RESEARCH STUDY

The Effects of an Exercise Program on Diastasis Recti Abdominis in Pregnant Women

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ABSTRACT

Background: Diastasis Recti Abdominis (DRA), a separation of the 2 bellies of the rectus abdominis at the linea alba, may occur in more than half of all pregnancies. Due to hormonal changes and a growing uterus, the abdominal muscles become over-stretched and weak, compromising posture, trunk stability, respiration, trunk motion, and vaginal delivery. Exercise to strengthen the abdominal musculature during pregnancy may affect the presence and size of DRA, however, no research has specifically examined this relationship. **Purpose:** The purpose of this project was to determine the effect of an abdominal strengthening exercise program on the presence and size of DRA in pregnant women. **Study Design:** A 2 group, between subjects, quasi-experimental post-test design. **Methods:** Subjects were comprised of 8 pregnant women participating in an abdominal exercise program and 10 non-exercising pregnant women. Diastis recti abdominis was measured using a digital caliper at 3 marked sites along the midline of each subject's abdomen: 4.5 cm above the umbilicus, at the umbilicus, and 4.5 cm below the umbilicus. Two measurements were taken at each site, and the average was used for statistical analyses. Descriptive statistics were generated, and independent t-tests were performed on each subject characteristic. An analysis of covariance was computed with the number of previous pregnancies as the covariate to control for the difference between the subject groups. **Results:** Ninety percent of non-exercising pregnant women exhibited DRA while only 12.5% of exercising women had the condition. The mean DRA located 4.5 cm above the umbilicus was 9.6 mm (± 6.6) for the exercise group and 38.9 mm (± 17.8) for the non-exercise group. The mean DRA located at the umbilicus was 11.4 mm (± 3.82) for the exercise group and 59.5 mm (± 23.6) for the non-exercise group. The mean DRA located 4.5 cm below the umbilicus was 8.2 mm (± 7.4) for the exercise group and 60.4 (± 29.0) for the non-exercise group. **Conclusions:** The occurrence and size of DRA is much greater in non-exercising pregnant women than in exercising pregnant women. Because of the integral role the abdominal muscles play in functional activities we recommend examining pregnant and postpartum women for the presence of DRA.

Key Words: diastasis, linea alba, pregnancy, exercise

BACKGROUND

Diastasis recti abdominis (DRA) is a frequent consequence of pregnancy. It is a separation of the two bellies of the rectus abdominis muscles along the linea alba with widening and fibrous division of the linea alba.[1] Boissonnault and Blaschak[2] noted DRA to be present in 66% of women who were in their third trimester of pregnancy while Hannaford and Tozer[3] reported a 100% incidence of DRA in pregnant women. Nobel[1] believes that most postpartum women have some degree of separation. Immediately postpartum, Bursch[4] found all women had some degree of abdominal muscle separation with 85% presenting with at least a 2-finger width separation, the traditional determination for DRA.

Diastasis recti abdominis does not spontaneously resolve for many postpartum women[2] and may even persist for many years. While there is an absence of longitudinal investigations on the natural resolution of DRA, Ranney[5] examined 1,738 parous women undergoing a hysterectomy several years postpartum and determined that 39% still exhibited a DRA. Additionally, many of the 80,607 abdominoplasties performed on

women in United States in 2002 included surgical correction of rectus abdominis muscle and fascial separation.[6] Thus it appears that DRA and the functional consequences of abdominal separation may persist throughout adulthood.

Causative factors for DRA appear to be either hormonally mediated or result from the mechanical effects of pregnancy on the abdominal musculature.[1] During pregnancy increased levels of relaxin, progesterone, and estrogen soften connective tissue, weakening the linea alba.[7] Together with the mechanical strain placed on the anterior abdominal wall by the enlarging uterus, this weakening can result in a DRA.[7] As pregnancy advances, the rectus abdominis muscles become stretched and elongated around the enlarging uterus.[1,8] Gilleard and Brown[8] noted a 115% increase in the length of the rectus abdominis during pregnancy and a change in the angle of insertion, reducing the muscle's ability to generate torque. Fast et al[9] found that pregnant women had significantly weaker abdominal musculature than nonpregnant women during a sit-up performance test and attributed this weakness to their over-stretched abdominal muscles. Multiparity, especially without recovery of abdominal tone between successive pregnancies, places a woman at risk for developing DRA due to repeated and prolonged stretch on the abdominal wall.[2,10] Multiple pregnancies closely related in time, place a women at risk because there is insufficient time for the abdominal wall to recover function inbetween the pregnancies.[11]

