# Seat belt fit and body position of pregnant female automobile occupants: an exploratory study

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## INTRODUCTION

- Motor vehicle crashes (MVCs) are a **leading cause of injuries and trauma-related fatalities** for pregnant individuals [1].
- Research involving this population historically has been **limited due to a lack of biofidelic tools** (ATDs, HBMs, etc.) as well as **ethical considerations** for studying a vulnerable population.

### OBJECTIVE

This study aims to **expand the availability of pregnant occupant research data** by measuring belt fit and body position among pregnant individuals of varying gestational ages.

## METHODS

- Pregnant individuals were recruited to participate in a volunteer study that assesses seat belt fit in their personal vehicles (N = 62+).
- **15 anthropometric and in-vehicle environment variables** were collected from the participants.
- A **Principal Component Analysis (PCA)** was performed in R; the top four Principal Components (PCs) were chosen for analysis.
- Principal Component interpretations were validated using original photos.
- **Logistic regression of the top four principal components** was conducted to assess the impact on optimal belt fit in three body locations per official NHTSA guidelines [2].

## RESULTS

Table 1. Description of measured variables and corresponding label

| Type | Label | Variable |
|---|---|---|
| Anthropometric | X9 | Abdomen Circumference (mm) |
| | X10 | Hip Circumference (mm) |
| | X11 | Fundal Height (mm) |
| | X12 | Seated Shoulder Breadth (mm) |
| | X13 | Seated Abdomen Depth (mm) |
| | X14 | Seated Shoulder Height (mm) |
| Vehicle Environment | X24 | Shortest Distance from Knee to Dashboard (mm) |
| | X31 | Tension in Shoulder Belt at the Shoulder D-ring (lbf) |
| | X32 | Tension in Lap Belt at the Outboard (lbf) |
| | X33 | Tension in Shoulder Belt at Buckle (lbf) |
| | X35 | Distance from Top of Sternum to Top Edge of Shoulder Belt (mm) |
| | X36 | Distance from Shoulder Belt to Belly Button (mm) |
| | X37 | Distance from Belly Button to Top of Edge of Lap Belt (mm) |
| | X38 | Length of Lap Belt (mm) |
| | X39 | Length of Shoulder Belt (mm) |

Table 2. Variance within principal components found in dataset

| Eigenvalues | PC1 | PC2 | PC3 | PC4 |
|---|---|---|---|---|
| Variance | 5.29 | 1.70 | 1.48 | 1.40 |
| % of var. | 35.3 | 11.3 | 9.85 | 9.33 |
| Cumulative % of var. | 35.3 | 46.6 | 56.4 | 65.8 |

