ABSTRACT

Objective: The purpose of this study was to determine the effect size in measurable change of abdominal musculature morphology using ultrasonography in postpartum women within 1 month of a healthy, vaginal delivery.

Methods: One hundred fifty-six participants were recruited for this study. B-mode ultrasound imaging was used to measure abdominal muscle thickness on 80 nulliparous women and 76 mothers who had delivered within the past 4 weeks. Measures were taken for the upper and lower rectus abdominus, external and internal obliques, and transversus abdominus at rest.

Results: Statistically significant differences were found in the thickness of the rectus abdominus muscle at both sites; upper ($P < .0001$) and lower ($P < .0001$) as well as the internal oblique ($P < .0001$). All 3 muscles were thinner in postpartum participants (8.29 ± 1.83 mm, 8.89 ± 2.29 mm, and 7.06 ± 1.82 mm, respectively) within the first month of delivery than in controls (10.82 ± 1.93 mm, 11.13 ± 2.38 mm, and 8.36 ± 1.87 mm, respectively). Large effect sizes were found for the influence of pregnancy on the rectus muscle segments (1.35 for the upper rectus abdominus and 1.00 for the lower rectus abdominus) and a medium effect size for the internal oblique (0.71). No significant differences were observed in the remaining 2 muscles.

Conclusion: This study showed that there are differences in morphology of the abdominal muscles in pregnant women vs nonpregnant controls. The large effect sizes reported may provide the basis for future studies examining relationships between morphology, functional change, and back pain during pregnancy. (J Manipulative Physiol Ther 2015;38:352-357)

Key Indexing Terms: Back Pain; Pregnancy; Abdominal Muscles; Postpartum Period; Ultrasonography

INTRODUCTION

Back and posterior pelvic pain are common complaints experienced by women who are pregnant. Estimates of the prevalence for back pain during pregnancy range from 24% to 90%, and the etiology remains unknown. The source of symptom as arising from the lumbar spine or pelvis may be difficult to discern, leading to the use of various diagnostic labels including sciatica, facet joint syndrome, lumbar insufficiency, or “mixed” back pain. It has been suggested that causation may be multifactorial with proposed mechanisms including, but not limited to, the influence of altered circulating relaxin on ligamentous laxity, maternal weight gain, and/or biomechanical changes of weight bearing due to pregnancy. More specifically, it has been postulated that weakened abdominal musculature to accommodate the growing baby, coupled with a history of low back pain may be key factors.
Therefore, the purposes of this study are to evaluate the change in ultrasound morphology of the abdominal musculature, defined by healthy nulliparous women and those who are within 4 weeks postpartum, and to identify effect sizes for future studies on biomechanics of pregnancy. Knowledge of relevant ultrasound changes within muscle groups might give foundation to future clinical approaches to prevent and treat back pain associated with pregnancy.

**METHODS**

**Participants**

Recruitment for the study was through word of mouth and poster notice within the academic institution, local obstetrician, and gynecology offices, and in local organizations. A larger sample of healthy participants was selected in order to ensure a broader distribution in morphology measure. Persons responding to recruitment information were prescreened by research staff for eligibility. All participants provided informed consent. The current study was approved by the Canadian Memorial Chiropractic College Ethics Review Board (0801X06) and Sunnybrook Health Sciences Centre (193-2009).

Postpartum women and nulliparous controls between the ages of 20 and 40 years were eligible for participation. Postpartum women, within 1 month of a normal vaginal delivery, and healthy nulliparous controls were included. The decision to evaluate women within 1 month after delivery came from the work of Coldron et al.12 This group clearly demonstrated that rectus abdominis (RA) thickness and width had not returned to normal values by 1 day, 2 months, 6 months, or 12 months postpartum compared with controls. Therefore, thickness values within 4 weeks of giving birth would likely be representative of findings during the final month of pregnancy. Exclusion criteria included a history of abdominal surgery, with the exception of childhood appendectomy or herniorrhaphy, and those with significant trunk deformity identifiable on inspection such as scoliosis.

**Procedure and Data Collection**

On induction into the study, participants were scheduled for a single assessment appointment lasting up to 30 minutes (Fig 1). A brief history and measure of height, weight, age, date of parturition, and presence/absence of low back pain were collected. Participants were placed in the supine position with the abdominal area exposed from the xiphoid process to the suprapubic bone landmarks. Palpation of the soft tissues about the suprapubic, xiphoid and anterior superior iliac spine along with visualization of the umbilicus was used to define the boundaries and orientation for placement of the ultrasound transducer. Ultrasound gel was applied liberally to the areas of imaging to ensure good sonic coupling between the transducer and skin.