Since abdominal musculature plays a crucial role in trunk control and function, compromise of the abdominal musculature due to DRA can diminish the mechanical control of the abdomen and its functions. These include posture, trunk stability, respiration, parturition, elimination, trunk flexion, trunk rotation, trunk side bending, and support of the abdominal viscera.[1,2,7,10] Furthermore, DRA may be implicated in low back pain. Toranto[12] reported relief of chronic low back pain in 24 out of 25 women following surgical correction of DRA, which was still present 28.5 months postsurgically.

The American College of Obstetricians recommends exercise for pregnant women stating its benefits are maintaining muscle tone, strength, and endurance as well as improving overall well-being and reducing low back pain and the pain associated with labor.[13,14] Research efforts examining the effects of exercise in pregnant women have largely focused on physiological responses of the fetus and birth outcomes after aerobic exercise.[15] An exhaustive computerized literature search reveals a paucity of scientific studies on the effects of exercise on the health, muscle strength, and function of the pregnant mother. Additionally, Hall and Kaufmann[16] report that the effects of strengthening exercise on pregnant women have not been adequately studied in scientific literature. Exercise improves the tone and strength of the abdominal muscles. As a result, strengthening the abdominal muscles during pregnancy should help to decrease the incidence and/or size of the DRA.[1] To date, no studies have specifically examined pregnant women who performed abdominal exercises in relation to DRA.

PURPOSE

The purpose of this investigation was to determine if there was a difference in the presence and size of DRA in women who exercised their abdominal musculature compared to those who did not exercise during pregnancy. In this study, we considered a DRA to be separation of the rectus abdominis muscles at the linea alba greater than 2 cm above the arcuate line and greater than 1 cm below the arcuate line. A secondary purpose was to determine if there was a difference in the location of the DRA between the two groups. We hypothesized that DRA would be more frequently found and larger in size at each location in non-exercising women.

METHODS

Subjects

Twenty-four pregnant women agreed to participate in this study. Women were included if they were between 20 and 40 years of age, and between 16 and 35 weeks of a singleton pregnancy. Women were excluded from participation if they were carrying multiple fetuses or their pregnancy was considered to be high risk secondary to hypertension, diabetes mellitus, heart conditions, alcohol, or drug use. Potential subjects for the pregnant, exercising group were women who had completed a 6- week prenatal exercise program (exercising group). Specific exercises are listed in Table 1. Subjects in this group were recruited following their participation in a prenatal exercise class in which the examiners briefly explained the study purpose and procedures and provided a written flyer with study information. Subjects who wished to participate placed their name and telephone number on a separate list and were contacted by the investigators to arrange an appointment. Potential subjects for the pregnant, non-exercising group were recruited at a private obstetrics/gynecology office (non-exercising group). For recruitment, the physician's staff presented

