Dimensional changes of the feet in pregnancy

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Dimensional Changes of the Feet in Pregnancy*†

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ABSTRACT: **Serial measurements of the volume, length, and width of the feet of seventeen pregnant women were made at, or close to, the thirteenth and thirty-fifth weeks of pregnancy and eight weeks postpartum. The same measurements were made twice on a control group of sixteen nulliparous women at intervals that ranged from sixteen to twenty weeks. There was no change in the length or width of the feet in either group. The mean volume of the feet increased 57.2 milliliters between early and late pregnancy ($p < 0.001$) and decreased by only 8.42 milliliters between late pregnancy and eight weeks postpartum. These changes were attributed to retention of fluid or to an increase in soft tissue and not to stretching or relaxation of the ligaments.**

Women commonly report that the feet become larger during pregnancy. These changes could be due to the accumulation of fluid or fat, or both, or to changes in ligaments caused by the extra weight that is carried during pregnancy or by hormonally induced alterations of the connective tissue in the ligaments. Mechanical stress has been shown to induce remodeling of tissue[9,12], but it is unlikely that the increase in weight that is associated with pregnancy persists long enough to induce such changes. Therefore, changes in the size of the feet during pregnancy have been presumed to be secondary to retention of fluid or to increased laxity of ligaments.

The amount of retained water at term averages 6.5 liters[8,10]. The gain is accounted for by fluid in the fetus, placenta, uterus, breasts, and extracellular spaces; by amniotic fluid; and by increased blood volume. Women who have pregnancy-induced hypertension retain even more fluid[5,10]. Many pregnant women have pitting edema of the ankles and legs late in the day, and this is attributed to compression of the venous system by the uterus. The average weight gain at term is about twelve kilograms[8]. Dennis and Bytheway found that about 75 per cent of this gain disappears by eight weeks postpartum, but many women never fully return to their former weight. Dennis and Bytheway also reported rapid diuresis postpartum and that, at eight weeks postpartum, primipara weigh an average of about two kilograms more than they did before the pregnancy, whether or not they had clinically evident edema during gestation. Finally, the authors attributed this change to a persistent increase in fat and not to an increase in fluid. If change in the size of the feet were due to retention of fluid, one would expect the excess fluid to be eliminated early postpartum, whereas changes in the ligaments would be expected to persist and cause irreversible changes in the feet.

Ligaments may relax during pregnancy due to hormonal changes[4]. Relaxin, a hormone that was identified by Hisaw, relaxes the symphysis pubis of some mammals and may produce remodeling of collagen[11]. Bird et al. found increased laxity of the metacarpophalangeal joints in pregnant women that was suggestive of a peripheral action of relaxin. This increase in laxity was greater in gravida-II than in gravida-I women, but there was little further increase with subsequent pregnancies.

The present study was designed to answer two questions: do the dimensions of the feet change during pregnancy, and if so, are these changes still present eight to ten weeks postpartum?

Materials and Methods

Design of the Study

The volume, length, and width of the feet of the patients in the study group were assessed at the thirteenth and thirty-fifth weeks of gestation and at eight weeks postpartum (all plus or minus one week), the usual time for the patients' obstetrical follow-up visit. At the initial interview, the patients were questioned about problems with the feet, previous operations on the feet, shoe size, habits in standing, the surfaces of the floors at home and at work, and the appearance of the feet. At subsequent visits, a questionnaire concerning changes in these variables as well as edema of the feet and ankles was completed by each participant.

To provide controls, we obtained the same information and measurements on two occasions, sixteen to twenty weeks apart, from a comparable group of women who had never had a full-term pregnancy.

Selection of Patients and Controls

Twenty consecutive consenting patients and sixteen

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TABLE I

CHARACTERISTICS OF THE STUDY GROUP*

	Age (Yrs.)	Body Weight (kg)			Height (m)
		Visit 1	Visit 2	Visit 3	
Patients (n = 17)	26.8 ± 3.2 (23-33)	58.4 ± 8.3 (43.5-74.8)	75.3 ± 10.2 (61.2-101)	63.2 ± 10.0 (50.3-88.9)	1.66 ± 0.06 (1.57-1.78)
Control group (n = 16)	25.3 ± 0.8 (24-27)	58.5 ± 4.2 (54.9-65.8)			1.65 ± 0.1 (1.48-1.78)

* Values are given as mean and standard deviation, with range in parentheses.

controls were recruited for the study. For three of the twenty patients the pregnancy did not reach full-term, so seventeen were evaluated until eight weeks postpartum. However, five of these seventeen were unable to come for the scheduled measurements at thirty-five weeks.

