

Muscle Activity in Upper and Lower Portions of Rectus Abdominis During Abdominal Exercises in Postnatal Women Having Diastasis Recti

Amel M.Youssef*, Adly A. Sabbour* and Ragia M. Kamel**

*Department of Physical Therapy for Gynaecology and Obstetrics, Faculty of Physical Therapy, Cairo University.

** Department of Basic Science, Faculty of Physical Therapy, Cairo University.

ABSTRACT

Background: Controversy exists around exercises that attempt to differentially activate the upper and/or lower portions of the rectus abdominis (RA) muscles in normal subjects. **Objective:** The purpose of this study was to assess the activation of the upper and lower portions of the RA muscles during a variety of abdominal muscle exercises in women having diastasis recti after normal vaginal delivery. **Study design:** Twenty eight multiparous (2-3 times) women after two months of normal vaginal delivery with the separation between two recti more than two fingers were selected from El Mataria Teaching Hospital. Electromyographic (EMG) activities of the upper and lower portions of the RA muscles, amount of separation between two recti, region of greatest separation and the presence of bulge of the abdomen were measured during curl up, posterior pelvic tilt, unilateral straight leg raising and double straight leg raising exercises. **Results:** Data revealed a statistically non significant difference in the muscle activity between the upper portions of the RA muscles, whereas there is a significant difference between the lower portions of the RA muscles across all exercises. Curl up exercise demonstrated a small difference between the two portions of the muscles while posterior pelvic tilt and double straight leg raising activated the lower portion than the upper portion of the RA muscles. There is no statistically significant change in the separation between two recti and bulge of the abdomen with all exercises except with performing double straight leg raising which represented a statistically significant increase in the separation as well as bulging of the abdomen. **Conclusion:** Posterior pelvic tilt and unilateral straight leg raising exercises is more strenuous than the curl up exercise on the lower portion of the RA muscles in women having diastasis recti after normal vaginal delivery but double straight leg raising should be avoided for such cases.

Key words: Rectus Abdominis, EMG, exercises, postnatal, diastasis recti.

INTRODUCTION

During pregnancy the female body undergoes many hormonal and anatomic changes that affect musculoskeletal system. These changes may cause various musculoskeletal complaints, predisposing to injury or alter the course of the preexisting ailments^{1,15}.

No doubt that, the abdominal muscles suffers a lot during pregnancy due to severely overstretching of their muscle fibers around the growing uterus. For this reason, they

usually seem flat, flabby and very weak immediately after delivery⁹. Because of this spinal stability is extensively affected by the lengthening of the abdominal muscles and the consequential changes in their ability to generate tension¹⁶. In which stretched and weakened abdominal muscles will not be able to support the back properly and this of course may cause severe backache¹⁴.

Diastasis recti occurs commonly in pregnancy and its incidence rates of more than 67%^{2,23} if the separation between upper and lower portion of them exceed 23cm

(2fingers)²³ and it is greater in multigravidae than primigravidae², that takes 3-6 months after delivery to return to the pre-pregnant state when there is a good planned postnatal exercise program²⁰.

Nowadays there is a contradiction about which type of abdominal exercise is more effective to restore their function capability without any hazard for these weak muscles after delivery. As Callinan-Moore³, stated that concentric oblique (diagonal sit-ups) exercises should be avoided in late pregnancy and postnatally, for fear of increasing the diastasis. A recent study reported by Ellson and Bullock-Saxton⁸, indicated that the non-resisted abdominal curl with rotation did not significantly increase the diastasis from its resting width. While Wohlfahrt et al.,²⁴ reported that slowly lift up to 30° and lower extended leg to the bed can increase abdominal strength without any harmful effects. In addition, Richardson and Jull²¹ reported that the isolated activation of the abdominal is achieved by asking the subject to slowly and gently draw the abdominal muscles for ten seconds particularly in the lower abdominal area. That resulted in a simultaneous isometric contraction of the multifidus posteriorly and this co-contraction assists in maintaining the neutral spinal posture. Also, Boissonnault and Blaschak² reported that dynamic trunk flexion exercise (trunk curl) should be avoided if there is a diastasis as it leads to bulging and loading on a weak muscle resulting in more weakness.