Table 1. Prenatal Exercise Program

Exercises	Position	Frequency
Pelvic Tilts	Supine, Standing, Quadruped	10 repetitions, one set for each position
Advanced Pelvic Tilts	Supine position with a head lift	At least 10 repetitions, one set
	Sitting	100 repetitions, 5 sets
	Supine	10 repetitions
Transverse Abdominis Contraction Head Lifts with Splinting Kegels		
1. Quick contractions	Sitting	At least 20 repetitions, 5 sets for quick contractions
2. Sustained contractions	Sitting	At least 10 reps, 5 sets for sustained contractions
Transverse Abdominis contraction with upper extremity strengthening using an exercise band.		
1. Military Press	Sitting	Sitting 12 repetitions, 2 sets
2. Lateral Raises	Sitting	12 repetitions, 2 sets
3. Chest Press	Sitting	20 repetitions, 2 sets
4. Shoulder External Rotation	Sitting	10 repetitions, 4 sets
5. Scapular Retraction	Sitting	20 repetitions, 2 sets
6. Biceps Curls	Sitting	20 repetitions, 2 sets
7. Triceps Extension	Sitting	10 repetitions, 2 sets
8. Forward Pull	Sitting	10 repetitions, 2 sets
9. Overhead Pull Sitting	Sitting	20 repetitions, 2 sets
Transverse Abdominis contraction with lower extremity strengthening using an exercise band.		
1. Hip Abduction	Sidelying	10 repetitions, 2 sets
2. Hip Flexion	Sidelying	10 repetitions, 2 sets
3. Hip Adduction	Sidelying	10 repetitions, 2 sets
4. Bridging	Supine	20 repetitions, 2 sets

potential subjects with a written flyer delineating general information about the study. Interested subjects left their name and telephone number on a separate sheet and were then contacted by the study investigators. Additionally, subjects in the non-exercising group were excluded if they were participating in regular exercise such as aerobic conditioning or strengthening for a duration of greater than 20 minutes per week.

The study sample initially consisted of 24 pregnant women, 12 of whom were exercising and 12 of whom were not currently in any formal exercise program. Two women were excluded because they developed high risk pregnancies, one was excluded because she did not maintain the exercise criteria, and 3 women who initially consented to participate did not appear for their appointments. Thus, the study sample consisted of 18 women, 8 of whom participated in a prenatal exercise program. All women in the exercise group were Caucasian. In the non-exercise group one woman was Hispanic, one was Asian, and the rest were Caucasian. Prior to testing, all subjects read and signed a statement of informed consent which had been approved by the Columbia Presbyterian Medical Center Institutional Review Board. Subject characteristics for exercising and non-exercising groups of pregnant women can be found in Table 1.

Exercise Program

This prenatal exercise program consisted of 6, 90-minute classes which focused on abdominal muscle strengthening, pelvic floor exercises, and education in prenatal body mechanics.

Instrumentation

A nylon digital caliper (Mitutoyo America Corporation, Aurora, IL) was used to measure DRA and is depicted in Figure 1. Reliability has previously been established using a dial caliper to measure DRA. Moderate inter-rater reliability [ICC (3,1)=0.62] was found by Boxer and Jones[17] while Hitchman et al[18] demonstrated high intra-rater reliability for 3 examiners [ICC (2,k) = 0.90-0.93]. A blinded inter- and intra-rater reliability pilot study of the digital caliper was conducted for the 2 examiners in this study prior to data collection. Using a sample of pregnant women not included in the study, examiners exhibited high inter-rater reliability [ICC (3,1) = 0.87] and high intra-rater reliability [ICC (3,1) = 0.997 and 0.995].

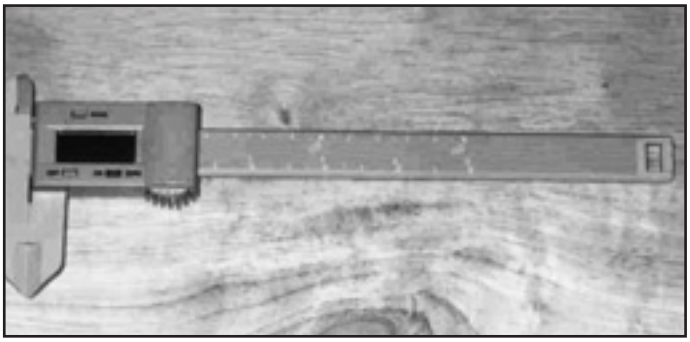

Figure 1. The nylon digital caliper used for DRA measurement (Mitutoyo America Corporation, Aurora, IL).

Procedures

The investigators contacted women who had indicated a willingness to participate and conducted a brief telephone interview to determine their eligibility. If a woman was suitable for this study, an appointment was made for the measurement session at the exercise facility or prior to or following her next scheduled obstetrician appointment. The subject's height, weight, age, and week of pregnancy were then recorded. Subjects from the exercise program were measured on a standard exercise mat. Non-exercising subjects were measured on a flat examination table in the doctor's office.

