Official Title of Study: -

EFFECT OF PREOPERATIVE GRADUATED ABDOMINAL EXERCISES AND RUSSIAN STIMULATION ON MUSCLE STRENGTH AFTER VENTRAL HERNIOPLASTY

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INTRODUCTION

Herniation refers to protrusion of an organ or tissue through an opening that may be natural or caused by a tear in the abdominal wall. Ventral abdominal hernia is a commonly acquired condition caused by the migration of viscera through a tear in the abdominal wall. The tear may be dorsal or ventral in the flank, along the costal arch or between the last few ribs. Ventral hernias commonly result from traumas caused by horn thrust, kick or violent contact with blunt objects or by an abdominal distension due to pregnancy or violent straining during parturition (Karanja et al., 2014).

Primary ventral hernias and ventral incisional hernias have been a challenge for surgeons throughout the ages. In the current era, incisional hernias have increased in prevalence due to the very high number of laparotomies performed in the 20th century. Even though minimally invasive surgery and hernia repair have evolved rapidly, general surgeons have yet to develop the ideal, standardized method that adequately decreases common postoperative complications, such as wound failure, hernia recurrence and pain. While the incidence of incisional ventral hernias has increased as abdominal surgery has become more prevalent (Vorst et al., 2015).

Ventric hernias include all hernias in the anterior and lateral abdominal wall. Midline defects include umbilical, paraumbilical, epigastric, and hypogastric hernias. Umbilical hernias are by far the most common type of ventral hernia; they are usually small and are particularly common in women. Paraumbilical hernias are large abdominal defects through the linea Alba in the region of the umbilicus and are usually related to diastasis of the rectus abdominis muscles. Epigastric hernias and hypo gastric hernias occur in the linea Alba above and below the umbilicus, respectively (Aguirre et al., 2005).
Hernias are very common conditions that most surgeons diagnose and treat in daily practice. Umbilical hernias account for 5-7% of all hernias; however, there is data suggesting a substantially higher rate, up to 14%. Most umbilical hernias are acquired; the associated major risk factors are: increased intra-abdominal pressure as noted in obese patients, pregnancy, the presence of an intra-abdominal mass, and ascites caused by cirrhosis, or peritoneal carcinomatosis. The correlation between the presence of an umbilical/paraumbilical hernia and an intra-abdominal malignancy is solely based on prior case reports (Barczynski et al., 2014).

Umbilical hernia is a rather common surgical problem. Approximately 10% of all primary hernias comprise umbilical and epigastric hernias. Recurrence may develop even in cases where a prosthetic mesh is used. Recurrent umbilical hernias often tend to enlarge faster than primary ones and may behave as incisional hernias. It has a tendency to be associated with high morbidity and mortality in comparison with inguinal hernia because of the higher risk of incarceration and strangulation that require an emergency repair (Kulacoglu et al., 2015).

Ventral hernias continue to be one of the most prevalent complications after abdominal surgery, with an incidence of 15%. Primary suture repair has met with dismal outcomes, with recurrence rates 50%. Different techniques of herniorrhaphy have been developed, but the use of synthetic mesh has been a major contributor to decreased recurrence rates, ranging from 10% to 23%. In addition to the advent of synthetic mesh, the adaptation of laparoscopy to ventral hernia repairs has led to shortened hospital stays, decreased pain, faster recovery times, decreased wound morbidity, and lower recurrence rates (Bhanot et al., 2013).

The abdominal muscles have a role to play in all movement. This makes perfect sense considering the higher number of nerve innervations into these...
muscles. To train the abdominal muscles effectively it requires far more than merely performing hundreds or even thousands of flexion movements, in the pursuit of attaining the most optimal results one must realize and understand that abdominal training should be of a holistic approach (George, 2012).

Use of exercise prior to an acute stress or surgery has emerged as a viable perioperative risk reduction strategy. This concept, known as prehabilitation, was first used in sports medicine to reduce the impact of an injury prior to its occurrence. It has been explored as a method of preoperative optimization in patients undergoing elective intra-abdominal surgery (Knight et al., 2017).

The Russian current is used for enhancing muscle; the muscular fiber by the electric stimulation is used in Type II as Type I oppositely with the voluntary contraction. According to Hudlicka et al, the property of muscular contraction changes by long-term electric stimulation with low frequency in Type IIb, and these changes are related to the stimulus duration, so if the long-term low-frequency current is applied for more than two weeks in minimum, it will change physiologically into I type fiber (Jung et al., 2014).