As mentioned above there are many exercises techniques for strengthening the abdominal muscles postnatal^{2,3,8,21,24}. Theoretically, there are many methods for strengthening the RA muscles in athletes. Many authors have postulated that exercises included movement of the trunk (curl up) could strength the upper portion of these

muscles^{19,22} and exercises involved straight leg raising and posterior pelvic tilt could influence strength in their lower portions^{4,21}, while others noting that trunk and/or raising lower limbs exercise create similar action potential within each portions of the RA muscles¹².

But, there is a lack of literature studying the effect of various types of exercise on the upper and lower portion of RA muscle recorded by EMG after normal vaginal delivery. So, the purpose of this study was to asses the activation of the upper and lower portions of the RA muscles during a variety of abdominal muscles exercises in women having diastasis recti after normal vaginal delivery.

SUBJECTS, MATERIALS AND METHODS

Subjects

Twenty eight multiparous (2-3 times) women were recruited from El Mataria Teaching Hospital after two months of normal vaginal delivery. Their average age, weight, height and body mass index were 24.5years, 62.6kg, 159.72cm, and 27.92kg/m² respectively. All women had no history of chronic low back pain, previous abdominal surgery, heart disease, musculoskeletal dysfunction or any other contraindications to exercise and did not take any medication that affect their EMG or performance of the exercise.

The separation between the upper (between xiphoid process and umbilicus) or lower (between umbilicus and symphysis pubis) portions of the two recti was more than two fingers (i.e. There was a diastasis recti abdomini muscles)²³ and the abdominal muscle power was less than score 3 and above score 1 according to Janda's muscle power score²⁵ in all participated women and they did not participate at ante and/or postnatal exercise

program and were housewives. Informed consent to participate in the investigation was obtained from all of them.

Instrumentation of EMG data recording

EMG system is Biopac, TEL 100-MP400 system. It is HEWLE PAKARD, Pentium III, designed for Microsoft windows 98. The data stored in MP unit and transferred to a computer and analyzed with acqknowledge version 3.7 that used to record muscle activities from the upper as well as lower portion of the right and left RA muscles at Motion Analysis Lab at Faculty of Physical Therapy, Cairo University. Skin preparation of the electrodes sites was performed using alcohol. Electrodes were placed parallel to the muscle fibers. Two pairs disposable silver chloride surface disc electrodes with a diameter of 1cm were placed in bipolar configuration symmetrically on each side of the abdomen with a center to center spacing of 2.5cm in the following position: in the upper portion of the RA which was 3cm lateral to midline on the second to topmost rectus bead and in the lower portion which was 3cm lateral and 2cm inferior to the umbilicus. An earth electrode was placed on the 5th to the 6th rib of both sides¹⁸.

The raw EMG signals were collected and band-pass filtered at 20Hz and 500Hz and was simultaneously digitized at 1KHz sampling rate and stored on memory card of the computer. The microcomputer converted the raw EMG signals into digital signals, which were then transformed into absolute value (full wave rectification). The signals were then normalized to amplitude obtained during each voluntary contraction.

Procedures

Women were taught how to perform the exercise. Warm up exercise for five minutes

was adequately performed before recording EMG. After resting five minutes, each woman was asked to take the starting position to perform each exercise in which both hands were put under the lower back in an attempt to maintain constant position for spine. A set of five repetitions of each exercise was performed in which one repetition every three seconds (one second up, two seconds isometric hold without jerky movements and third second down). Hence after completion of the five repetitions of each exercises two minutes of rest was allowed. The average EMG activity was recorded for each exercise during the two seconds of the isometric hold which is expressed as a percentage of maximum voluntary contraction.

Rectus diastasis test was performed for each woman before involving in this study to confirm that there was a separation between two recti more than two fingers as well as at the same timing of performing each exercise and recording of the EMG activity, in which the therapist were fitted the four fingers of each hand vertically across the linea alba, fingers of one hand placed midway between the xiphoid process and the umbilicus and the fingers of the other hand placed midway between the umbilicus and the symphysis pubis. The woman was started to perform the exercise while the therapist turned the fingers horizontally across the linea alba at two levels one above and the other below the umbilicus to assess the following:

- 1- Amount of separation between two recti.
- 2- Region of greatest diastasis.
- 3- Bulge of the abdomen on recti contraction²³.

