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AN INVESTIGATION INTO THE WITHIN AND BETWEEN PARTICIPANT VARIANCE IN THREE-DIMENSIONAL BREAST KINEMATIC DATA DURING A 5 KM RUN

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The purpose of this study was to examine the within and between participant coefficient of variance (%CV) in three-dimensional (3D) breast kinematic data during a 5 km run. Participants (n=9) performed a 5 km treadmill run in two levels of breast support (low and high) and an additional two minute treadmill run without breast support. A significant increase in within participant %CV for vertical breast displacement and velocity at the second kilometre of the 5 km run, was found when breast support was increased from a low to high level. Peak between participant %CV was found in the low level breast support and reported to be greater than 50% for 3D breast kinematics. This study is the first to report within and between participant variance in 3D breast kinematic data during prolonged running and will inform future research within this area.

KEYWORDS: Variance; Breast support

INTRODUCTION: A degree of variance is common in kinematic data and has previously been documented and accepted as either biological or systematic variance. It is important to quantify and report the magnitude of variance in data as it informs the reliability of a method of measurement and enables the meaning of differences observed to be determined (Atkinson & Nevill, 1998). Within participant variance in resultant breast displacement was presented in a recent study using the typical error measurement (TEM) presented as a coefficient of variance (%CV) (Scurr, et al., 2009). The within participant variance in resultant breast displacement for walking and running was 0.9% and 1.3%, respectively. Scurr, et al., (2010) investigated the between participant percentage coefficient of variance in resultant breast displacement during a two minute incremental treadmill test and found a peak between participant variance of 72%CV. These data provides an insight into the within and between participant variance in resultant breast displacement data over short duration walking and running. However, it would be beneficial to examine the within and between participant %CV in breast kinematics over a longer-duration run as it is currently unknown if the degree of variance in breast kinematic data changes over time. In addition, rather than examining resultant breast kinematics, analysis of its individual components will aid the interpretation of the variance observed. The aim of the current study is therefore to assess and quantify the within and between participant variance in 3D breast kinematics over a prolonged run. Firstly, it is hypothesised that the within participant %CV will increase as the level of breast support is decreased. Secondly, it is hypothesised that the within participant %CV will significantly increase from the start to the end distance intervals of the 5 km run within both breast supports.

METHODS: Following institutional ethics approval, nine female volunteers participated in this study. Participants were non-parous, had not experienced any surgical procedures to the breast, and were either a 34 B or 34 D bra size. Participants' had an average (± sd) age of 21 years (± 1 year), body mass 65.4 kg (± 6.8 kg), and height 1.70 m (± 0.10 m). Following a warm up, retro-reflective markers (5 mm) were positioned on the suprasternal notch, the left and right nipples, and the left and right anterioinferior aspect of the 10th ribs (Figure 1) (Scurr, et al*.,* 2009; 2010). During the bra conditions, participants repositioned the markers on the bra, directly over the nipple (Scurr, et al., 2010). Gait cycles were determined using a marker positioned on the right heel. Two 5 km treadmill run trials were performed in two levels of breast support in a random order: (1) high level combination sports bra and (2) low level everyday t-shirt bra.

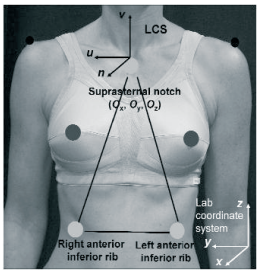

Figure 1: The anatomical landmarks for marker positioning and the axes of the global (GCS) and local coordinate system (LCS) (Scurr, et al., 2009; 2010).

Participants were asked to select a comfortable running speed that could be maintained for both 5 km runs. A bare-breasted treadmill run was also performed by each participant. Due to discomfort participants only ran without breast support for two minutes, performed at the same running speed as the 5 km run trials. Marker coordinate data were collected for five gait cycles at the end of each distance interval and used to calculate relative breast displacement, velocity, and acceleration (Scurr, et al., 2009; 2010). Within and between participant variance in 3D breast displacement, velocity and acceleration data was calculated using the following formula: %CV = standard deviation/mean*100 (Atkinson & Nevill, 1998). Two-way repeated measures ANOVAs assessed the main and interaction effects of the 5 km distance intervals and the level of breast support on the %CV for each breast kinematic variable. Post-hoc paired samples T-tests with Bonferroni adjustments (α = .008) were performed to examine any differences in the within participant %CV across each kilometre interval of the 5 km run between the two levels of breast support.

RESULTS: Mean anterioposterior breast acceleration was 1.6 *g* in the high level breast support during the two minute run. The greatest within participant %CV was found in the anterioposterior breast acceleration (28%CV) in the high level breast support (Table 1), a variance of 0.4 *g*. Repeated measures ANOVA revealed no significant differences between the three support conditions for within participant %CV in anterioposterior, mediolateral and vertical breast displacement and acceleration, and in anterioposterior and mediolateral breast velocity. However, a significant increase in the within participant %CV for vertical breast velocity was found as breast support was increased from no bra to low breast support to high breast support ($F_{(2)} = 5.876$, $p = .012$, $\eta^2 = .423$, $1\text{-}\beta = .802$).