The Ultrasonix RP (Ultrasound Medical Corp, Burnaby, BC) unit was used for trunk muscle image capture. A 60-mm linear array transducer captured images using a frequency range of 6 to 14 MHz and depth of 4 to 10 cm based on participant stature and image optimization. Only images from the right side of the abdomen were obtained based on the assumption of symmetry and the work of Rankin et al.13 Prior to obtaining images for measurement, the ultrasound was used to scan the muscle to ensure uniformity and identify landmarks.14 Muscle thickness was measured for the abdominal wall from 3 sites.

1. The anterolateral, lower quadrant abdomen (Fig 2): the probe was placed at a point midway between the costal margin and iliac crest along the right axillary line.14–16 This region captures the external oblique (EO), internal oblique (IO), and the distinctive terminus of the transverses abdominus (TrA) into the abdominal fascia. The TrA terminus was positioned at the center of the screen to standardize relative position for taking measures of the muscle thicknesses.

2. The mid-upper abdominal parasagittal (Fig 3): the probe was placed at a point approximately 2 to 3 cm above...
umbilicus, lying along the midclavicular line. This region captures the upper rectus abdominus (URA) muscle belly medial to the linea alba.

3. The mid-lower abdominal parasagittal (Fig 4): the probe was placed at a point approximately 2 to 3 cm below the umbilicus, lying along the midclavicular line and approximately in line with the anterolateral measure described above. This region captures the dimension of the lower rectus abdominus (LRA).

Each target muscle within the image was confirmed by use of standard movements consistent with daily activities that are known to preferentially activate them. To determine the TrA, the participant was asked to perform a slow Kegel exercise, mentally visualizing an effort to draw the vaginal tissues into the body, resulting in a sequential activation of the TrA followed by the obliques. Once the TrA was identified, the fascial planes and fiber orientations for the EO and IO are clearly evident, making them easily distinguishable. For both the mid-lower and mid-upper regions, a simple lifting of the head from the examination table was sufficient to initiate the stabilizing actions of the rectus abdominus.

A cine-loop image captured the validating maneuver for each muscle. The participant resumed a relaxed supine posture, and digital measures of muscle thickness were obtained. On completion, the surface gel was removed and the skin wiped dry. The total time for the assessment and imaging session was less than 30 minutes.

Data Analysis

Few quantitative data on morphology of abdominal muscles in pregnancy currently exist, and as such, the current study used descriptive and comparative statistics. Participant data were stratified by group, and primary comparisons, using an unpaired Student t test, were based on these groupings across the 4 muscles measured (EO, IO, TrA, RA). Based on these comparisons, the current study wanted to establish baseline understanding of the effect size for changes in morphology due to pregnancy. Means and standard deviations were also used to set parameters for future studies. The combination of these results will help determine if these types of measures will have clinical utility in guiding future therapeutic and biomechanical studies.

RESULTS

Eighty nulliparous female controls and 76 postnatal women participated in the study. Nonpregnant women averaged 61.53 kg in weight and 165.47 cm in height and ranged in age from 21 to 32 years. The postpartum women were 70.73 kg and 166.78 cm in stature and ranged in age between 21 and 39 years. The mean time interval from delivery to muscle thickness measure was 23.9 days (range, 7-31 days). Sample differences were noted in age and weight. The nulliparous women serving as the normal control group were significantly younger (26.86 ± 2.92 years) than postpartum counterparts (33.03 ± 3.92 years). Postpartum women tested within 1 month of delivery were...
significant differences (0.71 < .0001) than their nulliparous controls (70.73 ± 9.09 and 61.65 ± 9.03 kg, respectively). There was no significant difference in height among participants (P = .27; Table 1).

Upper rectus abdominus (P < .0001) and LRA (P < .0001) were significantly thinner in the postpartum participants (8.29 ± 1.83 and 8.89 ± 2.29 mm, respectively) within the first month of delivery than their nulliparous controls (10.82 ± 1.93 and 11.13 ± 2.38 mm, respectively). Internal oblique in women within 1 month postpartum was significantly different from nonpregnant controls (7.06 ± 1.82 and 8.36 ± 1.87 mm, respectively). External oblique (P = .07) and TrA (P = .71) were not significantly different between the groups (Table 2). Effect size for the upper and lower rectus changes were determined from the pooled standard deviation measures. Large effects were identified for both upper (1.35) and lower (1.00) RA, and a medium effect size was identified for the IO (0.71).

**DISCUSSION**

The etiology of low back pain during pregnancy remains unclear. There is an absence of normal reference ranges for abdominal muscle size and symmetry during the pregnancy period. This gap in the literature makes it difficult to assess the influence of trunk musculature on pregnancy-related back pain.

