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ABDOMINAL EXERCISES ENHANCE CLOSURE OF DIASTASIS RECTI ABDOMINIS CONDITION AND IMPROVES QUALITY OF LIFE AMONG WOMEN WHO HAVE UNDERGONE MULTIPLE PREGNANCIES

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Abstract: Background: Diastasis recti abdominis (DRA) is a common maternal ailment seen especially among women who have undergone multiple pregnancies and births. This condition presents as an abnormal gap existing between adjacent recti abdominis muscles, also known as inter-recti distance (IRD). It is characterized by weakness of the abdominal segment and impairment of effective trunk function. The purpose of this work was to examine the impact of abdominal exercises on the closure of IRD dysfunction and enhancement of quality of life among multiparous women. **Method**: A cross-sectional survey method was utilized in the study. Thirty multiparous women who also present with various degrees of symptoms of DRA were randomly assigned into two groups of experimental – 23 and control - 7. The 23 women in the experimental group also served as their own control while 8 of them compared with the control group. **Results:** Using the analysis of variance (ANOVA), the exercise group recorded significantly decreased mean IRD at $p< 0.05$, and also were able to carry out more sustained crunch exercises, when compared to the control group. Within the exercise group, there was also comparative significant increase in mean abdominal muscle strength. **Conclusions:** The outcome of the study shows that exercises may enhance abdominal muscle strength and potentiate closure of IRD, as well as improve functional activities of daily living in postpartum women.

Keywords: Inter-recti distance, Postpartum, Exercise, Multiparous

Background of the study

Closely associated with postpartum abdominal muscle weakness is a condition known as diastasis recti abdominis (DRA), which is defined as an increase in the inter-recti distance, or width of the linea alba. This condition is variously defined by different authors as separation of the recti bellies at the linea alba when the inter-recti distance is greater than 1.5 cm; greater than 2 cm; greater than 2.5 cm; greater than 2 finger widths during a partial sit-up.[1 - 5] Inter-recti distance in some cases is believed to resolve spontaneously, but the extent to which this resolution occurs is uncertain.[6] The prevalence of DRA is essentially pronounced in multiparous women. This is exemplified in a previous work which recorded 35% immediate occurrence on postpartum women.[3] A similar work also

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recorded the existence of IRD in as much as 66% of third trimester women in a cross-sectional study.[7]

The locations of IRD are mainly above and below the umbilicus. Rett et al.,[8] noted that the prevalence of DRA and mean DRA were greater above the umbilicus both among multiparae and primiparae. Below the umbilicus, the mean DRA was greater among multiparae. Boissonnault and Blaschak[7] also recorded the greatest incidence of DRA around the umbilicus. The objective of this study was therefore to evaluate the effect of exercises on the reduction of inter-recti distance, as well as improvement in abdominal muscle strength and quality of life in women with DRA.

Methods

Study Design

This was a cross-sectional survey of effects of exercise in the reduction of IRD and improvement of muscle strength and quality of life of women with diastasis recti abdominis.

Data collection procedure

Thirty multiparous postpartum women with age range 29 – 44 years, and mean age 36.7 ± 2.76 years who participated in the study were randomly assigned into two groups, group A (isometric) 23 in number, and group B (control) 7 in number. The 23 women in the experimental (isometric) group A also served as their own control while 8 of them compared with the control group. Initial IRD were measured for all participants using 7.5-MHz Linear diagnostic ultrasound transducer, model: NeuSonic Pi by NewTech Medical. Group A subjects were then placed on isometric abdominal muscle contraction, two sessions daily (morning and evening) at 30 minutes per session in three batches of 10 minutes each, with 2 minutes resting period between each batch and for a period of four weeks. Baseline IRD measurement was first done and recorded for each participant, followed by weekly measurements, for the entire duration of the study. The group B subjects were not given any abdominal exercises but were placed on routine 30 minutes morning jog for the same period of four weeks, with weekly IRD measurements. The avoidance of abdominal exercise in group B subjects was necessary so as to check for any possible spontaneous IRD resolution. Each subject was asked to lie supine in a crook-lying position (knees bent, feet flat on the couch) with her arms at her side. The measurement sites on the abdomen were marked with a water-soluble pen at the superior and inferior borders of the umbilicus, 2.5 cm above the superior border of the umbilicus, and 2.5 cm below the inferior border of the umbilicus. These landmarks on the abdominal wall were regarded as typical locations for prevalent occurrence of DRA.[7, 8] Next, the woman was asked to perform a modified curl-up. The examiner demonstrated one curl-up for the subject to show how high the curl-up should be (scapula about 10 degrees off the couch, back supported with pillows). Ultrasound imaging transducer was then placed perpendicular to the linea alba on the marked points (2.5cm above and 2.5cm below the umbilicus) as proposed by Chiarello and McAuley,[9] and measurement values recorded.