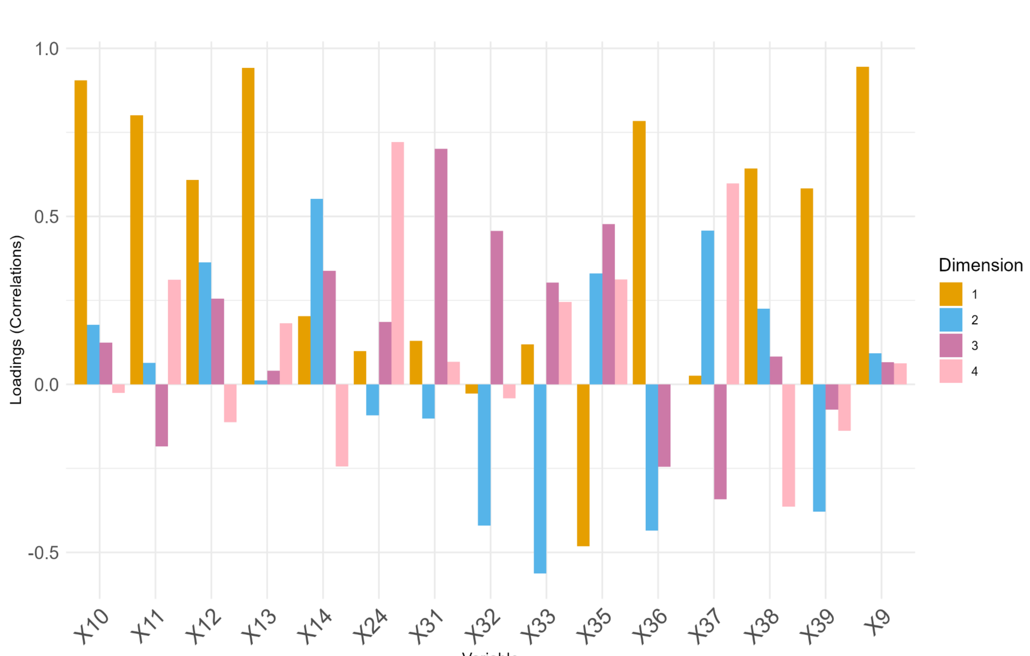


Figure 1. Loadings for each variable onto the four leading principal components

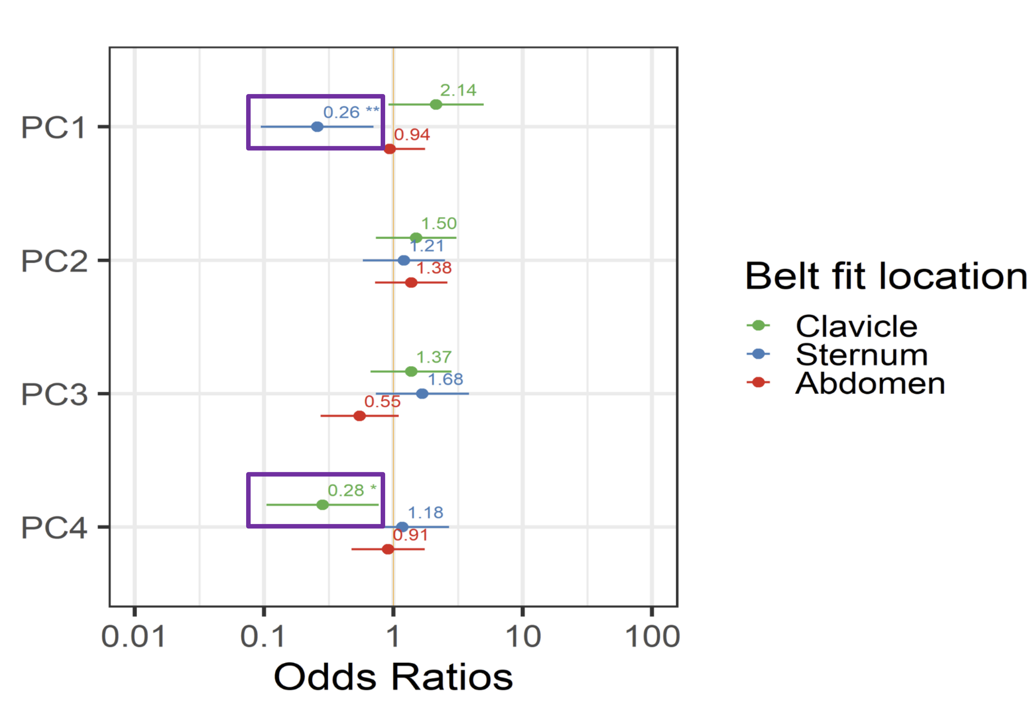


Figure 2. Odds ratios from regression output of how the four leading principal components predict poor belt fit

