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LEADING LIMB FORCES IN GAIT TERMINATION DURING PREGNANCY

[1] Marcus Fraga Vieira, [1] Sara Rosa de Sousa Andrade, [1]Viviane Soares, [2] Paula Hentschel Lobo da Costa
[1] Bioengineering and Biomechanics Laboratory, Federal University of Goias, Brazil
[2] Movement Analysis Laboratory, Federal University of Sao Carlos, Brazil
email: marcus@fef.ufg.br, web: sites.google.com/site/labioengufg/

SUMMARY
A safe gait termination is a process that requires slowing down the forward movement of the body to achieve a stable standing position. It is possible that this process may be affected differently according to the pregnancy period, because of body mass and inertia changes that happen in a relatively short time. Thus the present study aims to investigate leading limb adjustments during gait termination in the three different periods of pregnancy. Fifty seven pregnant women in three different pregnancy periods participated in this study. Two AMTI force platforms were used to measure ground reaction forces at 100 Hz. Data were filtered by a zero-lag second order low-pass Butterworth filter at 30 Hz and normalized by the participant's body weight. Principal component analysis (PCA) was performed and Wilcoxon rank sum tests were applied to verify statistical differences in PC scores between the participants in the three trimesters. The significant differences observed in anterior-posterior and medial-lateral GRF components between first trimester Group and the other two groups (second and third trimesters) suggest a gradual increase in the necessity of breaking forces in pregnancy probably due to changes in body mass and center of mass inertia in order to adjust gait termination.

INTRODUCTION
A safe execution of gait termination requires the control of the transition from cyclic walking to standing still, a process which imposes greater demands on the neuromuscular system in controlling balance when compared to normal walking [1]. Pregnant women experience a substantial body change in a relatively short time which may affect the ability to adapt gait pattern to various situations in order to prevent falling, including gait termination.

A safe gait termination implicates slowing down the forward movement of the body to achieve a stable standing position. In general the leading limb, which stands still first, is principally responsible for braking ground reaction forces (GRF) [1]. It is possible that this process may be affected differently, according to the pregnancy period.

Thus the present study aims to investigate leading limb adjustments during gait termination in the three different periods of pregnancy.

METHODS
Fifty seven pregnant women participated in this study (19 in the first trimester – 29.2±4.5 yrs, 60.4±10.2 kg, 1.6±0.1 m Group 1T; 19 in the second trimester – 25.9±3.9 yrs, 67.8±11.4 kg, 1.6±0.1 m – Group 2T; and 19 in the third trimester – 27.1±4.6 yrs, 72.7±1.6 kg, 1.6±0.1 m – Group 3T). All participants signed a consent form.

Two AMTI force platforms were positioned in the center of a 10 m walkway. The force platforms recorded GRF at 100 Hz and the data were filtered by a zero-lag second order low-pass Butterworth filter at 30 Hz and normalized by the participant's body weight.

The participants executed 5 trials of a short-step one-step gait termination in which, following right contact (leading limb) in one force plate, the left foot contacts the other force plate beside the right foot [2]. Each GRF was interpolated with cubic splines and re-sampled to 100 sample points. The first trial was not included in data analysis. The average of the second to fifth trials was used in the analysis. Only leading limb GRF was analyzed.

Each vertical, anterior-posterior and medial-lateral GRF was stored in a matrix D[57 x 100], with rows corresponding to one of the 57 participants. The principal component analysis (PCA) was applied to the covariance matrices C[100x100]. The first principal component (PC) corresponds to the largest sources of variation. For each GRF relevant PCs for the analysis were selected by the scree test. Each eigenvector represents the loading factor of the original GRF and it was used to interpret the information retained in each PC. The signal from each participant was represented by the PC scores [3]. Wilcoxon rank sum test was applied to verify statistical differences in PC scores between the participants in the three trimesters. Data processing was implemented in Matlab 7.14 (The Mathworks, USA).