**Statement of the Problem:**

- Are the preoperative graduated abdominal strengthening exercises able to improve abdominal muscle strength after ventral hernioplasty?
- Is the Russian stimulation for abdominal muscles able to improve abdominal muscle strength after ventral hernioplasty?
- Is the combination between preoperative graduated abdominal strengthening exercises able to improve abdominal muscle strength after ventral hernioplasty?
**Purpose of the study:**

The purpose of the study will be focused on investigation of the effect of preoperative graduated abdominal strengthening exercises and Russian stimulation on the abdominal muscles strength after ventral hernioplasty.

**Significance of the study:**

The need of this study will be designed from the lack of the primary related researches about the role of preoperative graduated abdominal strengthening exercises and Russian stimulation on abdominal muscle strength after ventral hernioplasty.

The recurrence rate after standard repair of ventral hernias may be as high as 12-52%, and the wide surgical dissection required often results in wound complications *(Park et al., 2003)*.

Umbilical hernia has gained little attention in comparison with other types of hernias (inguinal, postoperative); however, the primary suture for umbilical hernia is associated with a recurrence rate of 19-54% *(Kiudelis et al., 2008)*.

Physical conditioning including overall fitness and obesity is associated with ventral hernias. Obese patients are at increased risk of hernia formation, hernia incarceration. As well as all adverse events following ventral hernia repair including wound complications, surgical site infections, and hernia recurrence. While preoperative physical conditioning and weight loss programs have been shown to be effective in achieving weight loss, studies have demonstrated variable results on the impact on outcomes. In addition, these studies have largely been performed in bariatric surgery, cardiac surgery, and orthopedic surgery and no studies have evaluated this in patients with ventral hernias. It is unclear if the
effectiveness of these programs to improve weight loss and physical conditioning can be translated to ventral hernia repair (Holihan et al., 2016).

**Delimitations:**

The study will be delimited to the following respects:

- **Subjects:**
  Sixty patients with ventral hernia, their age ranged from 20 to 45 years will be selected from South Valley University Hospital.
  The patients will classify into four groups:

  **Group A (study group):** will receive graduated abdominal strengthening exercises for 30 min., 3 times per week for 6 weeks preoperatively.

  **Group B (study group):** will receive Russian stimulation on abdominal muscles for 30 min., 3 times per week for 6 weeks preoperatively.

  **Group C (study group):** will receive combination between graduated abdominal strengthening exercises and Russian stimulation on abdominal muscles for 30 min., 3 times per week for 6 weeks preoperatively.

  **Group D (control group):** will be instructed to presume in normal activities of daily living preoperatively, without abdominal exercises or Russian stimulation.

- **Equipment Used:**
  The main equipment that will be used in the study will be delimited as following:

  **Measurement Equipment:**
  - Biodex 3, Isokinetic Dynamometer System (with the back/abdominal unit).
  - Ultrasonography System.

  **Therapeutic Equipment and Tools:**
  The equipment that will be used for treatment protocol includes:
- Swiss ball and elastic theraband.
- Mat, wedges, and wall bar.

**Basic Assumption:**

**It will be assumed that:**
- All subjects will continue in the study.
- All patients will follow the instructions during the treatment.
- All patients will exert maximum effort during the test and treatment period.
- Environmental factors such as cold, noise, etc will be controlled during evaluation and treatment sessions.
- The clinical methods of measurement will be valid and reliable.

**Hypothesis of the study:**

**It will be hypothesized that:**
- The preoperative graduated abdominal strengthening exercises have a positive effect on abdominal muscle strength after ventral hernioplasty.
- The Russian stimulation has a positive effect on abdominal muscle strength after ventral hernioplasty.

**Definitions of terms:**

The following terms will be defined for the clear understanding of the terminology that will be used in the present study:

**Abdominal Wall:**

It is a complex composite structure composed of various layers which vary depending on specific anatomical location (e.g., medial/lateral, above/below the arcuate line) (*Deeken et al., 2017*).

**Intra-abdominal Pressure (IAP):**
It is the steady-state pressure concealed within the abdominal cavity, IAP should be expressed in mmHg and measured at the end of exhalation in the supine position after ensuring that abdominal muscle contractions are absent and with the transducer zeroed at the level where the midaxillary line crosses the iliac crest (Malbrain et al., 2016).

**Isokinetic Testing Dynamometer:**

It is testing performed with dynamometer that maintains the lever arm at a constant angular velocity, this type of strength evaluation account for velocity of movement that is controlled with free weights and machines, dynamometers resist generated forces proportionally to that which is applied (Kraemer et al., 2006).

