

# The efficacy of isokinetic strength training versus core stability training on the trunk muscle strength and quality of life after surgical repair of incisional hernia in adolescents

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## ABSTRACT

**Objectives:** The study aimed to compare the impact of isokinetic strength training (IST) with core stability training (CST) in terms of trunk muscle strength and quality of life (QoL) after surgical repair of incisional hernia in adolescents.

**Patients and methods:** The prospective, randomized, comparative study was conducted at the College of Applied Medical Sciences, Department of Health and Rehabilitation Sciences between August 2019 and June 2020. Thirty patients (16 males, 14 females; mean age: 17.1±0.6 years; range, 12 to 18 years) who had undergone primary incisional hernia repair surgery were included in the study. The patients were randomly divided into two groups: the IST group of 15 patients who underwent the isokinetic exercise program for trunk muscles and the CST group of 15 patients who practiced the core exercise program. Each group exercised three times per week for six weeks. All patients were assessed pre- and post-treatment by an isokinetic dynamometer for trunk flexors and extensors at 60 and 90°/s angular velocities and the European Registry for Abdominal Wall Hernias (EuraHS)-QoL questionnaire.

**Results:** The trunk flexor and extensor Peak torque/body weight ratio at 60 and 90°/s angular velocities and QoL were significantly improved in both IST and CST groups ( $p < 0.05$ ). The post-treatment values of both groups revealed marked but not statistically significant differences in all measured variables ( $p > 0.05$ ).

**Conclusion:** Both IST and CST are effective training programs that can improve the strength of trunk flexors and extensors as well as QoL after surgical repair of incisional hernia in adolescents.

**Keywords:** Core stability training, incisional hernia, isokinetic dynamometer, isokinetic strength training, quality of life.

Incisional hernia (IH) can be described as an abdominal wall flaw at the location of abdominal wall closure.<sup>[1]</sup> The prevalence of IH fluctuates from 11 to 23% according to the occurrence of some aspects, such as the site of the abdominal incision, the suture material, the technique of closure, diabetes mellitus,

obesity, and emergency operations.<sup>[2]</sup> Although IH may remain silent and without any symptoms for years, it may grow with time and cause complications, such as pain, uncomfortable sensation, bowel impediment, and restriction of activity, and have a negative influence on the quality of life (QoL).<sup>[3]</sup>

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The main functions of the abdominal wall are to provide mechanical support to internal structures and the intra-abdominal pressure and to facilitate trunk mobility/movement. Incisional hernias impair the mechanical functions of the abdominal wall.<sup>[4]</sup> Nondisabling pain, muscular weakness, and impairment of QoL are possible complications after IH repair, which the patients seek for an improvement in the motion efficiency.<sup>[5]</sup> Incisional hernia in adolescence may take place when the pressure developed on the abdominal muscles surpasses its strength.

Surgical techniques for IH repair have a risk of potential abdominal muscles weakness, and postoperative rehabilitation should be considered to rebuild normal muscular strength.<sup>[6,7]</sup> Performing strengthening exercises of the trunk flexor muscles with an isokinetic dynamometer can improve the trunk flexion after transferring a flap of the rectus abdominis muscle.<sup>[8]</sup>

The isokinetic apparatus was developed as an objective method for evaluating trunk muscle strength. Additionally, it can be used for all types of muscle contraction training (concentric-concentric, concentric-eccentric, or eccentric-eccentric actions) at different velocities to increase muscular strength.<sup>[9]</sup> The isokinetic approach can measure the muscular strength during isokinetic movement, which is a motion with a steady angular speed in a specific range against alteration of the resistance.<sup>[10]</sup>

Core stability training (CST) is a useful exercise program that is used to reinforce the stabilizing muscles of the trunk with significant impact during activities of daily life.<sup>[11]</sup> Core stability training can stabilize the spine during muscle activities and postures to achieve adequate stability without overloading the muscles, which depends on the cocontraction of the abdominal and back muscles.<sup>[12]</sup>

There were few studies on the utilization of isokinetic apparatus for the assessment of muscular strength after surgical repair of IH. To our knowledge, no previous studies have compared an isokinetic strength training (IST) with a core CST after the surgical repair of IH. Accordingly, the aim of this study was to compare the effects of IST versus CST in terms of trunk muscles strength and QoL after the surgical repair of IH in adolescents.