The pregnant women were recruited during their initial visit to the University of Vermont Department of Obstetrics and Gynecology. Criteria for entry into the study included a gestational age of less than fourteen weeks as determined by the date of the last menstrual cycle, a chronological age of eighteen to thirty-two years, a weight within 20 per cent of Metropolitan standard values[3], and not more than one previous pregnancy. The age-matched (within five years) controls (none of whom had had a pregnancy that had gone to term) were recruited from among medical students and health-care workers at the University of Vermont. In an attempt to control for swelling of the feet that might occur during the course of the day, measurements were performed between 9:00 AM and noon whenever possible.

The demographic data for the patients and for the controls were comparable (Table I). None of the women in the control group reported having had previous problems with the feet, but two of them were noted to have asymptomatic bilateral hallux valgus on clinical examination.

Measurement of the Volume of the Feet

The volume of each foot was measured by calculating the displacement of fluid using a volumeter made from a bread tin. The tin measured thirty by twelve by fourteen centimeters. Spigots were located 7.6 centimeters above the bottom to carry off the displaced fluid; they were placed in that location because it is the mean height of the tip of the medial malleolus[2] above ground level. Initially, a fixed volume of water was placed in each tin. When the foot was placed in the tin, the overflow was collected in a basin and was measured in a graduated cylinder that had a capacity of 250 milliliters. The volume of the foot was calculated as the volume of the displaced water added to a constant volume of water that corresponded to the volume that would have been required to bring the initial level of water in each tin up to the level of the spigot. This procedure, by which the tin was initially only partially filled, was used to save time. Repeated measurements on a single subject showed that the measurements of volume were reproducible to within thirty milliliters, which was about 4 per cent of the volume of the foot.

Measurement of the Length and Width of the Feet

The subjects stood with the feet on two sheets of ruled

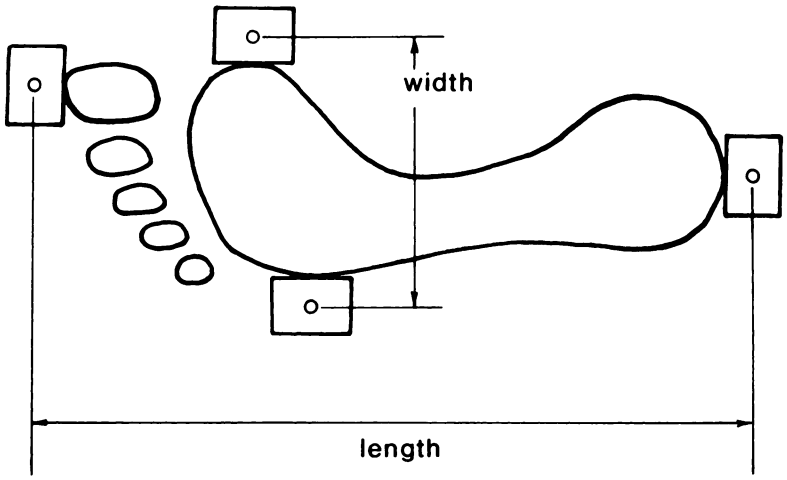

FIG. 1

The length and width of the feet were measured as the distances between pen marks that were made by inserting a pen through a hole in a block that was held lightly against the bone prominences. Subsequently, each measurement was adjusted for the distance between the surface of the block and the pen hole (twelve millimeters).

graph paper placed side by side, with the tips of the first toes and the backs of the heels aligned with the long axis of the paper. The distance between the feet was not controlled; each subject separated the feet in a way that was comfortable. The positions of the feet were standardized on the graph paper to minimize variation in length and width due to changes in body habitus and in the position of the center of gravity. A Plexiglas block that had a hole in its center to hold a pen was then placed lightly against the medial prominence of the head of the first metatarsal and the lateral prominence of the head of the fifth metatarsal, the tip of the first toe, and the posterior aspect of the heel (Fig. 1). In each position, the pen was used to mark the graph paper. Length and width were measured in the sagittal and coronal planes using the four marks on the graph paper. These measurements were then adjusted to account for the distance between the hole for the pen and the surface of the block that had been placed against the foot. Repeated measurements of length on a single subject were found to be accurate within 3.5 millimeters, which was about 1.5 per cent of the length of the foot. Repeated measurements of width were accurate within two millimeters, which was about 2 per cent of the width of the foot.

Results

The measurements made at the first, second, and third visits of the patients and at the two visits of the controls are summarized in Tables II and III. The changes in length, width, and volume between visits were analyzed using a Student paired-sample t test. No statistically significant changes were found in any measurement that was made on the control group. For the patients, the changes in volume between thirteen and thirty-five weeks of gestation and between thirteen weeks of gestation and eight weeks postpartum were statistically significant (both, $p < 0.001$). Between thirteen and thirty-five weeks of gestation, the mean increase in volume was 57.2 milliliters, and between thirty-five weeks of gestation and eight weeks postpartum the mean decrease in volume was 8.4 milliliters (not significant). Thus, the mean net gain in volume at eight weeks postpartum compared with thirteen weeks of gestation was 46.43 milliliters ($p < 0.001$). There were no significant changes in the length or width of the feet of the patients.