Table 1
Within participant %CV in anterioposterior, mediolateral and vertical breast displacement, velocity and acceleration in three levels of breast support

Breast support	Within participant percentage coefficient of variance (%CV)								
	Displacement			Velocity			Acceleration		
	x	y	z	X	y	Z	x	y	z
No bra	11%	12%	5%	19%	16%	5%*	18%	19%	9%
Low	11%	15%	8%	15%	16%	10%*	20%	21%	13%
High	10%	17%	13%	25%	22%	14%*	28%	21%	14%

*significant difference between support level ($p < 0.05$)

Mean vertical breast displacement during the second kilometre of the 5 km run was 45.7 mm and 28.4 mm in the low and high level breast support, respectively. Paired-samples T-test revealed a significant increase ($p = .006$) in the within participant %CV of vertical breast displacement during the second kilometre of the 5 km run as the breast support was increased from the low to high level. Peak within participant %CV during the 5 km run trial was found in the mediolateral breast displacement (21%CV); in the high level breast support

(Table 2). The peak within participant %CV of mediolateral breast displacement (21.4 mm) at the second kilometre equated to a variance of 4.5 mm in the high level breast support.

Table 2
Within participant %CV in three-dimensional breast displacement during a 5 km run, performed in a low and high level breast support

Displacement	Sampling intervals of the 5 km run											
	2 mins		1 km		2 km		3 km		4 km		5 km	
	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
Anterioposterior	11%	10%	10%	11%	11%	12%	13%	16%	12%	11%	10%	12%
Mediolateral	15%	17%	13%	15%	10%	21%	15%	16%	16%	14%	16%	10%
Vertical	8%	13%	8%	11%	7%	17%*	8%	12%	6%	11%	7%	9%

*Significant difference between breast supports $p<0.05$

Within participant %CV of three-dimensional breast velocity (Table 3) reached a peak in the anterioposterior direction in the high level of breast support (25%CV); during the first two minutes of the 5 km run. An interaction effect between the breast support and distance intervals ($F_{(5)} = 2.568$, $p = .042$, $\eta^2 = .243$) was found. Post-hoc paired sample T-tests revealed a significant increase in the within participant %CV vertical breast velocity at the second kilometre interval, as the level of breast support was increased from low to high ($p = .000$).

Table 3
Within participant %CV in three-dimensional breast velocity data during a 5 km run, performed in a low and high level breast support

Velocity	Sampling intervals of the 5 km run											
	2 mins		1 km		2 km		3 km		4 km		5 km	
	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
Anterioposterior	15%	25%	15%	17%	15%	16%	14%	20%	14%	15%	13%	20%
Mediolateral	16%	22%	15%	18%	13%	19%	17%	14%	13%	21%	15%	17%
Vertical	10%	14%	8%	17%	6%	14%*	9%	13%	6%	9%	8%	11%

*Significant difference between breast supports $p<0.05$

Peak between participant %CV during the two minute run was found in the anterioposterior breast acceleration (60%CV) in the low level breast support (Table 4), indicating a variance in anterioposterior breast acceleration of 1.4 *g*. During the 5 km run trials, peak between participant %CV in three-dimensional breast displacement, velocity, and acceleration was found in the anterioposterior direction (54%CV, 53%CV, and 66%CV, respectively) in the low breast support condition.

Table 4
Between participant %CV in anterioposterior (x), mediolateral (y), and vertical (z) breast displacement, velocity, and acceleration during a two minute run trial

Breast support	Between-participant percentage coefficient of variance (%CV)								
	Displacement			Velocity			Acceleration		
	X	y	z	x	y	z	x	y	z
No bra	31%	36%	29%	40%	35%	33%	54%	46%	39%
Low	23%	32%	31%	47%	39%	35%	60%	33%	37%
High	28%	39%	32%	36%	28%	20%	53%	37%	32%

DISCUSSION: The aim of this study was to investigate the amount of within and between participant variance present in three-dimensional breast kinematic data between different levels of breast support during running. Within participant %CV in vertical breast displacement and velocity was found to significantly increase at the second kilometre of the 5 km run from the low to high level breast support. This finding indicates an increase in magnitude of variance in a high level of breast support compared to a low level support. Furthermore, the greatest within participant %CV of breast kinematics was reported in the high level breast support, indicating greater variance in the high level breast support (sports bra), rejecting hypothesis one. No significant differences were found in the %CV for any breast kinematic variables from the start to the end of the run, therefore hypothesis two was rejected. An interesting observation was that the greatest between participant %CV for breast kinematics was found in the low level breast support, whereas the greatest within participant %CV in breast kinematics was consistently seen when the participants wore the high level of breast support.

A previous publication by Scurr, et al., (2010) assessed the between participant variance in resultant breast displacement, and reported a maximum of 72%CV between participants during a two minute incremental treadmill speed test. The present study examined the magnitude of between participant %CV in 3D breast kinematics across a 5 km run, with results indicating a maximum between participant %CV of 54% in breast displacement, 53% in breast velocity and 66% in breast acceleration. It is therefore apparent that regardless of duration of running, the between participant %CV in breast kinematic data was reported to be greater than 50%. Furthermore, separating the breast kinematic data into individual planes of motion (anterioposterior, mediolateral, and vertical) enables a greater understanding of which direction may have larger magnitudes of variance. Within the current study, the greatest between participant %CV in each breast kinematic variable was reported in the anterioposterior direction. These data could also be associated with specific changes to upper-body gait variables, such as rotation and oscillation of the trunk, further work within this area may help to identify this proposed link.

CONCLUSION: In conclusion, this study was the first to quantify the variance in 3D breast kinematics during a short and prolonged run (two minutes and 5 km). The greatest within participant %CV in each breast kinematic variable was found in the high breast support condition, whereas the greatest between participant %CV was reported in the low breast support condition. Peak between participant %CV in breast displacement, velocity and acceleration was reported as greater than 50% during the 5 km run, indicating that breast kinematic data can vary substantially from one participant to the next. Further understanding of the variance in breast kinematic data will inform future research within the area of breast biomechanics and may provide a valid explanation for differences between participants of the same cup size and across studies.

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