The transducer frequency of 7.5 MHz was chosen as it is considered appropriate in superficial and linear measurement of IRD both in females and males (Mendes *et al*., 2007). The sonographer was a specialist clinical radiographer and radiological scientist with sixteen years practical experience.

Exercise Prescription

These therapeutic exercise regimes were as adapted from Thomson *et. al*.,[10] Downie,[11] Brayshaw and Wright.[12] Subjects in the experimental group were made to undertake static muscle (isometric) exercises as follows: Supine lying- trunk raised to about 45 degrees from the couch and held to a slow count of 10, repeated to 10 times, with 30 seconds rest between each set; Progress to 20 counts in the same position and resting interval; Crook lying- both arms

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reaching for the knees and held for 15 slow counts, repeat 20 times, with in-between resting period of 45 seconds; Progress to 30 counts in the same position and resting interval.

These exercise regimes were done twice daily – morning and night, for a period of four consecutive weeks.

Measurement

Ultrasound Imaging (USI) machine

The ultrasound imaging (USI) unit was used to measure the gap between the two rectus abdominis muscles (IRD) created by recti diastasis at the linear alba. This instrument has been validated. The inter-rater validation by several authorities, [4, 6, 13 - 15] presents the instrument as a reliable source of measuring IRD with minimal error. The inter-rater reliability compared to caliper method is 0.79 - 0.71, Chiarello and McAuley.[9] The USI unit used in this study was 7.5-MHz Linear diagnostic ultrasound transducer, model: NeuSonic Pi by NewTech Medical. All measurement were in centimetres. Initial inter-recti distance for all subjects were recorded. Thereafter weekly IRD were likewise measured and recorded for consecutive four weeks.

Data analysis

A 2-way mixed ANOVA was utilized to draw comparison of the mean value differences both within and between groups. All analyses and imputation procedures were done using SPSS software version 15. Statistical significance was set at $p < 0.05$ at 95% confidence interval.

Results

Demographic Characteristics of Subjects in the Study

A total of 30 women of 4 to 6 weeks postpartum participated in this study. They were all multigravida who had two to five pregnancies, and were distributed as follows: eight experimental group A, seven control group B, and twenty three experimental group C (15 + 8 in group A) who also served as their own control. The participants were within the age range of 27 – 44 years, with a mean age of 39.33 ± 2.71 years.

Table 1: Descriptive Comparison of the closure of the upper Inter-recti Distance in experimental and control groups across the Periods.

Time	Group	mean	S.D	N
Baseline	Experimental	5.4500	1.87845	8
	Control	4.8000	2.04532	7
	Total	5.1467	1.91567	15
Week 1	Experimental	5.0250	1.93298	8
	Control	4.8000	2.04532	7
	Total	4.9200	1.91692	15
Week2	Experimental	4.7000	1.94275	8
	Control	4.7714	2.13675	7
	Total	4.7333	1.96093	15
Week3	Experimental	4.3625	1.91307	8

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	Control	4.6857	2.09478	7
	Total	4.5133	1.93349	15
Week4	Experimental	4.0750	1.98692	8
	Control	4.6571	2.09432	7
	Total	4.3467	1.98597	15

Table 3: Test of within subject effect for upper and lower Inter-recti distance resolution.

