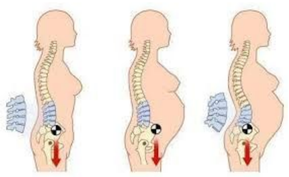
A COMPARISON OF LOWER BACK PAIN BIOMECHANICS THROUGH DIFFERENT GESTATION STAGES

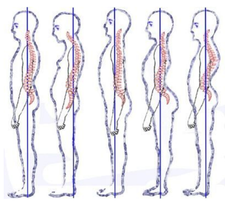
SHARANYA DATTA, LEAH KAUP, ANJALI VISWANATHAN, WILMARY FIGUEREO OBIJO, JAHNAVI SHAH
Biomedical Engineering, Rutgers University, Piscataway, New Jersey 08854

BACKGROUND

Spinal curves, gait pattern, and balance alter along different stages of pregnancy which results in postural changes which can lead to pelvic girdle pain, hip pain, leg problems, carpal tunnel, urinary incontinence, and lower back pain. These symptoms typically appear in the third and second trimester of pregnancy.Pregnancy-related lower back pain have been associated with disability, reduced quality of life, and postpartum depression

- A person's center of mass migrates anteriorly through a pregnancy which results in a lack of positional adjustment in the lumbar curve
  - The force of gravity deviates from the hip ⟶ decreased upper body stability and the generation of a larger moment at the hip
- Pregnant women develop a sway-back posture - the upper body moves posterior to the lower body which causes an increased tone between the head and neck muscles, allowing the head to shift anteriorly
  - Trunk movement accounts for the center of gravity shifting posteriorly which the head shift makes up for
  - Increased fall risk
- Increased movement of the center of pressure and increased stability indexes ⟶ postural control is reduced in pregnancy
  - Trunk range of motion, hip flexion, and extension are reduced
  - Decreased stride length, decreased gait velocity, and increased step width.





PURPOSE

Pregnancy-related lower back pain is abundantly common, occurring in about 20% - 90% of pregnancies

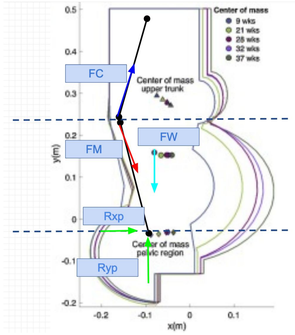
- Can have chronic effects on expectant mothers
- Increased pressure placed on the lower back ⟶ decreased quality of life, sleep disturbances, reduced mobility, and overall discomfort
- Affects both the mother's health and the fetal health

We intend to analyze the effects of different stages in pregnancy on back pain. Lower back pain is most common in the early stages of pregnancy, but it can evolve as women are further along in the process. By analyzing the changing postural effect of pregnancy, we hope to find how back pain evolves and what element would be the biggest contributing factor. This analysis can also be important to recommend specific exercises, ergonomic adjustments, or the development of support devices that can alleviate the discomfort caused by lower back pain.

ASSUMPTIONS

- The first trimester occurs from week 0 to week 12, however pregnancy typically becomes conspicuous after 9 weeks.
- Likewise, we will sampling data at times during each trimester in which women notice the most back pain.
- Approximated spine to be straight with angles between lumbar and thorax
- First trimester or nine-weeks is equivalent to non-pregnant
- Not considering reactions forces between vertebrae
- Location of the Sacroiliac does not move during pregnancy
- The distance between the sacroiliac joint and the back can be approximated as 4 inches or .1 m

METHODS



FW- Weight of Person located at Center of Mass

FC- Compressive Force in the Center of Vertebra

FM- Muscle Force along the spine

Rxp, Ryp- Reaction Force of the Sacroiliac joint (pelvic joint)

Hypothesis: If an average 50th percentile-weight woman gets pregnant, then the compressive force on the center of the vertebra (Fc) and the force of the extensor muscles that run along the back of the spine (Fm) will increase with each trimester and thus increase back pain per trimester.

We constructed a force diagram to solve for Fc, Fm, Rxp, and Ryp which are forces of interest that act upon the spine. Fm and Fc act about the spinal curvature. To perform an analysis against each trimester, we varied spinal curvature and factored in for a shifting center of mass. Below for our mathematical modeling , we have provided our methods for attaining values for our graphical representations for a Non-Pregnant women at variable weights.