**Ventral Hernia:**

It describes any protrusion of abdominal viscera, most often a piece of intestine, through the anterior abdominal wall, eventration of the anterior abdominal wall is a bulging that occurs from either paralysis of a portion of the abdominal musculature or congenital absence (Bathla et al., 2012).

**Strength training (strengthening exercise):**

It is a systematic procedure of a muscle or muscle group lifting, lowering, or controlling heavy loads (resistance) for a relatively low number of repetitions or over a short period of time (Kisner et al., 2012).

**Russian stimulation:**

It is alternating currents with a frequency of 2.5 kHz that are burst modulated at a frequency of 50 Hz with a 50% duty cycle. It is applied for a 10-sec. “on” period followed by a 50-sec. “off” period for 10 min. (Ganesh et al., 2018).

**Ultrasonography:**

A reliable method of measuring the cross-sectional area and volume of the muscles and is applied to analyze skeletal muscle adaptation to muscle strengthening programs. It used to measure and analyze the structural
characteristics of the muscles as muscle function and thickness, pennation angle, and fascicle length (Yu et al., 2015).

**SUBJECTS, MATERIALS AND METHODS**

In this part of the study, the materials and methods will be presented under the following headings: subjects, equipments, procedures of the study and the statistical procedures.

**1. Subjects:**

Sixty patients with ventral hernia, preoperatively, their age ranged from 20 to 45 years will be selected from South Valley University Hospital and randomly distributed into four equal groups.

**1.1 Design of the study:**

In this study the patients will be randomly assigned into four equal groups (15 patients for each group):

1.1(a). Group A (Study group):

This group includes 15 patients with ventral hernia who will receive graduated abdominal strengthening exercises for 30 min., 3 times per week for 6 weeks preoperatively.

1.1(b). Group B (Study group):

This group includes 15 patients with ventral hernia who will receive Russian stimulation on abdominal muscles for 30 min., 3 times per week for 6 weeks preoperatively.

1.1(c). Group C (Study group):

This group includes 15 patients with ventral hernia who will receive combination between graduated abdominal strengthening exercises and Russian stimulation on abdominal muscles for 30 min., 3 times per week for 6 weeks preoperatively.

1.1(d). Group D (Control group):
This group includes 15 patients with ventral hernia who will instruct to presume in normal activities of daily living preoperatively, without abdominal exercises or Russian stimulation.

1.2 Criteria for the patient selection:

1.2. (a) Inclusion Criteria:
The subject’s selection will be according to the following criteria:
- Age range between 20-45 years.
- All patients desire an elective surgical repair.
- All patients were diagnosed with ventral hernia (Grade II & III) based on surgeon assessment.
- All patients will participate in the study.
- All patients enrolled to the study will have their informed consent.
- All patients are able to act in abdominal training program.
- All patients are able to follow orders during testing and training times.

1.2. (b) Exclusion Criteria:
The participants will be excluded if they meet one of the following criteria:
- A strangulated hernia.
- History of surgical interference (abdominal surgery) less than one year.
- Liver cirrhosis with or without ascites.
- Hip or spine deformities or contractures.
- Bowel obstruction, peritonitis, or perforation.
- Local or systemic infection.
- Patient is pregnant or intended to become pregnant during this period.
- Patient has indication for urgent surgery determinate by surgeon.
2. Equipments:

2.1. Measurement equipment:

2.1. (a). Biodex 3, isokinetic Dynamometer System (with back/abdominal unit):

The Biodex® dynamometer studies muscle strength during isokinetic movement, which is a movement with a constant angular velocity within a certain range against a changing resistance (Den Hartog et al., 2010).

Isokinetic dynamometers may be used as scientific devices for testing, comparing, and confirming injured or treated body parts. Indeed, the constant technological advances over the past 15 yr facilitated the development of highly effective dynamometers usable for the assessment and rehabilitation of most joints in the upper and lower limbs. These devices are regularly used in osteoarticular disorders or in the framework of sports training programs. Most of the isokinetic machines used in pathology are rotating dynamometers. Results of an isokinetic assessment are generally expressed as the peak torque value developed by the tested muscle group. It is also possible to evaluate the work provided by the same muscle group and the power developed at the joint (Jee et al., 2015).