In keeping with previous research,[8] DRA was measured at the following 3 locations: at the umbilicus, 4.5 cm above the umbilicus, and 4.5 cm below the umbilicus (Figure 2). A tape measure was applied to the subject's abdomen and each site was marked with a water-soluble pen to ensure accuracy of repeated measurements. The subject was asked to lie on her back in a hook-lying position, arms extended at her side, with one pillow placed beneath the head. The subject was asked to lift her head and shoulders off the mat, reaching towards her knees with outstretched arms until the spine of the scapulae cleared the surface. The subject was asked to maintain this position for approximately 10 to 20 seconds to allow the examiner to palpate the rectus abdominis muscles. The subject was then allowed to rest with the examiner's fingers remaining on the rectus abdominis muscles. The subject then repeated the movement, maintaining a partial curl-up while the examiner placed the measuring probes of the calipers against the medial borders of the rectus abdominis muscles, perpendicular to the surface of the muscles (Figure 3). Two DRA measurements were made at each of the three abdominal locations. One examiner took measurements using the caliper and another examiner provided manual assistance and support beneath the subject's shoulders. Each subject's group membership was known based on the facility location. To limit the potential for bias, the examiner measuring the DRA held the caliper with the numerical display out of view and handed the caliper to the second examiner to read and record the measurement. The subject rested in a side-lying position in between measurements and was permitted to rest at any time if fatigued.

Figure 2. Skin markings and measurement location: at the umbilicus, 4.5 cm above the umbilicus, and 4.5 cm below the umbilicus.

Figure 3. Measurement of a Diastasis Recti Abdominis with digital caliper during an abdominal curl-up.

Data Analysis

Averages were computed for each of the two DRA size measurements obtained at the 3 abdominal locations and used in further analyses. Descriptive statistics were generated for subjects relative to height, weight, age, and week of pregnancy as well as DRA size at each DRA location site. Independent sample *t* tests were used to determine if differences existed in subject characteristics between groups (Table 2). There were no initial differences between groups ($P > .05$) for age, height, mass, or week of pregnancy. As the number of previous pregnancies was found to be significantly different between-groups ($P = .02$), this characteristic was used as a covariate in subsequent analyses. A mixed 2 X 3 analysis of covariance with one between subjects factor (group: exercising and non-exercising) and one within-subject factor (DRA location: 4.5 cm above umbilicus; at the umbilicus; and 4.5 cm below the umbilicus) was used to analyze differences between diastasis recti size with number of previous pregnancies as the covariate. Significance was based on $P < .05$ for all tests. All analyses were performed on a personal computer using the SPSS version 10.0 statistical software package (SPSS, Chicago, IL).

Table 2. Subject characteristics for exercising and non-exercising groups of pregnant women. There as no difference between groups ($P > .05$) for age, height, mass or week of pregnancy. There was a difference between groups for number of previous pregnancies ($P = .02$).

	Group		
Subject Characteristics	**Exercise (n = 8)**	**Non-exercising (n = 10)**	***P* Values***
Age (years)			
Mean	32.0	30.4	.322
Standard Deviation	2.20	3.95	
Range	29-35	25-37	
Height (cm)			
Mean	420.7	387.6	.324
Standard Deviation	9.30	5.08	
Range	160.0-177.8	157.5-170.2	
Mass (kg)			
Mean	75.1	69.2	.396
Standard Deviation	19.72	7.78	
Range	55.3 -117.0	63.9-86.2	
Week of Pregnancy			
Mean	25.5	25.6	.970
Standard Deviation	6.10	5.20	
Range	17-35	20-34	
Number of Previous Pregnancies#			
Mean	1.25	2.3	.029
Standard Deviation	0.46	1.16	
Range	1-2	1-4	

*Independent *t* tests performed.
$\alpha < 0.05$.