Source	sum of square	df	mean square	F value	p value
Upper IRD					
Time (Weeks)	5.438	4	1.360	32.351	0.000*
Time*condtn.	3.433	4	0.858	20.422	0.000*
Error	2.185	52	0.042		
Lower IRD					
Time	6.592	4	1.648	26.263	0.000*
Time*condtn.	4.384	4	1.096	17.466	0.000*
Error(time)	3.263	52	0.063		

Key: IRD = Inter-recti distance.Time = Inter-recti distance periodic closure effects in weeks.
Time*condtn. = Relationship between the initial status of inter-recti distance and its resolution effects through the weeks. *Statistically significant value

Table 3: Test of between subject effects for upper and lower inter-recti distance resolution using 2-way mixed ANOVA.

Source	sum of square	df	mean square	F value	p value
Upper IRD					
Intercept	1672.402	1	1672.402	84.078	0.000*
Condition	0.008	1	0.008	0.985	0.000 *
Error	258.583	13	19.891		
Lower IRD					
Intercept	1608.162	1	1608.162	80.845	0.000*

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Condition	0.213	1	0.213	0.011	0.919
Error	258.595	13	19.892		

Key: IRD = Inter-recti distance. *Statistically significant value.

A 2–way mixed ANOVA of the upper IRD closure performance in both experimental and control groups showed remarkable marginal difference in the mean values between the groups across time series (Table 1). However, this difference is not statistically significant set at $p < 0.05$ and $f > 2.61$. The test within subject revealed significant difference in closure with time ($f = 32.35$ $p = 0.00$). The interaction effect between time and condition was also statistically significant ($f = 20.422$, $p = 0.00$), as shown in Table 2 This is an indication that upper inter-recti distance (IRD) closure is directly related to time.

When compared, the upper IRD closure ($f > 4.67$, $p < 0.05$) in both groups presented no significant difference ($f < 4.67$, $p > 0.05$) as indicated in Table 3. However, the marginal closure difference between the experimental and control groups was consistent down the time series.

Comparison of Mean Inter-recti distance Resolution between the Experimental and Control Groups at the Lower aspect of umbilicus

All through the four weeks marginal lower IRD closure mean difference occurred in favour of the experimental group. However this difference is not statistically significant (Table 4). Essentially, the marginal difference within time is consistent for both groups. The difference within the control group could be considered to represent the spontaneous resolution as described by Liaw et al., (2011) in a cohort study of 40 postpartum women. It is not clear however what is responsible for marginal mean difference observed between the upper and lower IRDs across the time series. Notably, the marginal mean change in closure of lower IRD for the subjects in the experimental group over time was greater than that of control group.

Test within subject effect for the lower IRD closure (Table 2) at $p < 0.05$, $f > 2.61$ indicated statistical significance with time ($f = 26.263$, $p = 0.000$) showing that complete resolution of lower IRD could be achieved at longer time. The interaction effect between time and lower IRD closure was also statistically significant ($f = 17.466$, $p = 0.000$). Comparatively, lower IRD closure between subjects was found to be statistically significant ($f > 4.65$, $p < 0.05$), indicating relativity in closure among subjects in both groups, as shown in Table 3.

Table 4: Descriptive statistics of the closure of the lower inter-recti distance in experimental and control groups across periods.

Time	group	mean	S.D	N
Baseline	Experimental	5.4000	1.78165	8
	Control	4.7714	2.09819	7
	Total	5.1067	1.89189	15

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Week1	Experimental	4.9375	1.95224	8
	Control	4.7429	2.11619	7
	Total	4.8467	1.95845	15
Week2	experimental	4.5500	2.01494	8
	Control	4.6857	2.11773	7
	Total	4.6133	1.98921	15
Week3	Experimental	4.1625	1.88220	8
	Control	4.6429	2.05820	7
	Total	4.3867	1.91007	15
Week4	Experimental	3.8875	2.01667	8
	Control	4.6286	2.06778	7
	Total	4.2581	2.04221	1

*Statistically significant value

Table 5: Characteristic resolution of rectus abdominis separation in different weeks.