Exercise descriptions

Trunk Curl-up: from crock lying position (in which both hips as well as

knees were flexed and feet were rested on the plinth), each woman raised the neck and trunk to the point where the scapula is lifted from the plinth while curling the rib cage toward the pelvis and hold for two seconds in this position and repeated this task.

- Posterior pelvic tilt: from crock lying position, each woman isometrically contracted the abdominal muscles to roll the pelvis backwards while pulling the pubic symphysis up towards the chest with the lumbar region touch the plinth and hold for two seconds in this position and repeated this task.
- Unilateral straight leg raising: from half crock lying position (in which one lower limb was in extension and other limb was flexed hip, knee and foot was rested on the plinth), each woman was raised her straight leg up 30cm off the plinth and hold for two seconds in this position and repeated all previous tasks with the other lower limb again.
- Double straight leg raising: from supine lying position, each woman was raised both straight legs up as possible as she can but not more than 25cm off the plinth and

hold for two seconds in this position and repeated this task.

Data and statistical analysis

The mean percentage of maximum voluntary contraction of the five repetition of each exercise, per subject and per portion of the RA was used for making calculations. Also, the amount of separation, area of greatest separation and bulging of the abdomen was used for comparison between the exercises. The ratios and absolute difference between upper and lower portion of the RA was found for each task within each subject. A paired t test and one way repeated measures analysis of variances (ANOVA) were used to assess differences between tasks and differences between upper and lower portions of the RA muscles as well as amount of separation, area of greatest separation and bulging of the abdomen. The level of significance ($P < 0.05$) was used.

RESULTS

The physical characteristics of all the participated women in this study are presented in table (1).

Table (1): Physical characteristic of all women.

Variables	Range (minimum-maximum)	Mean \pm S.D.
Age(Years)	20 - 27	24.5 \pm 3.45
Height (cm)	156 – 164	159.72 \pm 24.78
Weight (Kg)	60 - 70	62.6 \pm 7.56
Body mass index (Kg/m ²)	25 - 28	27.92 \pm 2.34
Separation between two recti (Fingers)		
Above umbilicus	> 2 - 4	3.03 \pm 0.78
Below umbilicus	> 2 - 4	3.42 \pm 0.56

Table (2) represents the average group activity for each exercises and muscles as well as the average difference between the muscle segments for each exercise, paired t test revealed a statistically non significant

($P > 0.05$) difference as there was a small ratio between the upper and lower RA muscle during trunk curl-up exercise but the difference was statistically significant increase ($P < 0.05$) in the activity on the lower portion

than the upper portion of the RA muscles in posterior pelvic tilt and either unilateral or double straight leg raising exercises, (fig. 1).

The ANOVA test revealed a statistically non significant difference ($f = 1.202$, $P > 0.05$)

in the activity between upper portion of the RA muscles, while there was a statistically significant differences ($f = 6.802$, $P < 0.05$) between lower portion of the RA muscles across all exercises.

Table (2): Average muscle activity and difference between RA muscle portions in all women having diastasis recti after normal vaginal delivery.

Exercises	Percentage of RA muscle activity (%)				
	Upper RA portion	Lower RA portion	Difference between upper and lower RA activity	T value	Level of significance
Trunk curl-up	35.44±13.2	34.04±13.15	1.40	1.032	$P > 0.05$
Posterior pelvic tilt	33.21±14.9	42.63±17.18	9.42	2.164	$P < 0.03$
Unilateral straight leg raising	33.96±12.9	40.12±14.12	6.16	2.036	$P < 0.05$
Double straight leg raising	34.32±13.8	44.75±16.15	10.43	2.358	$P < 0.01$