RESULTS

Ninety percent of the non-exercising pregnant women exhibited a DRA or a separation of the rectus abdominis greater than 2 cm while only 12.5% (1 of 8) exercising pregnant women exhibited a DRA at any of the 3 locations (Figure 4). The mean size of the DRA or separation at each location is graphically represented in Figure 5. The mean DRA located 4.5 cm above the umbilicus was 9.6 mm (± 6.55) for the exercise group and 38.9 (± 17.80) for the non-exercise group. The mean DRA located at the umbilicus was 11.4 mm (± 3.82) for the exercise group and 59.5 (± 23.61) for the non-exercise group. The mean DRA located 4.5 cm below the umbilicus was 8.2 mm (± 7.43) for the exercise group and 60.4mm (± 28.96) for the non-exercise group. Thus, DRA averaged 29.3 mm larger above the umbilicus (405%), 48.1 mm larger at the umbilicus (522%), and 52.2 mm larger below the umbilicus (736%) in the non-exercising group of pregnant women. The results of the ANCOVA (Table 3) revealed that there was no significant interaction between abdominal location of DRA and group ($P = .063$) which is graphically depicted in Figure 6. The main effect of exercise group was statistically significant ($P = .0009$), however the covariate, number of previous pregnancies, was not statistically significant ($P = .611$). There was no statistically significant main effect of abdominal location of DRA ($P = .680$). Therefore, the group of pregnant women who did not participate in an abdominal exercise

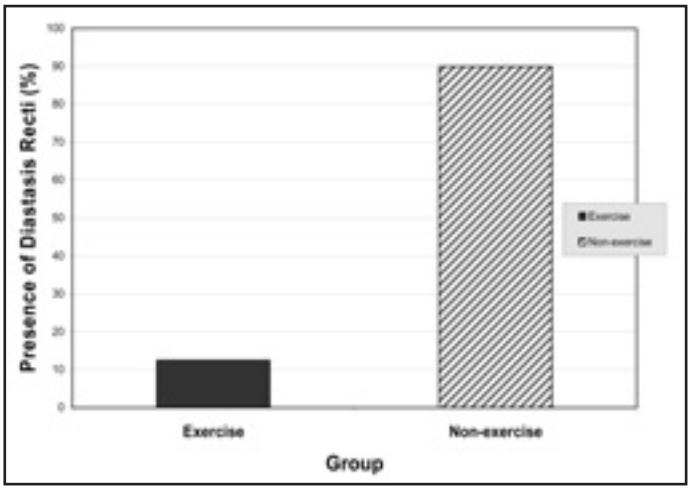

Figure 4. The percentage of pregnant women who presented with a Diastasis Recti Abdominis at any location by group: exercising women (12.5%) and non-exercising women (90%).

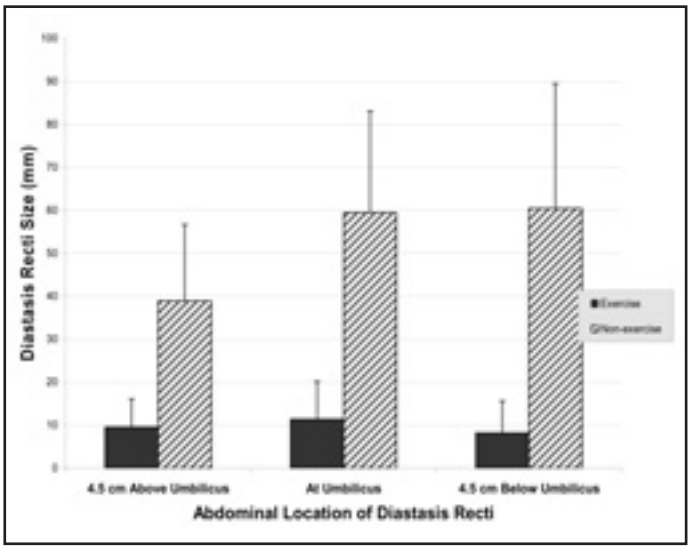

Figure 5. Means and standard deviations for Diastasis Recti Abdominis size at each abdominal location by group.

Table 3. Results of 2 x 3 ANCOVA. The with-in subject factor was DR location (4.5 cm above umbilicus, at the umbilicus and 4.5 cm below the umbilicus). The between-subject factor was group (exercise, non-exercise). The covariate was the number of pregnancies the subject had prior to this current pregnancy.