		Mean ± SD	95%Confidence Lower bound	Interval Upper bound	df	F	p-value
2cm above Umbilicus	Baseline	4.36 ± 1.46	3.73	4.99	4	3.83	0.006*
	Week 1	4.02 ± 1.42	3.40	4.63			
	Week 2	3.65 ±1.44	3.02	4.27			
	Week 3	3.25 ± 1.43	2.63	3.87			
	Week 4	2.86 ± 1.52	2.20	3.52			
2cm below Umbilicus	Baseline	4.23 ± 1.41	3.64	4.36	4	3.61	0.008*
	Week 1	393 ± 1.41	3.23	4.54			
	Week 2	3.62 ± 1.42	3.00	4.23			
	Week 3	3.19 ± 1.38	2.60	3.79			
	Week 4	2.84 ±1.49	2.20	3.49			

*Statistically significant value

Characteristic resolution of rectus abdominis separation in different weeks.

There was notable resolution of recti diastasis 2.5cm above and below the umbilicus as the isometric exercises progresses through the four weeks duration. It was found out that there were progressively significant reduction of inter-recti distance above and below the umbilicus from baseline to fourth week ($p< 0.05$). Characteristically, the

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resolution pattern indicates progressive approximation all through the four weeks in both the upper and lower aspects of the umbilicus. These closures are statistically significant in relation to the baseline in the two locations of the linea alba, 2cm above the umbilicus (P=0.006) and 2cm below the umbilicus (P = 0.008), as shown in table 5.

Though progressive in nature, this relativity in the resolution indicates that isometric abdominal exercises actually played strengthening role in the experimental group. When this toning effect was compared at the upper and lower aspects of the umbilicus, no significant difference was established between their extents of closure, though there was marginally higher improvement above than below the umbilicus. This finding means that exercise induced inter-recti distance resolution quality does not necessarily depend on location of occurrence of this separation.

Discussion

It is pertinent to note that isometric exercise played a leading role in approximation of the inter-recti distance both at the upper and lower abdomen. This may be attributed to the fact that the exercise type functions essentially in muscle toning and thus approximation of muscle fibres. This action is most likely responsible for the narrowing of the gap between the two recti muscles at the linea alba, above and below the umbilicus. Results from this study have shown a marginal difference in the reduction of inter-recti distance between the upper and lower margins of the umbilicus. This result seems to be in agreement with that of Liaw, et al.,[6] who recorded 1.80 ± 0.72 cm and 1.16 ± 0.58 cm respectively for upper and lower margins of the umbilical ring. However, it is not clear why this difference exists, and this provides justification for further research.

Significant mean differences in reduction of inter-recti distance also exist among experimental participants in the study. This could be as a result of individual intrinsic differences in muscle response to exercises. It could also represent level of accuracy in the exercise performance among subjects. Resolution of inter-recti distance was also progressive with time. This means that given a long time this effect could be greater, and may subsequently lead to complete closure.

Comparatively, the mean difference in inter-recti distance closure between the experimental and control groups was only marginal in favour of the experimental group. However this difference was not statistically significant. It is possible that spontaneous recovery effect may have played a major role in the control group. The combination of this effect, with the effects of isometric exercise could have given the experimental group the lead. The difference within the control group could be considered to represent the spontaneous resolution as described by Liaw et al.,[6] in a cohort study of 40 postpartum women. It is not clear however what is responsible for marginal mean difference observed between the upper and lower inter-recti distances across the periods.

The results obtained in this study (Table 4) further revealed that there was no mean significant difference in the baseline IRD in the lower abdomen between experimental and control groups (5.400 ± 1.781cm and 4.771 ± 2.098 cm respectively). However the experimental group achieved progressive IRD resolution marginally greater than the control group down the time series. At the fourth week the mean IRD resolution relationship were 3.887 ± 2.061cm and 4.628 ± 2.067cm respectively for experimental and control groups. This increased inter-recti distance closure in the experimental group over the control group was found to be statistically significant. This implies that inter-recti gap reduced more readily in the experimental group than in the control group. The overall closure mean values showed 1.513 ± 1.90cm for experimental group and 0.14 ± 2.08cm for control group. This result seems to have similar closure pattern with those obtained by Pascoal et al., [16] who recorded 1.07 ± 3.1cm and 1.34 ± 3.1cm respectively when

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they compared inter-recti distance resolution between postpartum women who had isometric contraction and others at rest. The upper inter-recti gap resolution pattern between the experimental and control groups followed an incremental order in favour of the former which was not essentially different from the lower abdominal values.