Fourteen of the seventeen patients complained that their shoes were tight at some time during pregnancy. Eight bought larger shoes while they were pregnant. Eight weeks postpartum, four of the seventeen were still unable to wear the original size of shoe, ten complained of tight shoes, and three reported having no problems with the feet. The mean increase in volume for the ten women whose shoes remained tight was 55.6 milliliters, compared with 42.0 milliliters for the three patients whose feet had subjectively returned to normal. Sixteen of the seventeen women reported that the feet were visibly swollen at some time during the pregnancy.

TABLE II

MEASUREMENTS OF THE FEET*

	Length (mm)	Width (mm)	Volume (ml)
Patients			
13 weeks of gestation (n = 17)	240.3 ± 10.6	89.3 ± 4.2	670.6 ± 57.7
35 weeks of gestation (n = 12)†	240.9 ± 10.4	90.0 ± 3.8	725.3 ± 63.4
8 weeks postpartum (n = 17)	240.5 ± 10.2	89.5 ± 4.2	717 ± 60.0
Control group			
Initial visit (n = 16)	241.6 ± 9.6	89.9 ± 5.3	709.5 ± 67.4
Second visit (n = 16)	241.5 ± 9.5	89.8 ± 5.4	707.6 ± 63.2

* Mean and standard deviation of the left and right feet.
† Five of the seventeen patients were not examined at the thirty-five-week interval.

TABLE III

DIFFERENCES IN MEASUREMENTS OF THE FEET*

	Length (mm)	Width (mm)	Volume (ml)
Patients			
13-35 weeks of gestation (n = 12)†	+0.75 ± 0.49 (ns)	−0.20 ± 0.45 (ns)	+57.2 ± 8.04 ($p < 0.001$)
35 weeks of gestation to 8 weeks postpartum (n = 12)†	−0.15 ± 0.43 (ns)	+0.30 ± 0.43 (ns)	−8.42 ± 7.52 (ns)
13 weeks of gestation to 8 weeks postpartum (n = 17)	+0.24 ± 0.35 (ns)	+0.21 ± 0.40 (ns)	+46.43 ± 4.99 ($p < 0.001$)
Control group			
0-12 weeks (n = 16)	−0.125 ± 0.23 (ns)	−0.063 ± 0.24 (ns)	−1.91 ± 2.8 (ns)

* Positive value = increase, negative value = decrease, and ns = no significant change. Values are given as mean and standard error.
† Five of the seventeen patients were not examined at the thirty-five-week interval.

Only one woman complained of pain in the feet while she was pregnant. This was diagnosed as being due to pressure on the saphenous nerve, and the pain resolved when she wore larger shoes. The average gain in body weight was 16.9 kilograms between the first and second visits, and the average residual gain at six to eight weeks postpartum was 4.8 kilograms compared with the weight at thirteen weeks of gestation (Table I).

Discussion

Theoretically the mechanical stress of pregnancy or the physiological effects of the hormone relaxin[1,4,7,11], or both, might cause laxity of the ligaments of the feet during pregnancy and might account for the complaints of pain and enlargement of the feet during and after pregnancy. Since there was no statistically significant change in the length or width of the feet during pregnancy or immediately postpartum, it seems unlikely that there is a real increase in the laxity of the supporting structures in the feet during pregnancy. However, it is possible that such changes had already occurred by the thirteenth week of pregnancy, when we made our initial measurements, since the level of relaxin appears to be elevated early in pregnancy[11]. On the other hand, no subject reported subjective problems such as tight shoes at the first visit.

During pregnancy, there was a statistically significant increase in the volume of the feet that was equivalent, on the average, to 8.5 per cent of the volume of each foot. At the eight-week postpartum visit, the mean volume had decreased by only 1.20 per cent compared with the volume at thirty-five weeks of gestation. This change in volume appears to be related to an increase in fluid or soft tissue in the foot, or both, as the result of pregnancy. If the increase in volume were due solely to retention of fluid, one would expect it to have resolved by the postpartum visit because of the rapid diuresis that occurs after delivery. Since it did not resolve, we must assume that some of this increase in volume was due to accumulation of soft tissue, presumably fat[6]. The design of our study, however, did not permit us to identify which factors were responsible for the persistent increase in the volume of the feet.

Subjective complaints of tight shoes and changes in the size of the shoes are consistent with the observed changes in the volume of the feet during pregnancy and postpartum. Increases in extracellular fluid or soft tissue explain the complaints of enlargement of the feet during and after pregnancy since there were no demonstrable changes in the width of the fore part of the feet or the toe-to-heel length.

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