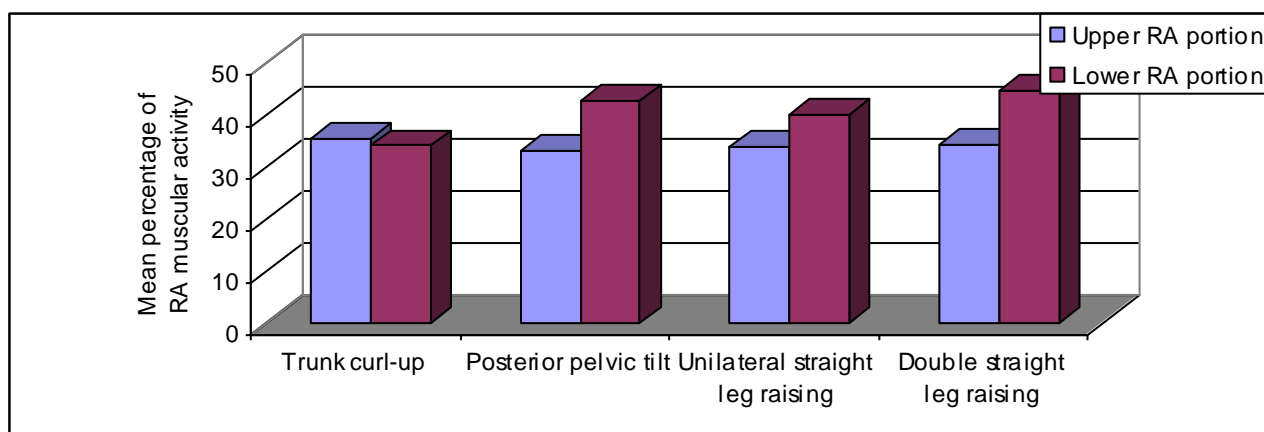


Fig. (1): Average muscle activity at upper and lower portions of RA muscle during exercises in all women having diastasis recti after normal vaginal delivery.

Table (3) represented the average group activity for each exercises and muscles as well as the average difference between the separation, region of greatest diastasis and bulging of the abdomen with each exercise, paired t test revealed a statistically non significant ($P > 0.05$) difference as there was a small ratio between performing rectus diastasis

test at the upper and lower portions of the RA muscles during trunk curl-up, posterior pelvic tilt and unilateral straight leg raising exercises but the difference was statistically significant increase ($P < 0.05$) in the separation, region of greatest diastasis and bulging of the abdomen either above or below the umbilicus with double straight leg raising exercises, (fig. 2).

Table (3): Rectus diastasis test and difference between RA muscle portions in all women after normal vaginal delivery.

Exercises	Rectus diastasis test					
	Separation between two recti (Fingers).		Region of greatest diastasis (Numbers)		Bulge of the abdomen (Numbers)	
	Above umbilicus	Below umbilicus	Above umbilicus	Below umbilicus	Above umbilicus	Below umbilicus
Trunk curl-up	2.95±0.59	2.89±0.66	2	0	2	0
Posterior pelvic tilt	2.65±0.45	2.87±0.54	0	0	0	0
Unilateral straight leg raising	3.10±0.98	3.22±0.68	5	6	5	7
Double straight leg raising	3.34±0.47	3.65±0.76	28	28	28	28