As far as we know, this is the first study to examine, using an ultrasound imaging, all 4 abdominal muscles immediately after pregnancy. Postpartum women tended to be older and weighed more than controls, which is expected given that the controls were recruited from within a postsecondary institution and postpartum women were tested within 1 month of delivery. Abdominal thickness revealed that URA, LRA, and IO muscles were significantly thinned in the postpartum group. Upper rectus abdominus and LRA changes were consistent with the findings of Coldron et al and Gilleard and Brown. Kim and colleagues found a trend toward reduction of IO dimension during rest, but not a clear difference statistically. Despite the speculations of some authors, no differences were observed in the TrA or the EO in our data or in the measures by Teyhen et al, Pinto et al, Beazell et al, and others. This project demonstrated an effect size associated with postpartum status: 1.35 for URA, 1.00 for LRA, and 0.71 for IO. Future studies may find these ratios useful in planning investigations involving the biomechanics of pregnancy.

Consideration of muscular insufficiency, imbalance, or weakness of trunk musculature as a contributing factor for low back pain in pregnant women is not new and is often extrapolated from studies regarding the nonpregnant population. In the nonpregnant population, the postural control, spinal stabilization, and movement coordination roles of these muscles are well known. The obliques and the TrA are thought to form a “brace” around the abdomen. The abdominal fascia anteriorly and the posterior lumbodorsal fascia layers correspond to the aponeuroses of muscles with different directions of pull, depending on the patient’s posture and intended activity. Any change in muscle thickness, timing or response to perturbation, altered direction of action have been implicated as potential sources of LBP in the nonpregnant state. However, based on the findings reported here and by others, it would appear that TrA and EO are not serious candidates contributing to the etiology of low back pain associated with pregnancy.

To better understand the potential role of abdominal muscles on pregnancy-related back pain other factors related to URA, LRA and IO, such as potential changes in fiber type, their mechanical advantage, and the influence of the enlarging abdomen should be evaluated more closely. For example, the IO can be divided anatomically into 2 halves based on fiber orientation. The upper fibers of the IO are obliquely oriented and located between the iliac crests and the ribs, whereas the lower fibers located below the anterior superior iliac spine run horizontally. As the abdomen become protuberant, the lower portion of the IO fibers, similar to the rectus fibers, may be affected, and as such, a change in muscle thickness may account for a change in overall strength impacting function, perhaps contributing to back pain in pregnant women.

In the nonpregnant population, the pattern of relative thickness has been reported as RA > IO > EO > TrA. The result of the current study confirmed the same pattern for nulliparous and postpartum participants; RA (both URA and LRA) was the thickest and TrA was the thinnest of the abdominal muscles. As suggested by Rankin et al. and Teyhen et al, this relationship maybe a simple screening tool to assess muscular changes associated with...
pathological conditions or atrophy. Future studies should examine if this pattern is altered in women who suffer from pregnancy-related back pain and those who do not.

The contribution of this work is the identification of large effect sizes in loss of abdominal muscle thickness during pregnancy using a large cohort of healthy individuals to maximize measure distribution. Information of this type can be used to construct future studies involving mechanisms for back pain during pregnancy. In addition, future studies may incorporate changes in orientation and muscle thickness to explore mechanisms of postpartum low back pain as well as evaluate exercise regimen intended to relieve it.

LIMITATIONS

Abdominal musculature does not have a homogenous thickness throughout the torso region regardless of pregnancy status. Three ultrasound sites representing 5 parts of the abdominal musculature were sampled in effort to provide representative measures.

The cross-sectional nature of the study samples is also a limitation. A longitudinal design, using nonpregnant participants who subsequently become pregnant and are remeasured would be ideal, but logistically challenging.

CONCLUSION

The results of measure for abdominal muscle thickness in this study show variation compared with the nonpregnant control group. These changes could be implicated in back pain during pregnancy as muscle imbalances have been shown to contribute to back pain in the nonpregnant state.

FUNDING SOURCES AND CONFLICTS OF INTEREST

No funding sources or conflicts of interest were reported for this study.

CONTRIBUTORSHIP INFORMATION

Concept development (provided idea for the research): C.A.W., J.J.T., J.B., M.D.C., M.C., J.R.
Design (planned the methods to generate the results): C.A.W., J.J.T., J.B., M.D.C., M.C., J.R.
Supervision (provided oversight, responsible for organization and implementation, writing of the manuscript): C.A.W., J.J.T., J.B., M.D.C., M.C., J.R.
Data collection/processing (responsible for experiments, patient management, organization, or reporting data): C.A.W., J.J.T., J.B., M.D.C., M.C., J.R.
Analysis/interpretation (responsible for statistical analysis, evaluation, and presentation of the results): C.A.W., J.J.T., J.B., M.D.C., M.C., J.R.

Practical Applications

- There are differences in morphology of the abdominal muscles in pregnant women vs nonpregnant controls, specifically URA, LRA, and IO.
- These differences may help explain the relatively large incidence of back pain during pregnancy.
- The large and medium effect sizes reported provide the basis for future studies examining relationships between morphology, functional change, and back pain.

REFERENCES

20. Fast A, Weiss L, Ducommun EJ, Medina E, Butler JG. Low back pain in pregnancy. Abdominal muscles, sit-up perfor-

21. Full text upload error. Refer to original source for complete bibliography.