Am J Clin Exp Immunol 2024;13(5):226-232
www.ajcei.us /ISSN:2164-7712/AJCEI0159201

Original Article

Application research of core stability training based on biofeedback in postpartum rectus abdominis muscle separation

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Received July 15, 2024; Accepted October 8, 2024; Epub October 25, 2024; Published October 30, 2024

Abstract: Objective: To investigate the efficacy of core stabilization training based on biofeedback for postpartum rectus abdominis muscle separation. Methods: Thirty patients aged 20-35 years with rectus diastasis after pregnancy were randomly divided into experimental group and control group. The control group received routine core stabilization training, including abdominal breathing training, bridge exercises and kneeling abdominal exercises. The experimental group performed core stabilization training based on biofeedback. Before and after intervention, rectus abdominis muscle distance, waist circumference and abdominal circumference were evaluated in the two groups, and rectus abdominis muscle separation, waist circumference and abdominal circumference improvement were analyzed in the two groups. Results: There was no significant difference between the two groups before treatment ($P > 0.05$), and there was significant difference between the two groups after treatment and before treatment. After treatment, the experimental group was further improved compared with the control group. After treatment, the distance between rectus muscles, abdominal circumference and waist circumference in both groups were decreased compared with those before treatment ($P < 0.05$). The distance between rectus muscles, abdominal circumference and waist circumference of the experimental group were smaller than those of the control group ($P < 0.05$). Conclusion: Core stabilization training based on biofeedback can effectively improve the symptoms of patients with postpartum rectus diastasis, help to reduce waist circumference and abdominal circumference, and accelerate the recovery of postpartum body shape.

Keywords: Postpartum, diastasis rectus abdominis, core stabilization training, biofeedback therapy, rectus interval

Introduction

Diastasis rectus abdominis (DRA) refers to the separation of the linea alba between the muscle bellies on both sides of the rectus abdominis muscle and is a common complication during pregnancy as well as postpartum, with a relatively high incidence [1]. At present, it is clinically proposed that the distance between the medial edges of the two rectus abdominis muscles is more than 20 mm, which suggests DRA (inter-rectus distance, IRD) [2]. According to current research [3] data, risk factors for DRA may be related to maternal age during pregnancy, degree of body obesity, parity, mode of delivery, hormonal physiological changes, excessive fetal size or multiple births, weight bearing during postpartum recovery, abdominal surgery, intensity of exercise training and frequency, and underlying diseases such as diabetes. If DRA patients fail to receive professional rehabilitation in time after delivery and are misled by some wrong perceptions, it may cause abnormal body posture, abnormal muscle fascia, and bone and joint function [4, 5].

According to epidemiological study data [6], there is a significantly increased risk of having DRA in the third trimester of pregnancy, with an incidence as high as 66% to 100%. The incidence of DRA was approximately 60% at 6 weeks, 45% at 6 months, and 33% at 12 months postpartum. Elevated hormones such as progesterone, estrogen, prolactin and relaxin during pregnancy and the initial postpartum period affect maternal anatomical and meta-

Table 1. Basic information of subjects ($\overline{X} \pm s$)

Group	N	Age (years)	Height (cm)	Parity (case) One second birth	Days Postpartum (days)	Mode of delivery Cesarean section for spontaneous delivery
Control group	15	30.00 ± 2.65	163.87 ± 4.83	13 2	45.60 ± 5.93	12 3
Experimental group	15	30.47 ± 2.07	163.47 ± 2.90	12 3	43.87 ± 4.29	13 2
X^2 (t) value		0.54	0.28	0.48	0.92	0.48
P value		0.60	0.79	0.64	0.37	0.64

bolic adaptation; Long-term increases in internal abdominal pressure due to maternal weight gain, fetal growth and uterine dilation, combined with hormonal changes in connective tissue (such as increased production of relaxin, progesterone and estrogen), lead to the development of IRD [7]. The enlargement of the uterus causes the abdominal muscles to stretch and reduce their ability to exert force [8]. After delivery, the abdominal muscles are stretched to their elastic limits, and musculoskeletal mechanical stress and tissue structure changes can lead to postpartum DRA [9]. The maternal body undergoes huge physiological changes, resulting in a relatively weak immune system, and the decline in estrogen and progesterone may reduce the activity of immune cells, thus affecting the overall function of the immune system.