2.1. (b). Ultrasound imaging (USI):

A real-time ultrasound B-scanner with a linear array transducer was used to obtain images of the abdominal muscles. The penetration depth was 5.39 cm at a sampling frequency of 7.5 MHz. The transducer placed on the anterolateral wall of the abdomen between the iliac crest and the costal margin, perpendicular to the longitudinal axis of the body, at rest, the fascial borders of the 3 muscles; the oblique external (OE), oblique internal (OI), and transversus abdominis (TrA) appeared parallel on the screen (Linek et al., 2017).
Ultrasound is a reliable tool that is used to evaluate abdominal muscles in both adult and adolescents. It can be used to assess both muscle size and contraction. In other words, gives detailed information regarding isometric muscle contractions and muscle activation, even low levels, though difference between moderate and strong contractions can go unobserved. In their study, Hodges et al suggested US as a low cost non-invasive modality that can be used in examining deep abdominal muscles (Hodges et al., 2003).

To have a reliable measure, 3 thickness measurements taken at the end of expiration on both body sides should be done for transversus abdominis, internal oblique and external oblique in the supine, sitting, and standing positions. A recommended position for the assessment is the crock lying position to allow for relaxation of the anterior and posterior musculo-fascial trains (Linek et al., 2014).

2.2. Therapeutic equipment:

2.2. (a). Graduated Abdominal Exercises:

The following equipments will be used to achieve treatment approaches:

1. Exercise mat and inflatable Swiss ball 55 cm & 65 cm diameter.

2. Wall bar, wedges, elastic tubing (Thera-band) with resistance ranges from light to very heavy (yellow, red, blue, green, and gray colors).

2.2. (b). Russian Stimulation:

Russian current became popular to a large Extent as a result of the activities of Kots, who claimed force gains of up to 40% in elite athletes as a result of what was then a new form of stimulation. Kots’ argument for the use of electrical stimulation combined with voluntary exercise was that the commonly used exercise programs build muscle bulk and force (Ward et al., 2002).
The Russian current is used for enhancing muscle; the muscular fiber by the electric stimulation is used in Type II as Type I oppositely with the voluntary contraction. According to Hudlicka et al, the property of muscular contraction changes by long-term electric stimulation with low frequency in Type IIb type fiber, and these changes are related to the stimulus duration, so if the long-term low-frequency current is applied for more than two weeks in minimum, it will change physiologically into I type fiber (Jung et al., 2014).

3. Procedures of the study:

3.1. Measurement procedures:

3.1. (a). Isokinetic measurement:

- The evaluation procedures will be performed at faculty of physical therapy, south valley university, Laboratory of Isokinetic.
- Every patient will be instructed about the procedures of the evaluation and training.
- The environment of evaluation and training will be constant.
- The patients in all groups will be assessed 4 times, the first assessment will done 6 weeks preoperatively or before beginning treatment program, and the second assessment will done one week preoperatively, third assessment will done 2 months postoperatively, while fourth assessment will done 4 months postoperatively.
- The optimal position is the subject lay supine on a movable bench in a bent knee position. The lever arm of the isokinetic dynamometer was set at 180 degrees (horizontal with the ground) and the padded extension was placed just below the nipple line on the lower third of the sternum. The height of the bench was adjusted for each subject so that the extension arm remained at 180 degrees. Each subject was given several practice trials to make sure
the position of the lever arm was comfortable on their chest. Subjects then performed five isometric contractions, with approximately 30 seconds between each repetition. The average torque for the highest two repetitions was used in the analysis (Foster et al., 2005).

3.1. (b). **Ultrasound imaging:**

- Every patient will be instructed about the procedures of the evaluation and training.
- The environment of evaluation and training will be constant.
- The patients in all groups will be assessed 4 times, the first assessment will done 6 weeks preoperatively or before beginning treatment program, and the second assessment will done one week preoperatively, third assessment will done 2 months postoperatively, while fourth assessment will done 4 months postoperatively.
- A real-time ultrasound B-scanner with a linear array transducer was used to obtain images of the abdominal muscles. The penetration depth was 5.39 cm at a sampling frequency of 7.5 MHz. The transducer was always placed on the anterolateral wall of the abdomen between the iliac crest and the costal margin, perpendicular to the longitudinal axis of the body, at rest, the fascial borders of the 3 muscles; the oblique external, oblique internal, and transversus abdominis appeared parallel on the screen. Measurements of the thickness of the 3 muscles at rest were made in the supine rest position. In this position, the knees of the examined individuals were extended and the upper limbs placed along the sides of the trunk. The thickness of the muscles was stored at the end of normal expiration. All images were saved on an external drive in jpg format (Linek et al., 2017).
3.2. Therapeutic procedures:

3.2.(a). Procedures of Graduated Abdominal Exercises:

- All patients will be instructed to keep glottis open and to exert activity on exhalation as much as possible.