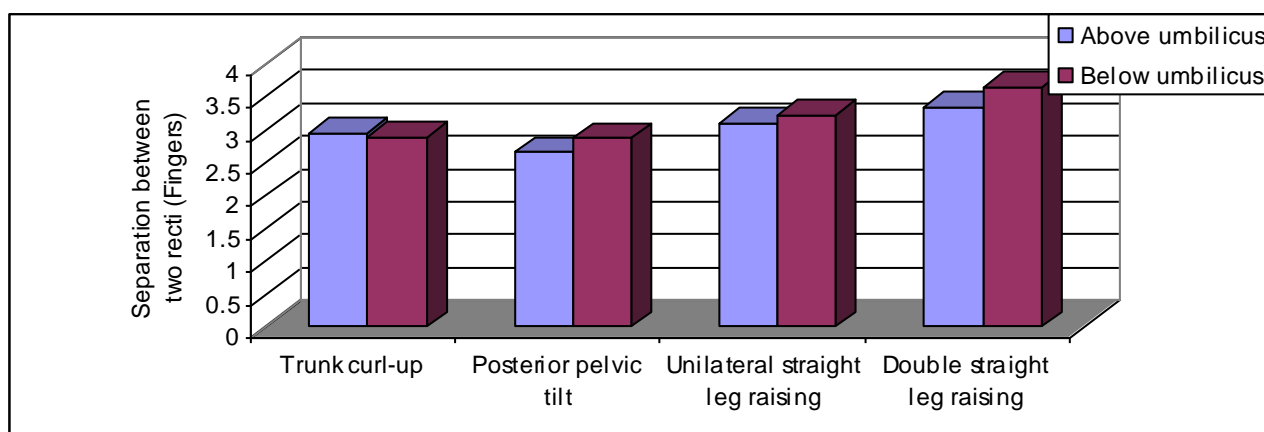


Fig. (2): Amount of separation between upper and lower portions of RA muscle during exercises in all women having diastasis recti after normal vaginal delivery.

DISCUSSION

The results of the present study demonstrate that for all exercises there was a statistically significant difference between the upper and lower portions of the RA muscles except for trunk curl-up exercise when the EMG signals were normalized and spinal posture was controlled. Comparing of the results of this investigation with the results from similar studies was difficult as there is no previous studies performed on the same sample i.e. women with diastasis recti after normal vaginal delivery. For this reason, an explanation of some methodological and anatomical aspects may be helpful to relate the present results. So, the great interelectrode

distances are preferred⁵ as well as the speed of the performance of the exercise seems to be an influential factor when recording EMG activity at the muscle¹⁰. For this reason, in the present study EMG recordings were taken on the RA muscle on each side at each portion (upper and lower) and the speed of the performance of the exercise was controlled during data collection. However, other investigations^{10,12,21} related the activity recorded in the RA muscles from standardized distances from the umbilicus and did not take the speed of the performance into consideration^{13,21}. These two aspects could have been sources of bias in the results of those investigators.

Theoretically, sit-up and trunk curl up exercises are practiced for strengthening the upper RA muscles, and either unilateral or double straight leg raising as well as posterior pelvic tilt exercises for strengthening the lower RA muscles. The justification for this regimen has not frequently been stated, but in (1998)⁷ anatomical evidence indicating separate innervations to the different portions of the RA muscles i.e. segments innervated independently suggests that the possibility exists for differential recruitment to occur.

The sample of this study involved women with diastasis recti i.e. who had low level of physical activity thus, this last methodological aspect in the present study made the information about the topics studied in the previous researches^{10,12,19,21} more difficult to be related.

The results of this study showed that the use of trunk curl –up exercise did not significantly affect the motor action potential MAP obtained from upper versus lower portion of the RA muscles. This result did not support the findings of Sarti et al.,²² and Carman et al.,⁴. In comparison Richardson & Jull,²¹ found that posterior pelvic tilt exercise was more strenuous on the lower RA muscles than on the upper RA muscles. This finding was confirmed our results, while Lehman and his associated (2001)¹⁸ found no difference in the two portions of RA muscles during trunk curl-up and straight leg raising exercises.

Hence, the existence of small difference between the two portions of the RA muscles in this study especially for the trunk curl-up exercise could be related to the normalization of the EMG technique which is important in recording MAP¹⁷. Thus, the differences founded when performing other form of exercises were actually dependent on the activation of the muscles with the performed exercise. Also, all women had a BMI less than

28 kg/m² which mean low subcutaneous tissue that optimizing the magnitude of EMG signal collection⁶. So, all of the above results confirmed that the ability to perform the exercise was an influential factor rather than the level of physical activity.

The results of this study showed that the use of trunk curl –up, posterior pelvic tilt and unilateral straight leg raising exercises did not significantly affect the amount of separation between two recti at upper or lower part of them as well as they did not produce any bulging of the abdomen when performed. But double straight leg raising exercise increased the separation between recti and bulging of the abdomen. These results confirmed by the study of Wohlfahrt et al.,²⁴ who reported that slowly lift up to 30° and lower extended leg to the bed can increase abdominal strength without any harmful effects. On the other hand, Boissonnault & Blaschak², reported that dynamic trunk flexion exercise (trunk-curl) should be avoided if there is a diastasis as it leads to bulging and loading on a weak muscle resulting in more weakness. Thus, the physical therapist deal with women having diastasis recti after delivery should monitor the effect of abdominal exercises on the diastasis by palpating the muscle and prescribe exercises accordingly and place more emphasis in exercise prescription on restoring the abdominal muscles strength.