Core muscle group stabilization training is based on the concept of musculoskeletal movement protection and core muscle system function training, through the core region muscle group control and training can improve muscle coordination control ability. The stability training of core muscle groups can not only improve the coordination and sensitivity of muscles, but also effectively activate the overall core muscles and local stable muscles of the body [10]. Strengthening core muscle strength is beneficial to repair rectus abdominis dissociation, stabilize pelvis and relieve lumbago [11, 12]. Kaya et al [13] found that control training of core muscles better promoted recovery from postpartum DRA in their study.

Biofeedback therapy, as a novel treatment, helps patients to better understand and control their own muscle activity by converting biological information related to abdominal muscle activity into visual and auditory signals using modern physiological and scientific instruments to display muscle activity in real time and provide immediate feedback. Li Jiangying et al [14] observed in the study that surface EMG biofeedback therapy, with the help of visual and auditory feedback information, can guide patients to perform autonomous training, help effectively relax or enhance target muscles, and allow training to be completed on time and with high quality. In the study of postpartum pelvic floor muscle, biofeedback electrical stimulation enhanced neuromuscular excitability, activated partially inhibited neuromuscular cells, and improved the function recovery of nerve cells [15-17].

Methods

Study design

Randomized and controlled trial design will be adopted in this study, and subjects will be divided into control group and experimental group according to random number table method, with 15 cases in each group. The treatment time of the same subject was arranged at the same time period on the next day, and the total time between completing one treatment was 30-45 min. Patients are required to complete a personal profile form (**Appendix I**) before starting treatment, including age, height, weight, number of births, number of births and mode of delivery. After the professional rehabilitation therapist explains the treatment process and precautions to the patient, the patient needs to sign the informed consent and voluntarily participate in this study. The information of the subjects is shown in **Table 1**.

Participants

In this study, we planned to select 30 patients aged 20-35 years who developed rectus abdominis symptoms after pregnancy and met the inclusion criteria from Nanxiang Hospital, Jiading District, Shanghai. Rectus abdominis muscle strength is II-IV; Patients or family members informed consent to this study and voluntarily signed informed consent. Inclusion criteria include patients who did not receive other treatment regimens before treatment in our hospital; age 20-35 years, 42 d-6 months after delivery; rectus abdominis distance > 20 mm measured, in line with the diagnostic criteria; be able to carry out core stabilization training and biofeedback therapy; rectus abdominis muscle strength is II-IV; patients or family members informed consent to this study and voluntarily signed informed consent. Exclusion criteria include receiving relevant treatment in the past 2 months; contraindications to experimental treatment methods; congenital abdominal wall dysplasia; patients with severe heart, liver, kidney dysfunction; patients with severe cognitive impairment, mental illness, etc. who cannot cooperate with the treatment.

Control group

Core stabilization exercises were used, including abdominal breathing training, bridge exercises, and kneeling abdominal retraction exercises.

Abdominal breathing exercises: The patient lies supine and the body is relaxed. Breathe in through your nose and let your belly bulge and keep your chest immobile. Breathe out through your mouth and contract your abdomen inward as you breathe out. After waiting for the air to expel, rest for 5 seconds and continue repeating the movement. Every 10 groups, 2 groups/d.

Bridge exercises: The patient was placed in the supine position with both legs flexed 90 degrees, both feet flat and as wide as the hip, both knees separated by a fist distance, and both hands placed on both sides of the body. With abdominal breathing, the stomach is drummed during inspiration, the buttocks are lifted during expiration, and the abdominal core is tightened and lifted from bottom to top section until the knee hip and shoulder form a straight line and remain for 3 seconds; the trunk is kept motionless during inspiration, the trunk is relaxed during expiration, the spine falls from top to bottom section, and the pelvis returns to the neutral position. Every 10 groups, 2 groups/d.

Kneeling abdominal exercises: The patient kneels at four o'clock, the shoulder and wrist joints are vertical, and the hip and knee joints are vertical. Abdomen relaxed during inspiration; forced inward contraction of abdomen during expiration. Every 10 groups, 2 groups/d.

They were trained every other day for 5 weeks and rehabilitated 4 days a week.

Experimental group

Core stabilization training based on biofeedback was used. Use of Micron AM1000B Biofeedback Therapeutic Apparatus for Pelvic Floor Rehabilitation.