## PATIENTS AND METHODS

The prospective, randomized, comparative study was conducted at the College of Applied Medical Sciences, Department of Health and Rehabilitation

Sciences between August 2019 and June 2020. The study consisted of 30 patients (16 males, 14 females; mean age:  $17.1 \pm 0.6$  years; range, 12 to 18 years) who had undergone primary IH repair surgery. One of the researchers contacted the outpatient clinic of the Department of Health and Rehabilitation Sciences, Prince Sattam Bin Abdulaziz University and recorded the contact information of the patients who had been discharged from the hospital within the last three to four months after confirming the inclusion criteria. The preliminary pathological conditions were appendicitis, congenital diaphragmatic hernia, stoma formation, and supraumbilical pyloromyotomy that required initial surgery before IH incidence. The patients were included if they had undergone primary IH repair surgery in the last three to four months in the form of laparoscopic or open repair surgeries and had not participated in any rehabilitation program to strengthen the trunk muscles after hernia repair. The exclusion criteria were as follows: patients with abdominal or inguinal hernia, previous repair of IH, bruising or swelling of the abdominal wall, diabetic patients, patients with neurological or muscular disorders, and patients with cardiac or pulmonary diseases. The basic characteristics and medical information of participants, including age, height, weight, body mass index, sex, the technique of surgical repair, and the number of months after the surgical repair, are demonstrated in Table 1.

At the beginning of the study, 34 patients were chosen considering inclusion criteria, after which each patient was given a number. Four patients were excluded (two with musculoskeletal injuries and two with inguinal hernia). After measuring the baseline of demographics, the randomization was completed for 30 patients utilizing closed envelopes. A researcher prepared 30 closed envelopes, and each envelope had a card labeled as either IST group or CST group. Each patient was requested to choose a closed envelope through 1:1 simple randomization, which determined whether they were randomly allocated to the IST group ( $n=15$ ) or CST group ( $n=15$ ). None of the patients dropped out. The flowchart of patient dropout and exclusion is shown in Figure 1. All patients were assessed for demographic characteristics.

An isokinetic dynamometer and the European Registry for Abdominal Wall Hernias (EuraHS)-QoL questionnaire were used to assess trunk muscles strength and patient's QoL, respectively, at the beginning and then one week after completing the six-week treatment program.<sup>[14]</sup>

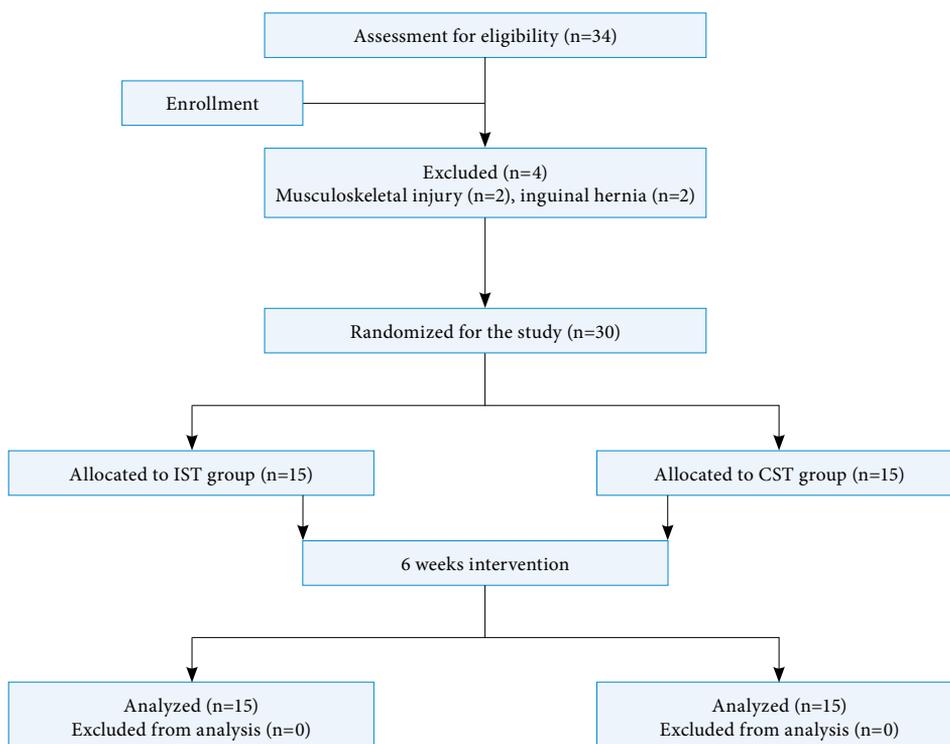
**TABLE 1**  
The demographic data clinical characteristics of IST and CST groups