Conclusion

As a conclusion trunk-curl up, posterior pelvic tilt and unilateral straight leg raising exercises could influence the different portions of the RA muscles in women with diastasis recti after normal vaginal delivery. In addition, women wanting more strenuous exercise on the lower RA muscles should select the posterior pelvic tilt safely as well as unilateral

straight leg raising exercise but double straight leg raising should be avoided for such cases.

REFERENCES

- 1- Bjorklund, K., Bergstrom, S., Nordstrom, M. and Ulmsten, U.: "Symphyseal distention in relation to serum relaxin level and pelvic pain in pregnancy", *Acta Obstet Gynecol Scand*, 79: 269-275, 2000.
- 2- Boissonnault, J. and Blaschak, M.: "Incidence of diastasis recti abdominis during childbearing year", *Phys Ther*, 68: 1082-1086, 1988.
- 3- Callinan-Moore, K.: "Managing diastasis recti", *J National women's Health Group*, 12(1): 15-19, 1993.
- 4- Carman, D., Blanton, P. and Biggs, N.: "Electromyographic study of the anterolateral abdominal musculature utilizing indwelling electrodes", *Am J Phys Med*, 51: 113-129, 1972.
- 5- Clarys, J. and Cabri, J.: "Electromyography and the study of sports movements: a review", *J Sports Sci*, 11: 379-408, 1993 (Abstract).
- 6- DeLuca, C.: "The use of surface electromyography in biomechanics", *J Appl Biomech*, 13: 153-163, 1997.
- 7- Duchateau, J., Decletry, A. and Lejour, M.: "Innervation of the rectus abdominis muscle: Implication for rectus flaps", *Plastic and Reconstructive Surgery*, 82: 223-227, 1998.
- 8- Ellson, D. and Bullock-Saxton, J.: "The effect of abdominal muscle contraction on diastasis recti in post natal women determined by diagnostic ultrasound", *Proceedings CPT Congress*, Washinton, PP. 1202, 1995.
- 9- Gilleard, W. and Brown, J.: "Structure and function of the abdominal muscles in primigravid subjects during pregnancy and the immediate post birth period", *Phys Ther*, 76: 750-762, 1996.
- 10- Godfrey, K., Kinding, L. and Windell, E.: "Electromyographic study of duration muscle activity in sit ups variations", *Arch Phys Med Rehabil*, 58: 132-135, 1977.
- 11- Grander-Morse, M. and Stokes, I.: "The effects of abdominal muscle co-activation on lumbar spine stability", *Spine*, 23: 86-92, 1998.
- 12- Guimaraes, A., Vaz, M., DeCampos, M. and Marantes, R.: "The contribution of the rectus femoris in twelve selected abdominal exercises. An electromyographic study", *J Sports Med Phys Fitness*, 31: 223-230, 1991.
- 13- Halpern, A. and Bleck, E.: "Sit up exercises: an electromyographic study", *Clin Orthop*, 172: 172-178, 1979.
- 14- Hodges, P. and Richardson, C.: "Inefficient muscular stabilization of the lumbar spine associated with low back pain: a motor control evaluation of transverses abdominis", *Spine*, 22: 271-276, 1997.
- 15- Ireland, M. and Ott, S.: "The effects of pregnancy on musculoskeletal system", *Clin Orthop*, 372: 169-179, 2000.
- 16- Juker, D., McGill, S., Kropf, P. and Steffen, T.: "Quantitative intramuscular myoelectric activity of lumbar portions of psoas and the abdominal wall during a wide variety of tasks", *Med Sci Sports Exerc*, 30: 301-310, 1998 (Abstract).
- 17- Lehman, G. and McGill, S.: "The importance of normalization in the interpretation of surface electromyography: a proof of principle", *J Manipulative Physio Ther*, 22: 444-446, 1999.
- 18- Lehman, G. and McGill, S.: "Quantification of the differences in electromyographic activity magnitude between the upper and lower portions of the rectus abdominis muscle during selected trunk exercises", *Phys Ther*, 81: 1096-1101, 2001.
- 19- Lipetz, S. and Gutin, B.: "An electromyographic study of four abdominal exercises", *Med Sci Sports*, 2: 35-38, 1970(Abstract).
- 20- Livingstone, L.: Postnatal management: in Sapsford, R.; Bullock-Saxton, J. and Markwell, S. (eds.): *Womens' health A text book for physiothapists*, 1st ed., W.B. Saunders Company, London, PP. 220, 1998.
- 21- Richarson, G. and Jull, G.: "Muscle control, pain control. What exercises would you prescribe?", *Manual Therapy*, 1: 2-10, 1995.