Source	***df***	**Type III SS**	**F**	***P* value**
Group	1	16363.1	16.914	0.001
Prior Pregnancies	2	89.4	0.422	0.659
DR	2	82.7	0.391	0.680
DR x Group	2	642.5	3.033	0.063

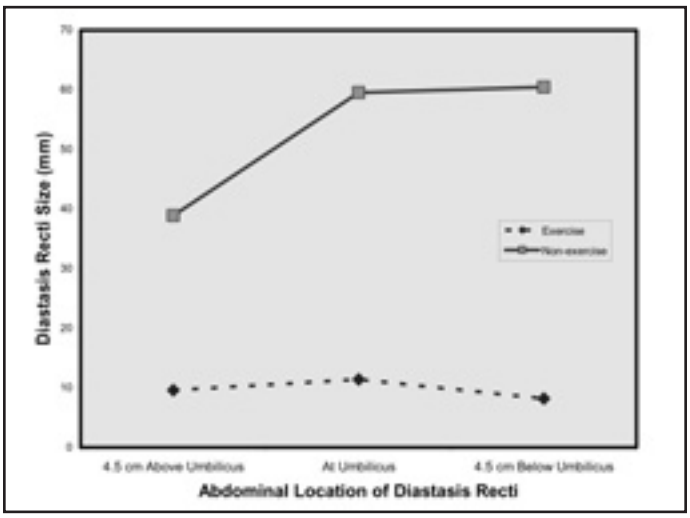

Figure 6. Plot of interaction between abdominal location of Diastasis Recti Abdominis and group (P = .063).

program exhibited a statistically larger separation of the rectus abdominis regardless of the location of measurement and the number of previous pregnancies.

DISCUSSION

This study is unique because it was specifically designed to precisely measure DRA in pregnant women who were actively engaging in an abdominal exercise program. To date, the direct effects of an abdominal exercise during pregnancy have not been reported in the literature. The group of pregnant women who participated in an abdominal exercise program exhibited a significantly smaller separation of the rectus abdominis regardless of the location on the abdomen. The abdominal exercises performed by the pregnant women in this study may have prevented the onset of DRA and suggest that abdominal strength is a critical factor in the development of abdominal muscle separation in pregnancy. We believe that the maintenance of abdominal strength throughout pregnancy should be a priority for clinicians and that the role of abdominal exercise in the amelioration of DRA should be investigated further.

Our findings are consistent with an observation made by Boissonnault and Blaschak[2] that women who were not exercising during their pregnancy, but had exercised prior to pregnancy and appeared with well-conditioned abdominal muscles, did not exhibit a DRA. In contrast, Gilleard and Brown[8] found a DRA in all women despite the fact that they were consistently exercising during their pregnancy, participating in a variety of activities such as cycling, aerobic classes, brisk walking, circuit training, weights, and swimming. These apparent discrepancies in the literature might be a result of the type of exercise performed. The distinctive feature of our study is that not only were the abdominal muscles specifically trained in the pregnant women's exercise program, but particular attention was placed on 'drawing-in' the umbilicus which activates the transversus abdominis.[19] Neumann[20] describes the connective tissue contributions of the abdominal muscles to the linea alba. The anterior rectus sheath is formed by the internal and external oblique muscles while the posterior rectus sheath is formed by the internal oblique and transversus abdominis. Both the anterior and posterior rectus sheaths surround and vertically orient the rectus abdominis, crisscross and fuse at midline, to provide strength to the linea alba and anterior abdominal wall. We believe that the exercises performed by the pregnant women in this study may have prevented the onset of a DRA because the exercises targeted the transversus abdominis as well as the internal and external obliques, thus strengthening the integrity of the linea alba as well as providing abdominal strengthening.

