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Effects of transporting an infant on the posture of women during walking and standing still

Lúcia Desideri Junqueira [a], Lia Queiroz Amaral [b], Alexandre Sadao Iutaka [c], Marcos Duarte [a,*]

[a] Biomedical Engineering, Federal University of ABC, Santo André, Brazil
[b] Institute of Physics, University of São Paulo, São Paulo, Brazil
[c] Instituto Vita, São Paulo, Brazil

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ABSTRACT

We investigated the effects on women of carrying an infant in front, focusing on the pelvic and spinal posture and the displacement of the body's center of gravity. For such, we compared mothers to non-mothers not carrying anything or carrying the same load (a doll) and the mothers carrying their infants. Twenty mothers and 44 women who did not have children were analyzed for their movement and posture during walking and standing still with a motion capture system. Walking while carrying a load was slower and with a shorter stride length than while not carrying a load. The mothers' group walked slower and with a shorter stride length than the non-mothers' group. During walking and standing still, the women decreased their angle of pelvic anteversion, increased lumbar lordosis, increased thoracic kyphosis, and increased trunk backward inclination while carrying a load in comparison with not carrying anything. In addition, we observed some small differences in the spinal angles of mothers when carrying their infants compared to when carrying a doll. When standing still, the women carrying a load displaced backwards their vertical projection of the center of gravity to exactly compensate the destabilizing load at the front that resulted in no net change of the body-plus-load center of gravity. In general, these changes are qualitatively similar to the ones observed during pregnancy.

1. Introduction

Carrying an infant literally places humankind's future in the hands of the mothers. This task, in fact, begins months before for the pregnant woman and it is associated with large changes in her body weight and her body posture as the fetus develops. During pregnancy, there are indications of progressive increases of the thoracic and lumbar curvatures, pelvic anteversion, and trunk extension [1–6]. These changes in body posture are thought to be biomechanical adaptations for maintaining balance with the new body weight distribution. Accompanying these biomechanical changes, pregnant women frequently experience pelvic and back pain, particularly in the lumbar region, and for many of the mothers, this complaint will persist or begin in the postpartum period when carrying their infants [7–10].

Carrying the infant in front with the arms may impose similar physiological and biomechanical demands on the mother as during the pregnancy. Although the infant is not constantly held, this new task will typically persist for more than nine months. The mechanical load would presumably be higher due to the infant's increased weight and the mother's increased lever arm in the sagittal plane with the infant in her arms. Therefore, similar posture alterations observed during pregnancy are expected when carrying an infant in front with the arms; however, this assertion is yet to be verified. Surprisingly, no study so far has quantified the actual changes on the posture of the mother carrying her infant with the arms during typical movements of daily life, such as walking or standing upright. The few known studies on this topic had a different focus. In the past, carrying an infant might have been a selective pressure that led to the evolution of bipedalism in ancestral hominids [11–14]. Studies were focused on the physiological cost of walking while carrying an infant [11,12], on mechanical analyses of infant-carrying in hominoids that have

* Corresponding author at: Biomedical Engineering, Federal University of ABC, Avenida dos Estados, 5001, ZIP Code 09210-580, Santo André, SP, Brazil. Tel.: +55 11 23206363.
E-mail address: duartexyz@gmail.com (M. Duarte).

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fur, for infant clinging [13], and on the effects of pregnancy on body posture [14]. A limitation of the studies investigating women is the fact that none investigated mothers carrying their own infants. For methodological reasons, they analyzed women carrying dummy infants, instead [11,12].

In view of that, the main goal of this study is to investigate the effects on the mother when she carries an infant in front, focusing on the pelvic and spinal posture and the displacement of the body's center of gravity during walking and standing still. For such, we compared mothers to non-mothers carrying nothing or carrying the same load (a doll) and the mothers carrying their infants versus carrying a doll. We hypothesize that: (1) Carrying a load (doll or infant) will affect the pelvic and spinal posture and the displacement of the body's center of gravity of both mothers and non-mothers. (2) Mothers carrying their infants will have a different effect than carrying a doll.

