UNEVENLY ADDED MASS DECREASES PEAK HIP FLEXION AND INCREASES HIP EXTENSION IN NON-PREGNANT WOMEN DURING OVER GROUND WALKING

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Introduction: Women with a normal weight BMI can gain 25-35 lbs during pregnancy, which increases the demand on the lower limb musculature during walking [1]. Previous biomechanical studies analyzed changes in walking kinematics during pregnancy have reported reduced peak hip extension during stance phase and shorter stride length in pregnant women during the second and third trimesters, as well as compared to non-pregnant women [2-4]. These changes may be due to multiple factors such as increased anterior pelvic tilt, added mass, hormonal variations and associated musculoskeletal adaptations. One study examined the effect of 100% anteriorly added mass on gait in non-pregnant women, and found reduced hip extension during stance phase and a shorter stride length with added mass increasing from 0 lbs to 20 lbs [5], which was consistent with previous studies in pregnant women. However, pregnancy-related weight gain is unlikely to be solely distributed in the anterior region, and previous studies mainly looked at changes in walking kinematics across the gait cycle, but not within a specific phase during walking. In this study, we further investigated the effect of unevenly distributed mass on lower limb kinematics in non-pregnant women during over ground walking, distributing 60% of the added mass to the anterior and 40% in the posterior region. We hypothesized that walking with unevenly added mass would increase peak hip and knee flexion, and decrease hip and knee extension during stance phase of walking in non-pregnant women.

Methods: Five healthy non-pregnant women (Age: 29±4 years old; Height: 1.7±0.1 m; Mass: 64±9 kg) walked with a pregnancy sac (0.28 lbs) at their self-selected speed (1.22±0.05 m/s). They walked under four conditions, including one no-mass (NM) condition with pregnancy sac only, and 3 mass conditions with 10, 20, and 30 lbs added mass to simulate weight gain during different stages of pregnancy. When adding mass, 60% of the mass was placed anteriorly, and 40% posteriorly to the sac. The participants performed at least five walking trials within 10% variation of their self-selected speed per mass condition, and the sequence of testing condition was randomized. We collected kinematic data at 100 Hz (Motion Analysis Corp, USA), and processed the data using Visual 3-D (HAS-Motion, CA) to obtain joint kinematics in sagittal plane for at least 3 strides per leg per condition. We analyzed the stance phase variables for all three joints including peak hip flexion during the 1st double limb support phase (DLS), peak hip extension, peak knee flexion during DLS, peak knee extension during single limb support phase, peak ankle plantar flexion (PF) during DLS, peak ankle dorsiflexion (DF), and joint range of motion (ROM) for hip, knee, and ankle joints across a gait cycle. We normalized added mass to the participant's body mass in percentage, and used a linear mixed effect model to estimate the effect of percentage of added mass on the variables.

Results & Discussion: Linear mixed effect model analysis of the kinematic data revealed a 5.5° reduction in peak hip flexion during DLS ($p=0.004$), a 6.1° increase in peak hip extension ($p=0.002$), and 13.9° increase in hip ROM ($p=0.008$) with every 10% added mass. Knee joint kinematics variables did not change significantly with added mass ($p=0.59$-0.94). Ankle peak PF in DLS increased by 6.7° ($p=0.04$) with every 10% added mass, but there was no significant difference in peak ankle DF angle or ankle ROM as added mass increased ($p=0.42$-0.71).

We rejected our hypothesis as our results indicated that compared to walking with no added mass, non-pregnant women presented a less flexed and more extended hip joint when walking with 10-30 lbs of added mass. These findings did not align with those reported in pregnant women. One possible reason is that the participants in the study experienced immediate weight gain during data collection, whereas pregnant women experience a gradual weight gain over a longer period. Furthermore, unlike pregnant women, non-pregnant women do not experience large hormonal variations that lead to musculoskeletal adaptations such as increased laxity in joints and tendons, and increased pelvic tilt [1]. Our results also contradicted the previous findings for non-pregnant women with 100% anteriorly added mass [5], which could be a result of a different weight distribution used in this study (60% vs. 40%). Given our limited knowledge of weight distribution and geometrical changes in a pregnant human body, it remained unclear what type of weight distribution can most accurately reflect the weight gain experienced by pregnant women. This preliminary study findings highlight the need for a more comprehensive understanding of the weight distribution and development of a model specific for pregnant women to understand the effect of added mass on their walking kinematics.

Significance: The findings of this pilot study will enhance our understanding of biomechanical adaptions of gait during pregnancy, specifically related to weight gain, independent of the physiological changes associated with pregnancy. Gaining insights into these changes could be useful in understanding the demand from lower limb muscles, reducing the risk of musculoskeletal issues, such as lower back pain and knee pain, and prevent pregnancy-related falls.

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