- 22- Sarti, M., Monfort, M., Fuster, M. and Villapana, L.: "Muscle activity in upper and lower rectus abdominis during abdominal exercises", Arch Phys Med Rehabil, 77: 1293-1297, 1996.
- 23- Thornton, S.I. and Thornton, S.J.: "Management of gross diastasis divercation of the recti abdominis in pregnancy and labour", Physiotherapy, 79: 457-458, 1993.
- 24- Wohlfahrt, D., Jull, G. and Richardson, C.: "The relationship between the dynamic and static function of abdominal muscles", Aust J of Physiotherapy, 39(1): 9-13, 1993.
- 25- Zauner-Dungel, A., Resch, K., Herczeg, E. and Piza-Katzer, H.: "Quantification of functional deficits associated with rectus abdominis muscle flaps", Plast Reconstr Surg, 96: 1623-1628, 1995.

المخلص العربي

النشاط العضلي للطرف العلوي والسفلي لعضلي البطن الطويلتين أثناء تمارين البطن لدى سيدات عندهن تباعد بين عضلي البطن الطويلتين بعد الولادة الطبيعية

مقدمة : هناك جدل حول مدى تنشيط التمارين للطرف العلوي و السفلي لعضلي البطن الطويلتين في الأشخاص الأصحاء.

هدف الدراسة : تهدف هذه الدراسة إلى تقييم مدى التنشيط الحادث للطرف العلوي و السفلي لعضلي البطن الطويلتين أثناء عمل تمارين متنوعة للبطن لدى سيدات عندهن تباعد بين عضلي البطن الطويلتين (دياستاز) بعد الولادة الطبيعية.

تصميم الدراسة : اشترك في هذه الدراسة 28 سيدة متكررة الحمل (2-3 مرات) لديها تباعد بين عضلي البطن الطويلتين (أكثر من 2 إصبع) من مستشفى المطرية التعليمي بعد شهرين من الولادة الطبيعية. و قد تم تقييم أقصى تباعد بينهما و كذلك وجود بروز في البطن أثناء أداء تمارين البطن المختلفة مثل ثني الجذع و ميل الحوض للخلف و رفع إحدى الساقين مستقيمة و رفع الساقين مستقيمتان معا .

النتائج : أظهرت النتائج انه مع جميع تمارين البطن لا يوجد أي اختلاف ذو دلالة معنوية في نشاط الطرف العلوي لعضلي البطن الطويلتين و لكن هناك اختلاف معنوي في نشاط الطرف السفلي لهما. وعليه فان تمارين ثني الجذع قد اظهر تغير قليل جدا في النشاط فيما بين طرفي العضلة و لكن ميل الحوض للخلف و رفع الساق منفردة أو مزدوجة فقد أظهرتا نشاط كبير جدا في الطرف السفلي عن الطرف العلوي لعضلي البطن أما مقدار التباعد و بروز البطن فلم يظهر أي فروق ذات دلالة إحصائية إلا عند عمل تمارين رفع الساقين مستقيمتين معا.

الخلاصة : فان تمارين ميل الحوض للخلف و رفع ساق واحدة مستقيمة يمكن أن تزيد من قوة الجزء السفلي لعضلات البطن عن تمارين ثني الجذع عن استخدامه مع سيدات عندهن تباعد بين عضلي البطن الطويلتين بعد الولادة الطبيعية ولكن رفع الساقين مستقيمتين معا يجب من عدم استخدامه في مثل هذه الحالات.

الكلمات الدالة : تباعد عضلي البطن الطويلتين(دياستاز)- رسم العضلات – تمارين علاجية- الولادة الطبيعية .