	IST group (n=15)			CST group (n=15)			p
	n	%	Mean±SD	n	%	Mean±SD	
Age (year)			16.9±0.8			17.3±0.5	0.112
Height (cm)			174.3±2			176±3.1	0.085
Body mass (kg)			71.8±5			74±6.9	0.326
Body mass index (kg/m <sup>2</sup> )			20.5±2			21.9±2.2	0.079
Sex							
Male	10	66.7		6	40		
Female	5	33.3		9	60		
Surgery type							
Laparoscopic	9	60		7	46.7		
Open repair	6	40		8	53.3		
Hernia repair duration (month)			3.5±0.7			3.2±0.1	0.116

IST: Isokinetic training; CST: Core stability training; SD: Standard deviation.

Trunk flexor and extensor torque for each patient in both groups were measured by a computerized isokinetic dynamometer (Cybex, Division of Lumex Inc. Ronkonkoma, NY, USA). It was reported as a reliable and efficient way to evaluate muscle strength.<sup>[13]</sup> The patient’s position was standardized according to the manufacturer’s guide. The axis of rotation was

set at the intersection between the midaxillary line and the lumbosacral junction (about 3.5 cm inferior to the top point of the iliac crest). Upright standing posture was resolved as the initial anatomical position. Cushions and straps (pelvic strap, popliteal cushion, thigh cushion, sacral cushion, scapular cushion, and chest cushion) were used to stabilize the pelvis, lower



**Figure 1.** Flowchart of the study.  
IST: Isokinetic training; CST: Core stability training.

extremities, and chest. The lower part of the body was positioned in 15° knee flexion by tibial, popliteal, and thigh cushions. The range of motion was restricted from 10° extension to 80° flexion. The isokinetic muscle strength of the trunk was usually evaluated by the same researcher and at the same time of day throughout the study to limit variances in muscular activity.

Before the assessment, patients were rest period was allowed between each test repetition. The assessed parameter was the peak torque (expressed in Nm), which was normalized to the patients' body weight (expressed in Nm/kg). They were informed about the isokinetic dynamometer procedure. Device calibration was done before each assessment. Before the isokinetic evaluation, each patient was asked to walk for 10 min, and afterward, the patient performed two submaximal repetitive movements of trunk flexion and extension at 90°/s angular velocity as a warm-up exercise. For the trunk muscle assessment, the isokinetic angular velocities were applied at 60 and 90°/s. For every patient, trunk flexion and extension contractions with maximum exertion were done five times at each speed. A 20-sec values of peak torque/body weight (PT/BW) of trunk flexors and extensors at 60 and 90°/s velocities were used for analysis.

The EuraHS-QoL is a short and valid hernia questionnaire with nine queries that are self-reported by the subject on an 11-digit score from 0 to 10.<sup>[14]</sup> The EuraHS-QoL questionnaire consists of three domains: "pain" (0-30), "activity restriction" (0-40), and "cosmetic discomfort" (0-20). The overall score varies from 0 to 90, with minimum values referring to the most satisfying results.

A 10-min walk was accomplished by patients in each group before starting the treatment procedure as a warm-up exercise. Patients in both groups underwent a six-week exercise program three days a week. The average exercise program time was 40 min for each group. The treatment procedures were supervised by a qualified physical therapist.

Patients in the IST group underwent a six-week isokinetic exercise program on the same device which was used for trunk muscle assessment. After the warm-up, the same testing position was reapplied. Each patient completed trunk flexion and extension contractions five times with maximum exertion at 60 and 90°/s angular velocities and rested for 60 sec in between the sets (three sets) under the supervision of a physical therapist. The patients were verbally

encouraged to complete the movements as quickly and vigorously as possible to enhance their compatibility with the program.