Before treatment, the rehabilitation therapist explained the treatment principle and precautions to the patient. During the treatment, the patient was placed in the supine position, the patient's abdomen was first disinfected with alcohol, and four electrode poles were attached to the separated rectus abdominis muscle belly around the navel, and the stimulation current intensity was adjusted from small to large, preferably with significant contraction of the patient's abdominal muscles without pain. During the treatment, the patients followed the electromyography on the speech and screen of the therapeutic apparatus with the core stabilization training of the control group for correct and effective muscle voluntary contraction training under the guidance and encouragement of the therapist.

Abdominal breathing exercises: When speech suggests contraction and current stimulation is felt, exhalation tightens the abdomen, speech suggests inspiration when relaxation, do not suffocate, and avoid upward and downward movement of the thorax during breathing. 10 min of training.

Bridge exercises: Raise the buttocks when speech suggests muscle contraction and fall back when relaxed. 10 min of training.

Kneeling abdomen: When the speech suggests contraction and the current stimulation is felt, exhale and retract the abdomen forcefully; inhale when relaxed and the abdomen naturally relaxes.

Each training session was performed for 30 min, every other day, and four times a week for 5 weeks.

Evaluation indicators

All patients were assessed by the same rehabilitation therapist before and after 5 weeks of treatment using ultrasound to measure rectus intermuscular distance, waist circumference and abdominal circumference with a flexible ruler and efficacy. Statistical analysis of functional improvement in the two groups.

Rectus abdominis distance

Measurement position: 3 cm above the umbilicus, 3 cm below the umbilicus, 3 cm above and below the umbilicus with the center of the navel as the reference point, umbilical level as the level of the upper edge of the navel.

Measuring method: Before measuring, mark the skin to determine the position of standard probe. The patient was placed in supine and relaxed position at rest, with both legs flexed to 90 degrees and the soles flattened. The probe was gently attached to the skin surface so that the pressure of the probe did not cause contraction of the abdominal muscles. The ultrasound probe was placed perpendicular to the plane of the linea alba, the connective tissue was hyperechoic, and the rectus abdominis muscle was hypoechoic, and the distance between the rectus abdominis muscles on both sides was measured at the end of quiet expiration with a value accurate to 0.1 cm. Each position was measured three times and averaged as the final IDR value, and ultrasound testing was performed by the same therapist.

Waist circumference, abdominal circumference

Waist circumference: The patient stands with feet apart and shoulders as wide, breathing evenly, and the therapist reads the value horizontally around the waist from the center of the line between the lower edge of the 12th rib cage and the highest point of the iliac crest with a flexible ruler.

Abdominal circumference: The patient stands with feet apart and shoulders as wide, breathe evenly, the therapist uses a flexible ruler to surround the abdomen along the navel level for a week, and reads the value at the end of expiration.

Statistical analysis

Statistical analysis was performed using SPSS 22.0. Measurement data were expressed as mean ± standard deviation. There was a paired relationship between the two groups of samples, and both met the normal distribution. Paired t-test was used for intra-group comparison of patients' own efficacy before and after treatment, and independent sample t-test was used for comparison between the two groups. Enumeration data were described as percentage (%), and chi-square test was used. $P < 0.05$ indicated statistical significance.

Results

Rectus abdominis distance before and after treatment

Before treatment, there was no significant difference in rectus abdominis distance between the two groups ($P > 0.05$). After treatment, the rectus abdominis distance was significantly reduced in both groups ($P < 0.05$); after treatment, the rectus abdominis distance in the experimental group was less than that in the control group ($P < 0.05$), so the experimental group was superior to the control group in efficacy (**Table 2**).

Waist circumference of the two groups before and after treatment

Before treatment, there was no significant difference in waist circumference between the two groups ($P > 0.05$). After treatment, the waist circumference was significantly reduced in both groups ($P < 0.05$); after treatment, the waist circumference in the experimental group was smaller than that in the control group ($P < 0.05$), so the experimental group was superior to the control group in the efficacy (**Table 3**).

