

Isokinetic strength of the trunk flexor muscles after surgical repair for incisional hernia

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Abstract

Purpose The repair of incisional hernias can be accomplished by open or laparoscopic techniques. The Biodex[®] dynamometer measures muscle strength during isokinetic movement. The objectives of this study are to compare the strength of the trunk flexors between patients who underwent repair for incisional hernia and a control group, and to compare trunk flexion after two kinds of operative techniques for incisional hernias with and without approximation of the rectus abdominis muscles.

Methods The trunk flexion of 30 patients after different operative techniques for midline incisional hernias and of 12 healthy subjects was studied with the Biodex[®] isokinetic dynamometer.

Results The mean torque/weight (N m/kg) for trunk flexion was significantly higher in the control group compared to the patient group after incisional hernia repair. A significantly higher peak torque/weight [coefficient 24.45, 95%

confidence interval (CI) $-0.05; 48.94$, $P = 0.05$] was found in the two-layered suture technique without mesh compared to the laparoscopic technique after adjusting for gender.

Conclusions The isokinetic strength of the trunk flexor muscles is reduced after an operation for incisional hernia. There is some evidence that a two-layered suture repair with approximation of the rectus abdominis muscles results in higher isokinetic strength of the trunk flexor muscles compared to the laparoscopic technique.

Keywords Ventral hernia · Abdominal hernia · Muscle strength dynamometer · Abdominal muscles · Rectus abdominis

Introduction

Incisional hernias are a serious complication of abdominal surgery and they occur in 11–23% of laparotomies [1]. After abdominal aortic resection, the incidence of incisional hernia can be as high as 60% [2]. The hernia can be repaired by either open or laparoscopic techniques. Laparoscopic correction is always performed with a mesh. The open technique can be simple hernioplasty (Mayo duplication or fascia adaptation), component separation technique after Ramirez or a mesh repair with (Rives–Stoppa) or without approximation of the rectus abdominis muscles. The open technique can be performed using a separate-layer technique without the use of mesh [3]. In this two-layered suture repair, the abdominal wall is anatomically reconstructed and the rectus muscles are placed in a normal median position. In this technique, the rectus muscles are attached to each other at the midline; as a result, they are thought to retain normal strength. However, muscle strength studies of the trunk flexors after abdominal operations

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Fig. 1 Set-up of the Biodex[®] isokinetic dynamometer



are rarely performed. Zauner-Dungl et al. studied trunk flexion strength after rectus abdominis muscle flap transfer in reconstructive surgery with an isokinetic dynamometer [4]. The same group studied trunk flexion strength comparing a laparoscopic technique with open cholecystectomy [5].

The Biodex[®] dynamometer studies muscle strength during isokinetic movement, which is a movement with a constant angular velocity (given by the dynamometer) within a certain range against a changing resistance, given by the subject [6–8].

The object of this study is to compare the trunk flexion strength between patients who underwent surgical repair for incisional hernia and a healthy control group. The second objective is to compare the trunk flexion strength after two different kinds of operative techniques for incisional hernia.

Patients and methods

This study consisted of 30 patients who underwent midline incisional hernia operations and 12 healthy subjects without any abdominal operation. Fifty-five percent of the subjects were male and their mean (standard deviation [SD]) age, height, body weight and body mass index were 60 (15) years, 173 (11) cm, 81 (18) kg and 27 (4) kg/m², respectively. The mean age was significantly lower in the control group than in the patient group (49 vs. 64 years, $P < 0.01$). The patients had undergone operations in either an academic ($n = 14$) or a teaching hospital ($n = 16$). Sixteen (53.3%) patients had operations with an open technique and 14 (46.7%) by laparoscopic access. In the laparoscopic technique, a mesh was used and the fascia was left open. In the open repair, the fascia was closed in a two-layered technique without using a mesh [3]. The mean

follow-up time between the Biodex[®] examination and the operation was 5.8 (1.8) years.

Trunk flexion strength measurements were conducted on a Biodex[®] isokinetic dynamometer (Model 2000, Multi-joint System 3, Biodex Corporation, Shirley, NY, USA). Each subject was seated on a chair with his or her body strapped to the back of the chair. The mechanical stops were positioned with an amplitude of 60° to prevent the subject from working in non-conventional zones (Fig. 1). One session of flexions and extensions was performed to get the subject accustomed to the exercise before testing. The second test session was used for collecting data measurements.

Trunk flexor muscles were assessed at 60°/s angular velocities. The subjects performed six flexions and extensions and were encouraged to generate maximal effort through the entire range of motion for all repetitions. The peak torque was expressed in Newton metres (N m) and was normalised to the body weight (N m/kg × 100%). Torque was proportional to power and the peak torque was the highest value within the range of motion (Fig. 2).