The role of myogenic satellite cells:

The approximation in the muscular myofibres which is largely responsible for the resolution of recti diastasis appears to be more marked during isometric contraction. It is therefore possible that some biochemical muscle markers that are naturally activated by damage or muscular exercise may play a role in reducing the gap created by recti diastasis. This assertion may be supported by the action of myogenic satellite cells seen in the works of Bischoff [17] and Schulz and Mc Cormick[18] where they found out that these cells though quiescent in unperturbed state are activated in response to myotrauma and vigorous muscular activities to proliferate and bring about regeneration of damaged skeletal muscles. This action is secondary to the fussion of these myogenic satellite cells to existing muscle fibres to form new myofibres. Mauro[19] also factored in these cells as essential mediators in the toning of postnatal abdominal muscles, as well as their regeneration and growth. Though the action of these myogenic satellite cells were not studied in this work, their theoretical non-activation status in this case could explain why the poor resolution of the recti diastasis in the control group was observed, as the muscle fibres solely depended on intrinsic spontaneous input. In other words, these cells were not activated since the muscle fibres were devoid of mechanical stretch and contraction that accompany isometric exercises.

Characteristically, the inter-recti distance resolution pattern as obtained in this work indicates progressive approximation all through the four weeks in both the upper and lower aspects of the umbilicus. These closures are statistically significant in relation to the baseline in the two locations of the linea alba, 2cm above the umbilicus ($P=0.006$) and 2cm below the umbilicus ($P = 0.008$).

Though progressive in nature, this relativity in the recti diastasis resolution indicates that isometric abdominal exercises actually played muscle strengthening role in the experimental group. When this toning effect was compared at the upper and lower aspects of the umbilicus, only marginal difference in favour of the former was established between their extents of closure. This finding means that exercise induced inter-recti gap resolution quality does not necessarily depend on location of occurrence of this separation.

Comparison of recti diastasis resolution among participants in the four weeks of isometric exercises shows statistical significance ($P < 0.05$) between the baseline and fourth week both 2.5cm above and below the umbilical margin. However this was not the case with the first, second and third weeks.

This finding shows that given a longer period of isometric exercises, patients of recti diastasis could achieve full resolution. However, this chance of full recovery would be predicated on consolidated and accurate exercise performance. The outcome can be compared with high IRD recovery achieved by Liaw et al, (2001) in their longitudinal cohort study of forty postpartum women after 7 weeks of isometric exercises.

Conclusion

Isometric exercise can improve the recovery of diastasis recti abdominis, especially when sustained for a long period of time, and this can improve abdominal muscle strength and functional quality of life. Approximation of inter-recti distance under the influence of exercise protocol should be expected to commence at about the second week of the programme. Closure rate of inter-recti distance between the upper and lower margins of the umbilical ring follow similar pattern, but slightly higher in the upper margin. Clinicians should integrate isometric exercises in

the intervention plan for the management of diastasis recti abdominis, so as to facilitate timely reduction in size and eventual resolution of inter-recti distance in postpartum women.

Treatment plan for diastasis recti abdominis should be assigned sufficient time in order to achieve maximum benefit of programmed exercises. Further randomized clinical trials utilizing additional outcome measures such as electromyography results of the abdominal muscles would give additional and more accurate information.

Limitations

This study was not concluded without some notable limitations. These limiting factors though effectively managed posed remarkable challenges to the overall outcome of this work. The location of the study was quite a distance from the researcher's base, with the implication of paucity of follow-up of subjects. Reluctance on the part of participants in carrying out exercise instructions in the absence of the researcher and presentation of self for routine sonographic checks posed serious challenge to accurate data collection. Paucity of fund also contributed to some of the inadequacies and challenges experienced in this research. In all, this study cannot be said to be exhaustive and so efforts should be made towards engaging more number of subjects, exploring other useful method options, as well as using current measurement instruments.