Abdominal circumference before and after treatment

Before treatment, there was no significant difference in abdominal perimeter between the two groups ($P > 0.05$). After treatment, abdominal perimeter was significantly reduced in both groups ($P < 0.05$); after treatment, abdominal perimeter in experimental group was lower than that in control group ($P < 0.05$), so experi-

Table 2. Comparison of rectus abdominis muscle distance before and after treatment between the two groups (unit: mm)

Group	N	Before treatment	After treatment	T value	*P* value
Control group	15	28.89 ± 2.50	23.87 ± 1.96	12.80	< 0.01
Experimental group	15	28.79 ± 3.39	18.93 ± 1.81	15.88	< 0.01
T value		0.09	7.17		
P value		0.93	< 0.01		

Table 3. Comparison of waist circumference before and after treatment between the two groups (unit: cm)

Group	N	Before treatment	After treatment	T value	*P* value
Control group	15	81.47 ± 4.96	77.20 ± 4.75	20.69	< 0.01
Experimental group	15	81.67 ± 4.45	73.07 ± 5.64	15.88	< 0.01
T value		-0.12	2.17		
P value		0.91	0.04		

Table 4. Comparison of abdominal perimeter before and after treatment between the two groups (unit: cm)

Group	N	Before treatment	After treatment	T value	*P* value
Control group	15	90.20 ± 4.86	86.13 ± 4.84	19.72	< 0.01
Experimental group	15	89.40 ± 3.40	82.27 ± 4.11	26.06	< 0.01
T value		0.49	2.36		
P value		0.63	0.03		

mental group was superior to control group in efficacy (**Table 4**).

Discussion

Core training can promote the recovery of the degree of rectus abdominis separation after delivery, enhance the strength of the core muscle groups, and then improve the coordination ability of the body by using various equipment and training methods [10]. Traumatic muscle tissue injury may delay activation of core muscle strength, which in turn impacts proprioceptive afferents and impacts control of core muscle groups [18]. Huang Danping et al [19] found that core muscle training helped improve the degree of rectus diastasis, pain, total abdominal fat mass and fat distribution and balance ability in postpartum DRA patients. Rastislav D et al [20] demonstrated in their study that activation of the transversus abdominis muscle and performing core stabilization training helped to restore rectus diastasis in postpartum patients. Therefore, core stabilization training is important for improving the physical condition of these patients.

By monitoring the patient's physiological parameters, such as electrodermal response and muscle tone, the biofeedback system helps the patient understand their physical response and teaches the patient how to relax and adjust their own respiratory response through a visual feedback signal. In this study, it was found that the experimental group using core stabilization training based on biofeedback had much better efficacy than the control group performing core stabilization training alone, and the rectus abdominis separation distance, waist circumference and abdominal circumference were also significantly reduced. This shows that biofeedback combined with core stabilization training has a significant effect on the efficacy of postpartum rectus abdominis muscle separation, which can promote the recovery of waist circumference and abdominal circumference, thereby accelerating the postpartum physical recovery of parturients.

After delivery, the rectus abdominis muscle needs to regain its normal anatomy and function, a process that usually involves muscle regeneration and repair. However, postpartum immune regulation may affect the speed and quality of rectus abdominis repair. The healthy state and immune activity of the immune system can affect the regeneration process of muscle tissue, which in turn affects the recovery of the function of the rectus abdominis after delivery. Although this study achieved some therapeutic effect, there are some limitations. First, the number of subjects selected in this study is small, and the size and representativeness of the study sample size may also affect the accuracy of the results, so larger and more comprehensive studies are needed to support the existing conclusions.

This study shows that core stabilization training based on biofeedback has a significant effect on the separation of the rectus abdominis after delivery. The improvement effect of core stability training based on biofeedback is obviously better than that of core stability training.

Disclosure of conflict of interest

None.

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Appendix I. Personal basic information form

Basic information			
Name	Age	Occupation	Contact information
Height (cm)	Body weight (kg)	BMI	Postpartum time (day/month)
Maternal history	G_ Mode of delivery P_	□ Spontaneous delivery □ Forceps □ Caesarean section	SIDE CUT/TEAR/OTHER
Neonatal weight (kg)	First birth	Second birth	
Surgical Scars Hyperplasia	□ Grade I □ Grade II □ Grade III	Degree of stretch marks	□ Mild □ Moderate □ Severe
Assessment Data			
Rectus diastasis classification	□ Detached in umbilicus □ Umbilical epigastric rectus diastasis □ Abdominal rectus diastasis □ Total rectus diastasis	Degree of rectus diastasis	□ Normal < 2 cm □ Mild 2-3 cm □ Moderate 3-4 cm □ Serious > 4 cm
Umbilical (cm)	Umbilical (cm)	Subumbilical (cm)	
Waist circumference (cm)		Abdominal circumference (cm)	

Note*: G represents the total number of pregnancies in women; P represents the total number of deliveries in women.