Comparisons of our results regarding the size and location of the DRA to the results of previous studies can be difficult because there is a lack of agreement on the size of an abnormal separation and the disparity in methodologies of DRA measurements. To determine the normal boundaries of the linea alba, Rath et al,[21] using abdominopelvic computed tomography, noted the normal separation of the 2 recti was 8.3 mm (± 5.6) above the umbilicus, 21.2 mm (± 8.1) at the umbilicus and 9.3 mm (± 6.7) below the umbilicus in subjects younger than 45 years. Despite the difference in techniques, the size of the separation seen in our pregnant exercising women (9.6 mm ± 6.6 above the umbilicus, 11.4 mm ± 8.8 at the umbilicus and 8.2 mm ± 7.4 below the umbilicus) is comparable to what Rath[21] found in nonpregnant normal adults. Thus, our results suggest that pregnant women who perform exercises specifically designed to engage the entire abdominal complex, including the transversus abdominis, may be able to retain the normal borders of the linea alba or prevent a diastasis.

However, we found conflicting results when we compared the size and location on the abdomen of the DRA in the non-exercising group of pregnant women to previous studies. Classifying a diastasis as any separation greater than 2 finger widths, Boissionault & Blaschak[2] reported the greatest percentage of women (52%) exhibited a DRA located at the umbilicus while only 36% demonstrated a DRA above umbilicus and 11% below the umbilicus. Using a 3-dimensional photographic method of measurement, Gilleard & Brown[8] also found the greatest separation above the umbilicus and the least below, reporting 62 mm at 4.5 cm above the umbilicus, 47 mm at the umbilicus, and 32 mm at 4.5 mm below the umbilicus. We found the opposite pattern of separation in our non-exercising group (38.9 mm $\pm$17.8 above the umbilicus, 59.5 mm $\pm$ 23.6 at the umbilicus, and 60.3 mm $\pm$ 29.0 below the umbilicus) with the greatest separation below the umbilicus and the least above. Statistically, the interaction between DRA size and location did not reach significance at .05 in our study. It is evident in Figure 5 that the greatest difference between groups is exhibited at and below the umbilicus. Our results suggest that our exercise program was most effective at decreasing the incidence of DRA at and below the umbilicus. It is unclear why we found a different pattern of separation, but this may be due to differences in measurement technique and unidentified sample characteristics. Due to the conflicting reports on the location for the greatest size of DRA, we recommend continuing to measure at all 3 locations as is customary.[2,8] It is however, important to note that for non-exercising pregnant women, all reports of DRA size exceed what Rath et al[21] believe to be a normal amount of separation thus substantiating the occurrence of this abnormality.

LIMITATIONS

Although our findings were significant, a few limitations exist which require interpretation of the results with some discretion. The relatively small, homogeneous sample size consisting of 8 exercising and 10 non-exercising women, most of whom were Caucasian, precludes the assumption that the sample was representative of all pregnant women. Additionally, the subjects were living in large urban or suburban areas and of high enough socioeconomic status to be seeing both a private physician and participating in a noncommunity based maternal fitness exercise program. The women who exercised were very conscientious about taking care of themselves, had good access to prenatal health care, and were extremely compliant with the exercises. Thus our findings may reflect these optimal conditions. We did not assess the women's level of fitness prior to pregnancy in either subject group, nor were pre-exercise measurements of DRA taken in the exercise group, and suggest that these factors be considered in further investigations. Future research should also investigate a

larger, more diverse sample of women with varying attitudes toward access to health care.

CONCLUSIONS

Based on the results of this investigation and despite its described limitations, we recommend that all clinicians examine pregnant and postpartum women for the presence of diastasis recti and intervene with appropriate abdominal exercises. While we believe that abdominal exercises are safe for normal pregnancies, it is important to observe the ACOG precautions for exercise during pregnancy and closely monitor patients' responses.

The results of this study suggest DRA during pregnancy may be prevented by abdominal exercise. The DRA occurred significantly less in pregnant women who participated in an exercise program targeting the abdominal muscle—specifically, the transversus abdominis. Diastasis recti abdominis appears to be common in non-exercising pregnant women as 90% exhibited a separation of the rectus abdominis. Because of the integral role the abdominal muscles play in functional activities, we recommend examining pregnant and postpartum women for the presence of DRA. We suggest abdominal muscle strengthening exercise be implemented during a normal pregnancy unless precluded by additional risk factors.