2. Methods

2.1. Subjects

Twenty mothers (mother's group) and 44 nulligravida women (non-mother's group), all without any current musculoskeletal problems, participated in this study. Fifteen mothers were primigravida (pregnant for the first time) and 18 of them gave birth by cesarean section. We selected mothers with children of approximately 10 kg weight who were one-year old. As a result, the mean (±1 standard deviation, SD) mass of the children was 9.9 ± 1.1 kg with a mean ± 1SD age of 11 ± 5 months old. The mean ± 1SD age, mass, height, and body-mass index of the mothers were 31 ± 5 years old, 61 ± 12 kg, 1.63 ± 0.07 m, and 22.9 ± 5.0 kg/m^2, respectively. For the non-mother's group, the mean ± 1SD age, mass, height, and body-mass index of the mothers were 29 ± 3 years old, 59 ± 7 kg, 1.66 ± 0.08 m, and 21.4 ± 2.0 kg/m^2, respectively. There was no between-group difference with respect to these characteristics. All participants signed an informed consent form approved by the local ethics committee, and the experimental procedure was conducted in accordance with the Declaration of Helsinki.

2.2. Tasks and instrumentation

The women were asked to complete two tasks: (1) walking straight for 10 m on a level floor at a comfortable speed, and (2) quiet upright standing for 30 s. For both tasks, there were three conditions for the mother's group: (a) carrying nothing (no load), (b) carrying her infant (infant), and (c) carrying a doll with the same weight as her infant (doll). We used a realistic, 50 cm-tall baby doll made of vinyl and wearing a bodysuit; see the supplementary material for a picture of a mother carrying the doll. The non-mother's group performed only the no-load and doll (with 10 kg) conditions. The order of conditions was randomly selected for each woman. We instructed the mothers to carry the infant or doll always at the front of the trunk with both arms. The women performed 10 trials of walking for each condition and only one trial of standing still. Once a walking speed was adopted by the woman at each load condition, she was instructed to walk at that speed at all trials. None of the infants was sleeping during data collection; the mothers tried to calm their infants, but we observed spontaneous movements by the infants during some of the trials.

For the kinematic description of the segmental displacements during the tasks, we employed a marker set and model [15] which allows the calculation of 2D projection angles based on three points for each region and plane of interest (see Fig. 1). Accordingly, reflective markers were placed on the seventh spinous vertebral process (C7), apex of kyphosis (T6 or T7, depending on the woman), apex of lordosis (L3), lower edge of sacrum (S2 or S3), and left and right posterior superior iliac spines (PSIS). In addition, we placed markers on the left and right sides of the anterior superior iliac spines (ASIS) and heels at the feet. The only difference in relation to the model from the literature [15] was that we defined a reference frame for the pelvis (the local frame) based on the PSIS and ASIS markers [16]. This evaluation was performed using a 3D movement analysis system (Vicon 460 with six M2 cameras, Oxford Metrics, UK) operating at 60 Hz and two force plates (OR6-7-2000, AMTI. Inc., USA) embedded in the middle of the 12 m-long floor operating at 120 Hz to measure the ground reaction forces. For the standing still task, the women stood on one force plate as still as possible for 30 s in each condition.

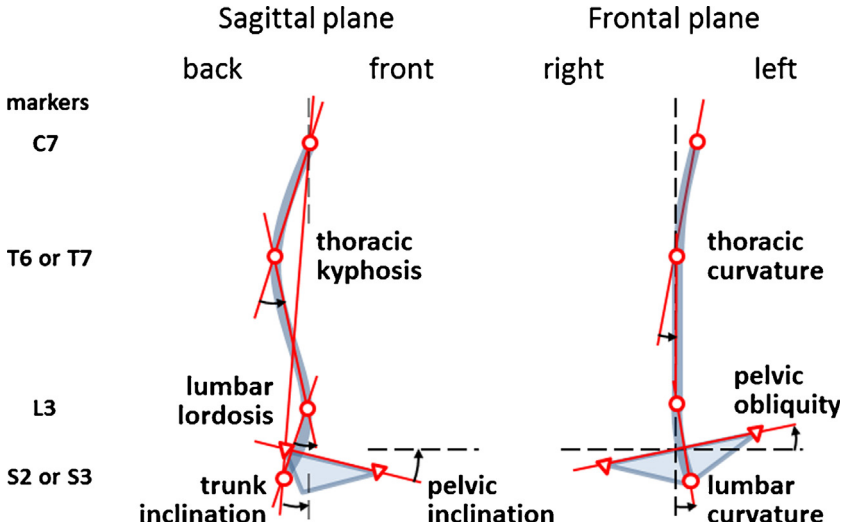

Fig. 1. Marker placement and angle convention adopted for the measurement of the spinal and pelvic angles [15]. Four markers on the pelvis (triangles in the figure) were placed on the left and right posterior and anterior superior iliac spines. The pelvic rotation angle (not shown) occurs at the transverse plane and is positive when the left foot is in front.