- **Activation of Rectus Abdominis:**
  - **Starting Position:** Supine with back and lower limbs supported on a wedge with restraining belts attached to the patients.
  - **Procedure:** Patients will be instructed to curl up trunk and raise lower limbs in low intensity isometric contraction for 10 sec., the resistance applied by the belts attached around patients.
  - **Exercise Repetitions:** 20 repetitions (Hold for 10 sec. and rest for 10 sec.).
  - **Graduation of Exercise:** The repetitions will be increased by one repetition each week and hold time will be increased by 2 sec. each week.

- **Posterior Pelvic Tilt:**
  - **Starting Position:** Crock lying with hands placed over ASIS on each side.
  - **Procedure:** The patient will ask to draw the pubic symphysis towards the umbilicus with emphasis on anterior musculature contracting.
  - **Exercise Repetitions:** 20 repetitions (Hold for 10 sec. and rest for 10 sec.).
  - **Graduation of Exercise:** The repetitions will be increased by one repetition each week and hold time will be increased by 2 sec. each week.

- **Rotational Planks:**
  - **Starting Position:** Prone with body held suspended on flexed elbow and feet.
Procedure: The patient should be keep elbows tucked in within alignment of trunk to limit latissimus dorsi contraction.
- The patient asked to hold lumbar spine in neutral position.
- Hold position for 20 sec. in prone position then ask patient to rotate to left and hold lumbar spine in neutral position for 20 sec. then rotate to right and hold lumbar spine in neutral position for 20 sec. then return to prone position and hold for 20 sec.

Exercise Repetitions: 10 repetitions (Hold for 20 sec. for each position).

Graduation of Exercise: The repetitions will be increased by one repetition each week and hold time will be increased by 2 sec. each week.

Abdominal Crunch on Swiss Ball with Elastic Resistance:

Starting Position: Patient site on Swiss ball then walk feet away while going lying down to allow ball stop under lumbar spine area. The feet placed 2 feet apart while knees bent at 90 degrees. Hands placed at shoulder level grasping the elastic resistance handles.

Procedure: Ask patient to curl the head, neck and shoulders up and towards the pelvic region (concentric phase). Then patient return slowly to starting position (eccentric phase).
- Several elastic tubing (Thera-band) with resistance ranges from light to very heavy (yellow, red, blue, green, and gray colors) will be used according to results of a 10 repetition maximum test to detect which elastic tube to start with it.

Exercise Repetitions: 40 repetitions (4 sets of 10 repetitions). With 1 min. rest after each set.

Graduation of Exercise: The repetitions will be increased in each set by 1-2 repetitions each session.
- The Elastic tube resistance should be tested every week.
Graduation of Exercises performance during rehabilitation period was modified from (Ellsworth et al., 2014, Sundstrup et al., 2012, Marchetti et al., 2011, and Kachingwe et al., 2008).

3.2.(b). Procedures of Russian Stimulation:

Device: ASTAR Etius ver. 3.0.

Patient position: Semi-recumbent.

Electrode positions: Place one of the electrodes over the center of the muscle belly and the other electrode distal on the muscle belly.

Carrier frequency: 2,500 Hz.

Burst modulated: The bursts are delivered at 50 bursts per second with burst duration of 10 msec and an interburst interval of 10 msec.

Duration: phase duration 200 μsec & cycle duration 400 μsec.

Duty cycle: 50%.

Protocol: 10/50/10 (10-second contraction time, 50-second off-time, 10 repetitions).

Frequency of treatment: three times weekly.

4. Statistical procedures:

4.1. Descriptive statistics:

In this study, the descriptive statistics (the mean and the standard deviation) will be calculated for all subjects in all groups of the study to determine the homogeneity of the groups.

4.2. Analytical statistics:

- In this study, t-test will performed for comparison of the mean age, between the groups.
• T test will performed for comparison of pre and post operative mean values of abdominal muscles peak torque between control and study groups.
• T test will performed for comparison of pre and post operative mean values of abdominal muscles thickness between control and study groups.
• Paired t test will performed for comparison between pre and post treatment mean values of abdominal muscles peak torque in each group.
• Paired t test will performed for comparison between pre and post treatment mean values of abdominal muscles thickness in each group.
• ANOVA with repeated measures will be performed for comparison between pre-operative, post-exercise and post-operative mean values of abdominal muscles peak torque.
• ANOVA with repeated measures will be performed for comparison between pre-operative, post-exercise and post-operative mean values of abdominal muscles thickness.
• The level of significance for all statistical tests will be set at $p > 0.05$.

References


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