatomical position. Breast extension displayed a strong relationship to breast pain and provides information on the mechanical loading of the breast beyond that of gravity. Therefore it is suggested that this measure could be considered alongside other breast kinematic variables.

KEYWORDS: Pain, gait, bras.

INTRODUCTION: During physical activity a number of negative consequences have been associated with a lack of appropriate breast support. Firstly, exercise-related breast pain has been reported in up to 72% of exercising females (Gehlsen & Albohm, 1980). Mason et al. (1999) hypothesised that this exercise-related breast pain arises from tension on both the skin and fascia of the breast during breast motion. However, the aetiology of this type of breast pain has yet to be established. Secondly, it is hypothesised that stretching of the supporting structures of the breast could occur with repeated loading during physical activity, leading to breast sag (Page & Steele, 1999). These negative consequences may discourage females from taking part in physical activity (McGhee et al., 2007).

Despite the significance of loading on the structures of the breast during activity, extension of the soft tissue of the breast has yet to be investigated thoroughly. It is not known whether tension on the skin and fascia causes the breast to extend beyond the anatomical reference position (when gravity loaded) and the relationship of this variable to exercise-related breast pain may broaden our understanding of the mechanical demands on the breast.

To quantify breast motion and understand exercise-related breast pain, previous research has linked improvements in breast comfort with reductions in vertical breast displacement (Mason et al., 1999) and vertical breast velocity (Scurr et al., 2010), while vertical breast acceleration has shown a limited relationship to breast comfort (Mason et al., 1999). Investigating the relationship between these previously reported variables and breast extension may help determine the importance of this biomechanical variable.

To determine whether stretching occurs on the soft tissue of the breast during treadmill running, this study aims to quantify the vertical movement of the breast beyond the anatomical reference position (breast extension) and to determine the effect of breast support at reducing breast extension. To understand the importance of this measure, this study also aims to investigate the relationship between breast extension and exercise-related breast pain and also the relationship to breast mass and other previously reported variables (displacement, velocity and acceleration). It is hypothesised that increases in breast support will reduce breast extension during running and that breast extension will demonstrate high correlations with exercise-related breast pain and breast mass.

METHODS: Following ethical approval, 23 active female volunteers (mean age 25.2, SD 4.6 years) who had experienced no breast surgery and had not gone through pregnancy within the last year, were selected to take part. Participants' breast size was determined by a trained bra fitter (range: 32A to 34G). Participant's breast mass (g) was estimated using the breast tissue resection weights presented by Turner and Dujon (2005).

Retroreflective markers (5 mm) were attached to the suprasternal notch, right nipple, and the left and right anterioinferior aspect of the 10th rib (Scurr et al., 2010). In the bra conditions nipple markers were repositioned on the bra, over the nipple (Scurr et al., 2010). Marker coordinates were tracked during a 2 s static recording (with the participant in the anatomical reference position) and during the last five gait cycles of a 2 minute run at 10 km/h (Oqus infrared cameras; Qualisys, Sweden; 200 Hz). Run trials were undertaken in three random order breast support conditions; 1. no bra, 2. everyday bra (Marks and Spencer™, T-Shirt bra), 3. sports bra (Shock Absorber™, B4490). Following the run participants rated their breast comfort (0 = comfortable, 5 = uncomfortable and 10 = painful; Mason et al., 1999).
Markers were identified and 3D data reconstructed (QTM, Qualisys, Sweden) throughout the static and dynamic trials. Trunk markers were used to establish relative breast kinematics, independent to the six degrees-of-freedom movement of the trunk. The suprasternal notch was the origin of the local coordinate system from which nipple translation was calculated. Vertical relative coordinates of the nipple (mm) were filtered using a 10 Hz low-pass Butterworth filter. To calculate breast extension, the vertical coordinate of the nipple during the static no bra trial was subtracted from the vertical coordinates in each dynamic trial. A negative value for nipple extension indicated movement beyond the no bra static anatomical reference position. Additionally, positional coordinates (mm) were used to calculate relative vertical nipple displacement, velocity and acceleration by subtracting minima values from maxima values during each gait cycle of the run trials.
All data were checked for normality using the Kolmogorov-Smirnov and Shapiro-Wilk tests. Non-parametric comparisons of breast extension and breast comfort across support conditions were investigated using a Friedman Test, followed by multiple post-hoc Wilcoxon Signed Ranks Tests. Spearmans rho correlation coefficients were calculated to determine the relationship between dependent variables (vertical breast extension, vertical breast displacement, velocity, acceleration, breast mass, and breast comfort), with r values of .10 to .29 defining a small relationship, .30 to .49 a moderate relationship and .50 to 1 a large relationship (Cohen, 1988).