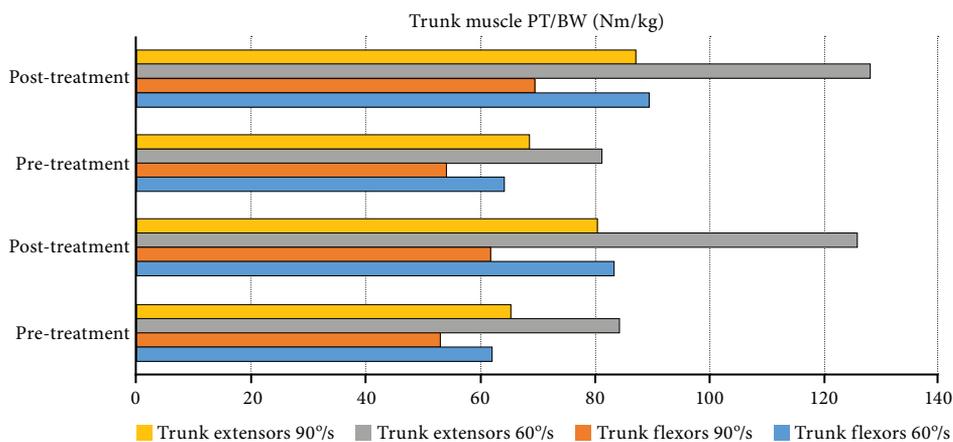
Patients in the CST group underwent a six-week core exercise program. Exercises were performed under a physical therapist's supervision. The CST program was composed of three categories of exercises on the bed, wedge, and Swiss ball. Initially, the bed exercises were conducted in the form of bridge exercises (alone, with crossed legs, and with a single leg), curl-up exercises (with straightforward reaching and oblique reaching), bird-dog exercises, and side-bridge exercises. Afterward, the wedge exercises composed of curl-up exercises (with straightforward reaching, oblique reaching, and crossed arms) were performed. Lastly, the ball exercises comprised of bridge exercises (alone, to the side, and bridge-ups), abdominal curl-ups, bird-dog exercises, and push-ups were done.<sup>[11,15]</sup> Each exercise in the program was repeated five times.

### Statistical analysis

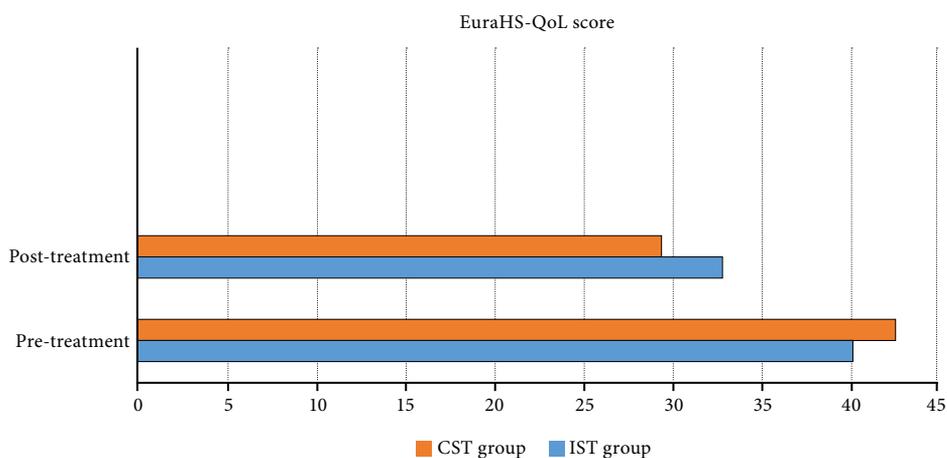
The statistical analysis was performed utilizing IBM SPSS version 19.0 software (IBM Corp., Armonk, NY, USA). The Shapiro-Wilk test was performed to test for normal distribution. The mean and standard deviation (mean±SD) were calculated for all the variables, and the paired and unpaired t-tests were implemented for the contrast of patients' characteristics within and between groups, respectively. The sample size of 30 adolescents was estimated depending on the probable effect size ( $d=0.4$ ) and at a power of 80%. The power was set at an 80% chance of correctly rejecting the null hypothesis of no difference with a total of 20 patients. We recruited 34 patients in anticipation of an approximately 10% patient dropout rate.<sup>[16]</sup> The level of statistical significance was set at  $p<0.05$ .