REFERENCES

1. Noble E. *Essential Exercises for the Childbearing Year.* Vol 4. Cape Cod: New Live Images; 1995.
2. Boissonnault JS, Blaschak MJ. Incidence of diastasis recti abdominis during the childbearing year. *Phys Ther.* 1988;68(7):1082-1086.
3. Hannaford R, Tozer J. An investigation of the incidence, degree and possible predisposing factors of rectus diastasis in the immediate post-partum period. *J Nal Obstet Gynecol Special Group of the Australian Physiotherapy Association.* 1985;4:29-32.
4. Bursch SG. Interrater reliability of diastasis recti abdominis measurement. *Phys Ther.* 1987;67(7):1077-1079.
5. Ranney B. Diastasis recti and umbilical hernia causes, recognition and repair. *S D J Med.* 1990;43(10):5-8.
6. National Plastic Surgery Statistics 2000/2001/2002. *The American Society of Plastic Surgeons*. Available at: http:www.plasticsurgery.org /medical_professionals/Publications. Accessed December 2, 2003.
7. Boissonnault JS, Kotarinos RK. Diastasis recti in obstetric and gynecologic physical therapy. In: Wilder e, ed. *Clinics in Physical therapy: Obstetrics and Gynecological Physical Therapy*. New York, NY: Churchill Livingstone, Inc; 1988:63-81.
8. Gilleard WL, Brown J, Mark M. Structure and function of the abdominal muscles in primigravid subjects during pregnancy and the immediate postbirth period. *Phys Ther.* 1996 1996;76(7):750-762.
9. Fast A, Weiss L, Ducommun EJ, Medina E, Butler JG. Low-back pain in pregnancy: Abdominal muscles, Sit-up performance and Back Pain. *Spine.* 1990;15(1):28-30.
10. Lo T, Candido G, Janssen P. Diastasis of the recti abdominis in pregnancy: risk factors and treatment. *Physiother Canada.* 1999:32 - 37.
11. Sheppard S. The role of transversus abdominus in post partum correction of gross divarication recti. *Man Ther.* 1996;1(4):214-216.
12. Toranto I. The relief of low back pain with the WARP abdominoplasty: A preliminary report. *Plast Reconstr Surg.* April 1990 1990;85(4): 545-555.
13. Patient Education Pamphlet AP119-Exercise During Pregnancy. *American College of Obstetrics and Gynecology*. Available at: http://www.acog.org/publicsearch/s97is.dll. Accessed December 2, 2003.
14. Patient Education Pamphlet AP115: Easing Back Pain During Pregnancy. *American College of Obstetrics and Gynecology*. Available at: http://www.acog.org/publicsearch/s97is.dll. Accessed December 2, 2003.
15. Kelderman C, Johnson L. Exercise and pregnancy: A review of the literature. *J Section Women's Health.* 1997;22(1):3-6.
16. Hall DC, Kaufmann DA. Effects of aerobic and strength conditioning on pregnancy outcomes. *Am J Obstet Gynecol.* 1987;157(5):1199-1203.
17. Boxer S, Jones S. Intra-rater reliability of rectus abdominus diastasis measurement using dial calipers. *Aust Physiotherapy.* 1997;43(2): 109-114.
18. Hitchman K, Thompson J, Boxer S, Jones S. Interrater reliability of rectus abdominis measurement using dial calipers. *Aust J Physiotherapy.* 1997;43(2):109-113.
19. Richardson CA, Jull GA, Hodges PW, Hides JA. *Therapeutic Exercise for Spinal Segmental Stabilization in Low Back Pain*. New York, NY: Churchill Livingstone; 1999.
20. Neumann DA. *Kinesiology of the Musculoskeletal System*. Philadelphia, Pa: Mosby; 2002.
21. Rath A, Attali P, Dumas JL, Goldlust D, Zhang J, Cheverl JP. The abdominal linea alba: an anatomo-radiologic and biomechanical study. *Surg Radiolc Anat.* 1996;18:281-288.