RESULTS AND DISCUSSION
Three PCs from each GRF component were used for analysis, representing 98,2%, 88,1% and 94,8% of the total variance of vertical, anterior-posterior and medial-lateral GRF components, respectively. Only the two first PC scores

from anterior-posterior and medial-lateral GRF were significantly different between first trimester and second trimester ($P < 0.05$ and $P < 0.027$, respectively) and between first trimester and third trimester participants ($P < 0.049$ and $P < 0.028$, respectively).

The Figure 1 presents the distribution of the PC loadings and scores in a biplot graph. The loadings of second and third trimesters tend to cluster together whereas the loadings of first trimester tend to cluster separately from the others two groups, but there are only absolute differences in medial-lateral and anterior-posterior GRF (top and middle plots, respectively).

Each PC constitutes the loading factor corresponding to the original GRF with higher factors corresponding to epochs of higher variance between groups. The loading factor analysis shows differences among the three groups on the epochs around the force peaks.

The amplitudes of anterior-posterior and medial-lateral GRF were more affected than the vertical GRF during pregnancy. This denotes a significantly increase in breaking forces, possibly due to the increase in body mass and resulting increase in the center of mass inertia. Furthermore, the center of mass displacement should be negotiated in order to remain on the support base to achieve a stable stopping [2].

CONCLUSIONS

The significant differences observed in anterior-posterior and medial-lateral GRF components between 1T Group and the other two groups (2T and 3T) suggest a gradual increase in the necessity of breaking forces in pregnancy probably due to changes in body mass and center of mass inertia in order to adjust gait termination.

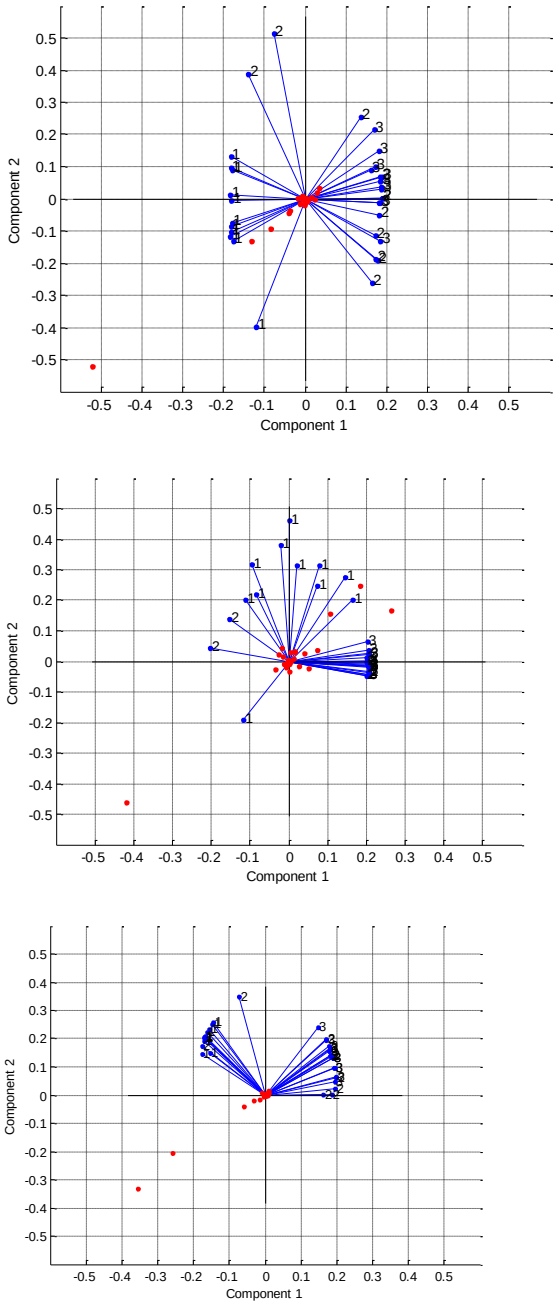

Figure 1: Distribution of the first and second PC loadings of the first trimester (1), second trimester (2) and third trimester (3) participants. Red dots: first versus second PC. Top plot: medial-lateral GRF. Middle plot: anterior-posterior GRF. Bottom plot: vertical GRF.

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