## RESULTS

Analysis of the preliminary demographic and clinical data of patients revealed no significant differences between the two study groups in terms of age, height, weight, body mass index, sex, the technique of surgical repair, and the number of months after the surgical repair (Table 1; Figures 2 and 3;  $p>0.05$ ). All 30 adolescents correctly completed the treatment sessions. After six weeks of regular training, trunk muscles strength improved significantly in both groups, as compared with the pre-treatment values at the two different angular velocities, which were measured by PT/BW. The statistical analysis revealed a significant improvement in the PT/BW ratio of trunk flexors



**Figure 2.** Mean values of trunk muscles PT/BW (Nm/kg) at 60°/s and 90°/s angular velocities. PT/BW: Peak torque/body weight.



**Figure 3.** Mean values of EuraHS-QoL score. EuraHS-QoL: European Registry for Abdominal Wall Hernias Quality of Life.

TABLE 2							
Differences of mean values (mean±SD) in terms of muscle PT/BW (Nm/kg) at 60 and 90°/s angular velocities and EuraHS-QoL score between the IST and CST groups							
Variables	IST Group (n= 15)			CST Group (n= 15)			Post-treatment difference between groups
	Pre-treatment	Post-treatment	p	Pre-treatment	Post-treatment	p	
	Mean±SD	Mean±SD		Mean±SD	Mean±SD		
Trunk flexors 60°/s	62.2±12	83.5±12.4	<0.001*	64.6±9.6	89.8±16.2	<0.001*	0.205
Trunk flexors 90°/s	53.2±12	62±11.24	0.042*	54.6±14.6	69.8±17.3	0.011*	0.441
Trunk extensors 60°/s	84.5±19.4	126.2±18.4	<0.001*	81.6±20.4	128.4±21.2	<0.001*	0.722
Trunk extensors 90°/s	65.6±16.8	80.7±14.9	0.011*	69±17.6	87.21±21.8	0.013*	0.321
EuraHS-QoL score	40.4±4	33±5.3	0.001*	42.6±5.2	29.5±4.5	<0.0001*	0.061

PT/BW: Peak torque/body weight; Nm/kg: Newton\*meter/ kilogram; EuraHS-QoL: European Registry for Abdominal Wall Hernias Quality of Life; IST: Isokinetic training; CST: Core stability training; SD: Standard deviation; \* Significant differences between groups (p<0.05).

at 60 and 90°/s in the IST group ( $p < 0.001$ ,  $p = 0.042$ , respectively) and the CST group ( $p < 0.001$ ,  $p = 0.011$ , respectively; Table 2). Similarly, in the IST group ( $p < 0.001$ ,  $p = 0.011$ , respectively) and the CST group ( $p < 0.001$ ,  $p = 0.013$ , respectively), the PT/BW ratio of trunk extensors significantly improved at 60 and 90°/s (Table 2, Figure 2).

The mean post-treatment values showed no significant differences in the PT/BW of trunk flexors at 60 and 90°/s between the IST and CST groups ( $p > 0.05$ ). There were no significant changes in the PT/BW of trunk extensors at 60 and 90°/s ( $p > 0.05$ ) between the IST and CST groups. Likewise, there was no significant difference between the two groups in the EuraHS-QoL score ( $p = 0.06$ ; Table 2; Figures 2 and 3).

## DISCUSSION

The rehabilitation program after the surgical repair of IH is imperative to strengthen the supporting muscles of the abdominal wall, decrease pressure on the muscles, provide compression support during activities, and prevent the recurrence of IH throughout the course of life. In the present study, the application of either of the programs (IST and CST) resulted in significant improvement in the strength of trunk flexors and extensors and the QoL after surgical repair of IH in adolescents. Both groups responded similarly to their respective treatment programs; however, there was a preference for the CST program due to the marked but not statistically significant changes. This can be justified as the CST program facilitates neuromuscular recall and improves poor postural (trunk muscle) control.