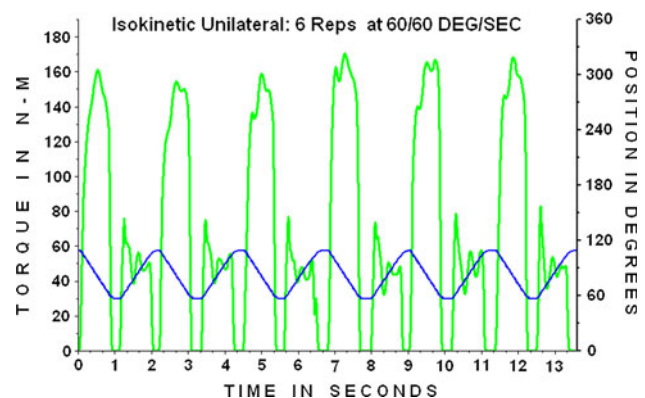


Fig. 2 Example of the torque course of six flexions and extensions as a function of time

Statistical analysis

Statistical analysis was performed with the PASW Statistics 17.0 package on a personal computer. All continuous data were given as means with SDs.

The two-sample *t*-test was used to compare the control and operative groups for age, weight and length. The Chi-square test was used to compare the control and operative groups for gender.

The two-sample *t*-test was used to compare the Biodex® measurements in the controls and the patients after operative repair for incisional hernia. This test was also used to compare the Biodex® measurements among themselves in patients after two operative techniques for incisional hernia, two-layered closure repair and laparoscopic repair with a mesh. A *P*-value < 0.05 was taken as the threshold of statistical significance.

The relationship between the peak torque (N m) and the operative technique (open or laparoscopic) was estimated using multiple regressions allowing for body weight, age and gender. Non-significant variables were removed one by one, removing the largest *P*-value first, until all of the remaining variables in the model were significant.

Because values of the Biodex® measurements with standard deviations from patients after incisional hernia opera-

tions could not be retrieved from the literature, sample size calculations could not be performed.

Results

Gender, height and weight were not significantly different between the patients and controls or between the open and laparoscopic groups.

The mean torque/weight (N m/kg) for trunk flexion was significantly higher in the control group than in the total patient group after incisional hernia repair (Table 1). This difference with the control group existed for both kinds of operative techniques, namely, the two-layered closure and the laparoscopic repair.

The mean torque/weight (N m/kg) for trunk flexion was not significantly different in a mutual comparison of the two operative techniques (two-layered closure repair and laparoscopic repair with a mesh) (Table 2). The post-hoc power calculation is presented in the last column of Table 2.

A significantly higher peak torque/weight (coefficient 24.45, 95% confidence interval [CI] −0.05; 48.94, *P* = 0.05) was found in the two-layered suture technique compared to the laparoscopic technique after adjusting for gender (Table 3).

Table 1 Mean peak torque related to body weight in N m/kg (standard deviation [SD]) in trunk flexion comparing two different operations for incisional hernia with the control group (*n* = 12)

Peak torque/weight (N m/kg)	Operation group	Control group (<i>n</i> = 12)	Confidence interval of the difference	<i>P</i> -value
Total operation group (<i>n</i> = 30) versus control	84.4 (38.9)	202.4 (88.6)	60.5; 175.4	<0.01
No mesh = two-layered technique (<i>n</i> = 16) versus control	95.8 (39.7)	202.4 (88.6)	47.9; 165.3	<0.01
Laparoscopic (<i>n</i> = 14) versus control group	71.4 (34.8)	202.4 (88.6)	72.6; 189.4	<0.001

Table 2 Mean peak torque related to body weight in N m/kg (SD) in trunk flexion comparing the two operations for incisional hernia

Peak torque/weight (N m/kg)	Laparoscopic group (<i>n</i> = 14)	Two-layered technique (<i>n</i> = 16)	Confidence interval of the difference	<i>P</i> -value	Power post-hoc
Laparoscopic versus two-layered technique	71.4 (34.8)	95.8 (39.7)	−52.5; 3.6	0.086	0.41

Table 3 Regression coefficients of peak torque related to body weight in N m/kg with respect to gender and laparoscopic access versus the two-layered suture technique

Variable	Coefficient	95% confidence interval (CI)	<i>P</i> -value	Standardised coefficient
Gender ^a	−37.58	−62.02; −13.14	0.004	−0.49
Laparoscopic versus two-layered suture technique ^b	24.45	−0.05; 48.94	0.050	0.32

^a Male gender is the reference category

^b Laparoscopic access is the reference category

Discussion

In this study, we compared the isokinetic muscle strength of the trunk flexor muscles measured with the Biodex® isokinetic dynamometer between patients who underwent repair for incisional hernia and a control group without any abdominal operation. The mean peak torque, as a measure of the isokinetic strength of trunk flexor muscles, was significantly lower in the patients with incisional hernia operations than in the healthy controls. We also compared the trunk flexion strength after two kinds of operative techniques for incisional hernias with and without approximation of the rectus abdominis muscles. A significantly higher peak torque/weight was found in the two-layered suture technique compared to the laparoscopic technique after adjusting for gender.