MATHEMATICAL MODELING

Section 1:

Sum of Fx:

$0 = F_c\sin(10.6) - F_m\sin(7.3)$

$F_c\sin 10.6 = F_m \sin 7.3$

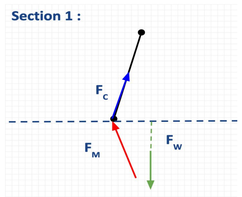
Sum of Fy:

$0 = -F_w + F_c \cos 10.6 - F_m \cos 7.3$

Moment about curvature:

$M_c = -(COM * F_w)$

*These angles and COM are for Non-Pregnancy, but do change for each trimester



Section 2:

Sum of Fy:

$0 = -F_w - F_m\cos(7.3) + R_{yp}$

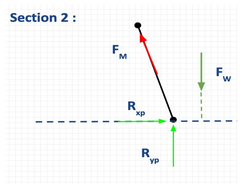
Sum of Fx

$0 = F_m\sin(7.3) + R_{xp}$

Moment about Sacroiliac joint:

M_p:

$0 = F_m * \cos(7.3) * (0.1) - F_m * \sin(7.3) * (0.24 + 0.02) - F_w * (COM - 0.08)$



QUANTITATIVE CHANGES DURING PREGNANCY

Table 1

2009 Gestational weight gain guidelines (Institute of Medicine, 2009)[1]

Pre-pregnancy BMI	Total weight gain at term	Rate of weight gain in the 2nd and 3rd trimester; Mean (range)
Underweight (<18.5 kg/m²)	12.5–18 kg 28–40 lbs.	0.51 (0.44–0.58) kg/week 1 (1–1.3) lbs./week
Normal weight (18.5–24.9 kg/m²)	11.5–16 kg 25–35 lbs.	0.42 (0.35–0.50) kg/week 1 (0.8–1) lbs./week
Overweight (25.0–29.9 kg/m²)	7–11.5 kg 15–25 lbs.	0.28 (0.23–0.33) kg/week 0.6 (0.5–0.7) lbs./week
Obese (≥ 30.0 kg/m²)	5–9 kg 11–20 lbs.	0.22 (0.17–0.27) kg/week 0.5 (0.4–0.6) lbs./week

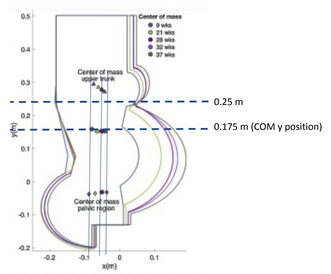
Table 2.

Changes in the spine curvature

	Pregnant women in the second trimester (n=16)	Pregnant women in the third trimester (n=16)	Nonpregnant women (n=15)
Thoracic curvature (°)	10.7 ± 2.1	11.5 ± 2.4*	10.6 ± 2.9
Lumbar curvature (°)	9.0 ± 1.7	1.0 ± 1.9*	7.3 ± 1.3[3]

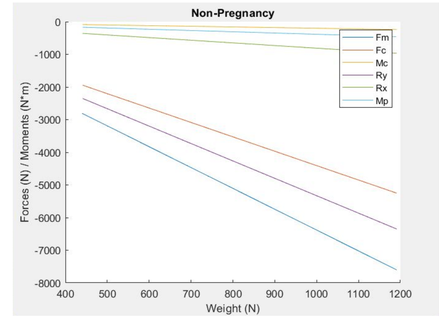
Open in a separate window

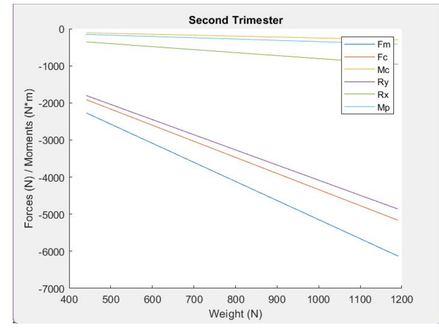
Outcome data: mean ± SD * Significant difference between the second and third trimesters [3] Significant difference only with the third trimester

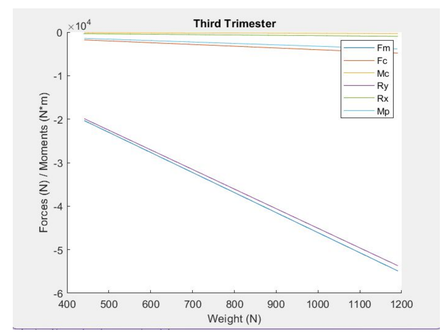


9 WEEKS CENTER OF MASS POSITION (X)	25 WEEKS CENTER OF MASS POSITION (X)	37 WEEKS CENTER OF MASS POSITION (X)
0.2 m	0.25 m	0.27 m

RESULTS







CONCLUSIONS

Based on these graphs, we can conclude that weight gain and spinal curvature are the most significant factors contributing to back pain during pregnancy. The compressive force and muscular force along the spine act oppositely in the x-direction so they show direct proportionality in magnitude. This is why we see a massive change in this two forces, because of a significant change in the curvature angle between 2nd and 3rd trimester.

FUTURE DIRECTIONS

Now that the largest contributing factor has been identified, additional research can be done to see how to alleviate these specific ailments.