The force-velocity correlation of skeletal muscles can be assessed by isokinetic devices *in vivo*. Numerous studies have discovered the influence of an isokinetic resisted training program on muscular strength or cross-sectional area.<sup>[17,18]</sup> The IST program develops maximal tension through the range of motion so that muscular strength or hypertrophy can be achieved.

The strength of the muscles can be increased after short periods of isokinetic resistance exercises due to more contractile activity that develops within the muscles.<sup>[19]</sup> Therefore, the factors that enhance muscular strength are neural and hypertrophic, creating muscular strength during early periods of the resisted training program and gradually dominating neurons in achieving the strength, respectively.<sup>[20,21]</sup> Another study showed that 90% of the increase in

muscular strength depends on neural factors after a two-week isokinetic resistance exercise program, according to electromyographic evaluations.<sup>[22]</sup>

An increment in angular velocities from 60 to 90°/s was found to optimize the nervous system's capability to produce rapid torque and improve muscular strength.<sup>[20]</sup> The augmentation of the peak torque findings of the specific muscles after an isokinetic exercise program may be owing to optimization of the recruitment of motor units and frequent stimulation. It can allow the coordination of the neuromotor patterns between the trunk flexors and extensors (i.e., between agonist and antagonist muscles) that strengthen the muscles and improve their performance.<sup>[21]</sup>

Core stability exercises can stimulate the adaptation process in the neuromuscular system, which improves muscle strength, movement performance, and balance. The CST program may motivate neural efficiency, activate the nervous system, enhance the synchronization of motor units, and reduce inhibitory reflexes.<sup>[22]</sup> During the core stability program, the spine can be stabilized by the synchronized contraction of the abdominal and back muscles.

The contraction of muscles (oblique abdominal and transversus abdominis) can occur in core function irrespective of the direction of force, while the rectus abdominis and back muscles have various response times related to the force direction that results in positive effects on muscle activation and strength.<sup>[23]</sup> The CST program can be practiced simply at home without any constraints of space, time, or finances. Additionally, the CST program can help regain muscular function after weakness by boosting the mechanical support of the spinal column and pelvis.

The strengths of this study are that it is the first study comparing the influence of an IST program versus a CST program on trunk muscles strength as well as QoL after surgical repair of IH in adolescents, including a six-week strength training program in the form of IST or CST leading to substantial improvements in trunk muscle strength (flexor and extensor) in addition to significant optimization in QoL in both groups, and utilizing a computerized isokinetic dynamometer as an objective, valid, and reliable modality for assessment of muscle strength. Moreover, both training programs (IST and CST), which are efficient, powerful, and appropriate methods for strengthening the trunk muscles and enhancing

QoL after surgical repair of IH, particularly CST, which can be applied simply at home and is financially low-cost, were conducted under a physical therapist's supervision.

The key limitation point of this study was the limited number of patients, as many patients were unavailable after the surgical repair of IH, and the global circumstances after the coronavirus disease 2019 pandemic. We tried to overcome the constraint of the limited number of patients by randomizing the patients into two equal treatment groups. Other limitations were the lack of a true control group, biases, and the lack of both short-and long-term follow-up periods. Hence, for future studies, it is recommended to have a larger population with different age groups, a combination of programs (IST and CST), a control group, and a follow-up period.

In conclusion, supervised IST and CST are equally effective as training programs to improve the strength of trunk flexors and extensors with no significant differences. Furthermore, both programs enhance the QoL in the same way after surgical repair of IH in adolescents.

**Ethics Committee Approval:** The study protocol was approved by the College of Applied Medical Sciences, Prince Sattam Bin Abdulaziz Univrsity Ethics Committee (RHPT/2019/014). The study was conducted in accordance with the principles of the Declaration of Helsinki.

**Patient Consent for Publication:** A written informed consent was obtained from each patient.

**Data Sharing Statement:** The data that support the findings of this study are available from the corresponding author upon reasonable request.

**Author Contributions:** Study conception and design: N.M.; Data collection: N.R.; Analysis and interpretation of results: M.I.; Draft manuscript preparation: A.S.; All authors reviewed the results and approved the final version of the manuscript.

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