RESULTS: Vertical breast extension peaked twice during each gait cycle, peak downward breast extension occurred at heel strike in each step (Figure 1). Results revealed that the nipple moved beyond its anatomical reference position during treadmill running in all breast support conditions. When averaged (SD) across all participants, the nipple extended -21 mm (-9 mm), -9 mm (-6 mm), and -4 mm (-5 mm) beyond its static no bra position during treadmill running in no bra, everyday bra and sports bra conditions, respectively. Statistical analysis identified significant reductions in breast extension as breast support increased ($p < .01$). Exercise-related breast pain also significantly reduced from 7 (2) running in no bra, to 5 (2) running in an everyday bra and to 1 (2) running in sports bra ($p < .01$).
Across all breast support conditions increases in breast extension were highly correlated with increases in breast pain (Figure 2: $r = .62$, $p < .01$). Breast mass demonstrated a low relationship to breast extension ($r = .17$, $p = .19$), when grouping the data into support conditions, breast mass demonstrated the strongest relationship to breast extension in the no bra condition (Figure 3: $r = .53$, $p = .01$). Interestingly across all breast support conditions, breast mass also displayed a low relationship with breast comfort ($r = .16$, $p = .22$).
As expected vertical breast displacement, velocity and acceleration reduced as breast support increased from no bra to everyday bra to sports bra (Table 1). Across all breast support conditions breast extension displayed significantly high correlations to breast kinematics, this was most noticeable in the no bra condition.

DISCUSSION: The aim of this study was to quantify the vertical movement of the breast beyond the anatomical reference position during running. The results of this study identified that breast extension occurred during running in all breast support conditions. Both of the bras tested were effective at significantly reducing breast extension by 57% in the everyday bra and 81% in the sports bra, when compared to running with no breast support, accepting hypothesis one. However, the soft tissue of the breast was still extended beyond the anatomical reference position during running, suggesting that additional tension is applied to the breast beyond that experienced by gravity. Page and Steele (1999) suggested that loading of the breast during physical activity could lead to a stretching of the supporting structures and ultimately breast sag. Whilst the longitudinal effects of breast extension are unknown, the results of this study have identified that acute breast extension occurred in the vertical downward direction during running.

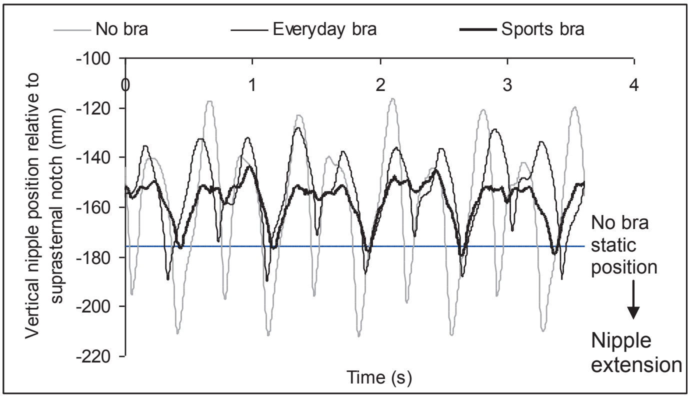

Figure 1: Example trace for vertical nipple position relative to the suprasternal notch in three breast support conditions during five running gait cycles at 10 km/h (n=1; 32D, 460 g).

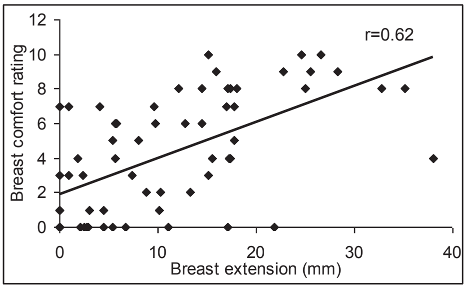

Figure 2: Correlation between breast comfort and breast extension in all breast support conditions during treadmill running at 10 km/h (n=23).