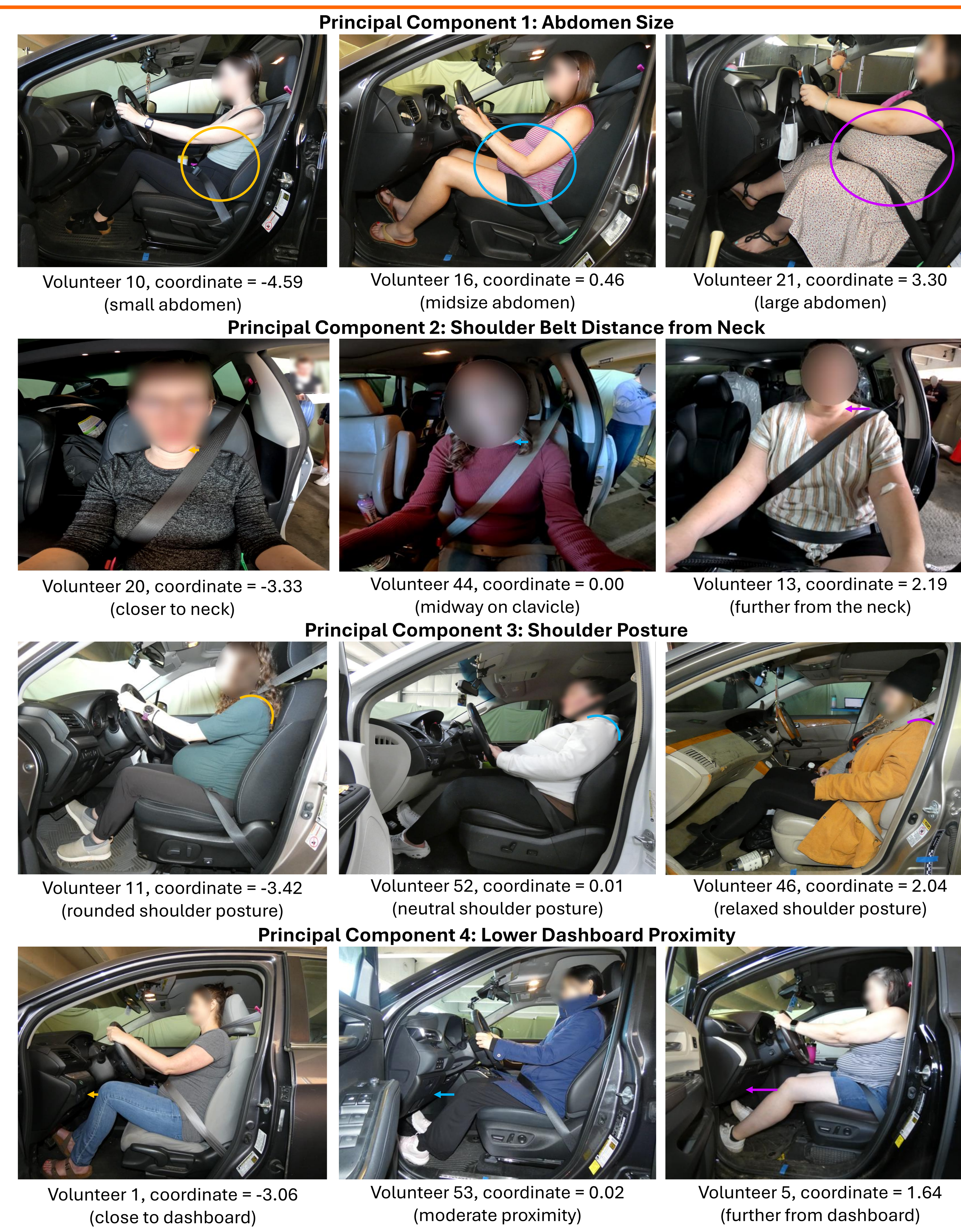


Figure 3. Volunteers who illustrate the four leading principal components

## SUMMARY

- The leading principal components were 1) Abdomen size, 2) Shoulder belt distance from neck, 3) Shoulder posture, and 4) Lower dashboard proximity
- These 4 PCs explained 66% of the variance in the data
- **Larger abdomen size** (PC1) is significantly associated with **lower odds of belt fit compliance** with official NHTSA guidelines **at the sternum**
- **Close proximity to the lower dashboard** (PC4) is significantly associated with **lower odds of belt fit compliance** with official NHTSA guidelines **at the clavicle**

## FUTURE WORK

- The final dataset is expected to include approximately 80 participants to allow us to perform more robust analyses.
- Adjusting for clinical and demographic variables into logistic regression (e.g., Gestational Age, Annual Household Income)

## REFERENCES

1. Beck et al. *TRB*, 2004.
2. NHTSA v6.0, 2025.

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Study website

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