Midline incisional hernias displace the rectus muscles laterally. This lateral position might be the cause of a weakened abdominal muscle strength. In a study comparing laparoscopic with open cholecystectomy, the open technique resulted in reduced muscle strength of the trunk flexor muscles compared to controls and the laparoscopic approach [5]. The open cholecystectomy was performed subcostally with transections of the right rectus abdominis muscle. This is in contrast with the laparoscopic technique through small incisions, which leave the rectus abdominis muscles intact. So, a scarred rectus abdominis muscle lowers the muscle strength of trunk flexion measured with an isokinetic dynamometer.

In contrast to the two-layered closure repair for incisional hernia, in which the rectus muscles are medially positioned and, as such, can exert greater strength, in the laparoscopic mesh technique, the rectus muscles remain in their lateral displaced position.

Despite the considerable academic interest, the clinical relevance of a reduced isokinetic strength of the trunk flexors is not exactly known and correlations between strength, signs and symptoms have not been studied. Significantly lower mean strength values have been found in patients with chronic back pain [7]. It will be interesting to study the relationship between the reduced muscle strength of trunk flexors in patients with incisional hernia and the patients' symptoms before and after surgical repair. Overall, incisional hernia symptoms have not been systematically studied [9]. The reduced muscle strength of trunk flexors in patients after laparoscopic repair techniques for incisional hernia could cause a higher prevalence of back pain than in patients after the two-layered closure repair with approximation of the rectus abdominis muscles.

The statistical power for finding a significant difference between the two operative techniques was low and was caused by the small sample sizes of the groups. Because we

only rented the Biodex® isokinetic dynamometer for a limited time, more patients could not be examined. The small sample size of our study is a flaw for making strong conclusions. Measuring the same patients before and after operation will increase the power of the study.

Another limitation of our study is the use of healthy controls. A better and more interesting study group for comparison would be a patient group with a well-healed scar after a median laparotomy or patients with a large primary incisional hernia. Our healthy controls were also younger than the incisional hernia patients. This could have resulted partly in the large difference between the controls and the patients. We did not examine the trunk flexor muscles in patients after a midline laparotomy and in patients with an incisional hernia. Balogh et al. studied isokinetic muscle strength of the trunk flexor muscles with the Cybex® isokinetic dynamometer 6 months to 1.5 years after open subcostal cholecystectomy and in healthy volunteers [5]. Their controls consisted of 10 men and 12 women, but these volunteers had a mean age of 23.5 years younger than our controls. Their mean peak torque at 30°/s angular velocity was 221.7 N m/kg. Keeping account of the higher age of our controls, this is comparable with the mean peak torque at 60°/s of 202.4 N m/kg. The mean peak torque at 30°/s of the open cholecystectomy group (13 men, 12, female, mean age 58 years) of Balogh et al. was 170.7 N m/kg, which is much higher than in our incisional hernia group (84.4 N m/kg). So, having an incisional hernia and incisional hernia surgery affects the peak torque more than having a laparotomy, such as an open subcostal cholecystectomy.

Moreover, it will be necessary to replicate the significant difference in peak torque between the laparoscopic group and the two-layered closure repair in larger sample sizes. It is important and interesting to establish whether the difference in trunk flexor torque also exists in other open procedures, in which the fascia is closed; this question should also be studied in larger sample sizes than those used in this study.

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References

1. Cassar K, Munro A (2002) Surgical treatment of incisional hernia. *Br J Surg* 89(5):534–545
2. den Hartog D, Dur AH, Kamphuis AG, Tuinebreijer WE, Kreis RW (2009) Comparison of ultrasonography with computed tomography in the diagnosis of incisional hernias. *Hernia* 13(1):45–48
3. Dur AH, den Hartog D, Tuinebreijer WE, Kreis RW, Lange JF (2009) Low recurrence rate of a two-layered closure repair for primary and recurrent midline incisional hernia without mesh. *Hernia* 13(4):421–426

4. Zauner-Dungl A, Resch KL, Herczeg E, Piza-Katzer H (1995) Quantification of functional deficits associated with rectus abdominis muscle flaps. *Plast Reconstr Surg* 96(7):1623–1628
5. Balogh B, Zauner-Dungl A, Nicolakis P, Armbruster C, Kriwanek S, Piza-Katzer H (2002) Functional impairment of the abdominal wall following laparoscopic and open cholecystectomy. *Surg Endosc* 16(3):481–486
6. Newton M, Waddell G (1993) Trunk strength testing with iso-machines. Part 1: review of a decade of scientific evidence. *Spine* 18(7):801–811
7. Newton M, Thow M, Somerville D, Henderson I, Waddell G (1993) Trunk strength testing with iso-machines. Part 2: experimental evaluation of the Cybex II Back Testing System in normal subjects and patients with chronic low back pain. *Spine* 18(7):812–824
8. Kannus P (1994) Isokinetic evaluation of muscular performance: implications for muscle testing and rehabilitation. *Int J Sports Med* 15(Suppl 1):S11–S18
9. Nieuwenhuizen J, Halm JA, Jeekel J, Lange JF (2007) Natural course of incisional hernia and indications for repair. *Scand J Surg* 96(4):293–296