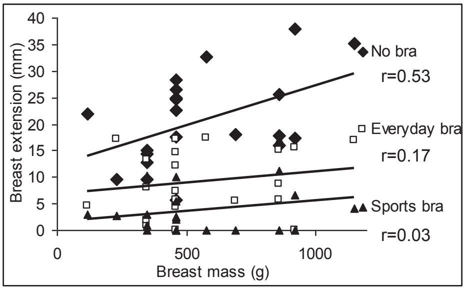

Figure 3: Correlation between breast mass and breast extension in each breast support condition during treadmill running at 10 km/h (n=23).

Table 1
Magnitude of vertical breast kinematics during treadmill running at 10 km/h in three breast support conditions and correlations to breast extension (n=23). * $p < 0.05$.

	Across all breast support conditions	No bra		Everyday bra		Sports bra	
	Correlation to breast extension	Magnitude	Correlation to breast extension	Magnitude	Correlation to breast extension	Magnitude	Correlation to breast extension
Vertical breast displacement (cm)	.66*	7.8	.68*	5.1	.46*	4.0	.18
Vertical breast velocity (m/s)	.69*	1.6	.71*	.9	.51*	.7	.15
Vertical breast acceleration (m/s^2)	.69*	47.8	.68*	28.6	.54*	22.0	.11

As exercise-related breast pain is a considerable negative consequence associated with inappropriate breast support, to determine the importance of breast extension, it is useful to consider the relationship of this variable to breast pain. The results found that as breast extension increased, exercise-related breast pain also increased, partially accepting the second hypothesis. However, the magnitude of the relationship between breast extension and breast pain (r = .62) was no greater than that between breast extension and breast displacement (r = .62) or acceleration (r = .63). It is interesting to note a relationship between vertical breast acceleration and breast pain as this contradicts previous literature (Mason et al., 1999). This contradiction may be related to the large range of breast sizes used in the current study. Vertical breast velocity demonstrated the strongest relationship to breast comfort (r = .65), which confirms previous research in the area (Scurr et al., 2010).
As expected, in the no bra condition increases in breast mass corresponded with increases in breast extension. Interestingly, the correlation between breast mass and extension reduced with an everyday bra and reduced further still in a sports bra. This suggests that the sports bra in particular eliminated the confounding influence of breast mass and all participants, regardless of breast mass, experienced similar levels of breast extension. This is an interesting result that partially rejects hypothesis two and warrants further investigation across groups with varying breast masses. Additionally, breast mass also displayed no relationship to breast comfort, suggesting that larger-breasted women did not experience greater exercise-related breast pain during running.

CONCLUSION: As breast extension displays a high relationship to exercise-related breast pain and it provides information on the mechanical loading of the breast beyond that of gravity, it is suggested that this measure could be considered alongside other breast kinematic variables. However, it appears that breast velocity could still be the key measure in understanding exercise-related breast pain.

REFERENCES:

Cohen, J. W. (1988). *Statistical Power Analysis for the Behavioral Sciences* (2nd Edition). NJ, USA: Lawrence Erlbaum Associates, Inc.

Gehlsen, G., Albohm, M. (1980). Evaluation of sports bras. *The Physician and Sports Medicine*, *8*, 89-96.

Mason, B., Page, K. A., Fallon, K. (1999). An analysis of movement and discomfort of the female breast during exercise and the effects of breast support in three case studies. *Australian Journal of Science and Medicine in Sport*, *2*, 134-144.

McGhee, D. E., Steele, J. R., Power, B. M. (2007). Does deep water running reduce exercise-induced breast discomfort? *British Journal of Sports Medicine*, *41*, 879-883.

Scurr, J. C., White, J. L., & Hedger, W. (2010). The effect of breast support on the kinematics of the breast during the running gait cycle. *Journal of Sports Sciences*, *28*(10), 1103-1109.

Turner, A. J., & Dujon, D. G. (2005). Predicting cup size after reduction mammaplasty. *British Journal of Plastic Surgery*, *58*, 290-298.