Conflict of Interest

There is no conflict of interest for the authors to declare

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Contributions of Authors

Sylvester E. Igwe: This author engaged essentially in the study concept, design, follow-up, and data collection, as well as initial drafting and revision of manuscript. Goddy C. Okoye: Data analysis and critical revision of the manuscript. Both authors worked together and approved the final version of this manuscript.

References

1. Gilleard WL and Brown JM (1996). Structure and function of the abdominal muscles in primigravid subjects during pregnancy and the immediate postbirth period. Physical Therapy 76:750–62.

2. Lo T, Candido G and Janssen P. (1999). Diastasis of the recti abdominis in pregnancy: risk factors and treatment, Physiotherapy Can. 51 (1): 32 – 37.

3. Candido G, Lo T , Janssen PA . (2005). Risk factors for diastasis of the recti abdominis. *Journal of Association of Chartered Physiotherapists in Women's Health,* 97: 49 – 54.

4. Bursch SG. (1987). Interrater reliability of diastasis recti abdominis measurement. *Physical Therapy.* 67: 1077 – 1079.

5. Sheppard S. (1996). The role of transverses abdominus in postpartum correction of gross divarication recti. *Manual Therapy.* 1: 214 – 216.

6. Liaw LJ, Hsu MJ, Liao CF, Liu MF and Hsu AT (2011). The relationships between inter-recti distance measured by ultrasound imaging and abdominal muscle function in postpartum women: a 6-month follow-up study. Journal of

Orthopedic and Sports Physical Therapy 41:435–43

7. Boissonnault J, Blaschak M. (1988). Incidence of diastasis recti abdominis during the childbearing years. Phys Ther; 68:1082Bischoff R. *(*1997*). Chemotaxis of skeletal muscle satellite cells. Dev Dyn 208:505–515.*

8. Rett MT and Braga MD, Bernardes NO, Andrade SC. (2009). Prevalence of diastasis of the rectus abdominis muscles immediately postpartum: comparison between primiparae and multiparae. Revista Brasileira de Fisioterapia: 13 (4):275 -280.

9. Chiarello CM and McAuley JA, *(2013). Concurrent validity of calipers and ultrasound imaging to measure interrecti distance.Jounal of Orthopadic and Sports Physical Therapy. 43(7):495-503.doi: 10.2519/jospt.2013.4449.*

10. Thomson A., Skinner A. and Piercy, J. (1991). Tidy's Physiotherapy, 12th Ed., Butterworth-Heinemann, London. p. 385 - 401

11. Downie, P.A (1993). Cash's Textbook of General Medical and Surgical Conditions for Physiotherapists, 2nd Ed., Jitendar P. Vij, and New Delhi. p. 16 – 39.

12. Brayshaw, E. and Wright, P. (1994). Teaching Physical Skills for the Childbearing Year, 1st Ed., Books for Midwives, England. p. 110 - 189.

13. Boxer, S (1997). Intra-rater reliability of rectus abdominis diastasis measurement using dial calipers. *The Australian journal of physiotherapy 43.2: 109 - 114.*

14. Mota P, Pascoal AG, Sancho F and Bø K. (2012). Test-retest and intrarater reliability of 2-dimensional ultrasound measurements of distance between rectus abdominis in women. *Journal of Orthopedic and Sports Physical Therapy. 42(11):940-6.*

15. Mendes A, Nahas FX and Veiga DF (2007). Ultrasonography for measuring rectus abdominis muscle diastasis. *Acta Cir Bras.* 22 :182 – 186

16. Pascoal AG, (2014). Inter-rectus distance in postpartum women can be reduced by isometric contraction of the abdominal muscles: a preliminary case–control study. Physiotherapy, http://dx.doi.org/10.1016/j.physio.2013.11.006

17. Bischoff R. *(*1997*). Chemotaxis of skeletal muscle satellite cells. Dev Dyn 208:505 -515.*

18. Schultz E and McCormick KM. (1994). Skeletal muscle satellite cells. Rev Physiol Biochem Pharmacol 123:213–257.

19. Mauro A. *(1961). Satellite cell of skeletal muscle fibers.Journal of Biophysical and Biochemical Cytolology 9:493–498.*