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Short Report

Impact of incisional hernia on abdominal wall strength

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Introduction

Incisional hernias are a common condition after abdominal wall incisions, with varying incidence rates and significant associated costs[1,2]. The rates tend to increase over time, reaching approximately 12.8% 2 years after the initial surgery[2], though they can be considerably higher when patient-related factors (obesity, uncontrolled diabetes, active smoking, malnutrition, etc.), hernia characteristics (hernia defect size, contaminated surgical field) or the type of surgical repair (closure technique, mesh placement, etc.) are taken into account[3–5].

Furthermore, recurrence after incisional hernia repair increases to reach 50% in the long term, also elevating the risk of other postoperative complications[4,6].

Patients with incisional hernia often experience symptoms that adversely affect their quality of life (QoL)[7,8]. These symptoms include pain, swelling, discomfort, and urinary and gastrointestinal issues[9,10]. The presence of incisional hernias can also impact domains of general health such as social functioning, mental health and physical performance[11]. However, reports assessing the effects of incisional hernias on abdominal wall strength and functional performance are scarce.

Muscle strength, particularly hand grip strength and lower limb strength, is widely recognized as a critical determinant of overall population health[12,13]. Extending this principle, it is reasonable to posit that abdominal wall strength may similarly influence an individual's health and overall QoL.

Therefore, the aim of this study was to analyse abdominal muscle strength in patients with incisional hernia compared with healthy control subjects.

Methods

A prospective case-control study (July 2022–June 2023) included midline incisional hernia patients (W2-3 per European Hernia Society classification, larger than 4 cm) in a 1:1 match with healthy controls, aligning for sex, BMI, age and body composition (variables related to abdominal wall strength)[14] (*Supplementary methods*).

Exclusion criteria included lateral hernias, prior abdominal surgery and patient refusal. The control group included healthy subjects (hospital staff and patients' relatives) matched for biometric criteria with the patients' group.

The primary aim was to compare abdominal muscle strength, while secondary objectives involved analysing strain gauge kinetic measurements and identifying predictive variables for abdominal wall strength.

Approved by the Andalusian Biomedical Research Ethics Portal (PEIBA), the study followed STROBE guidelines[15]. Data included demographics, body composition, hernia defect width, and strength measurements using bioelectrical impedance analysis and a strain gauge (Chronojump, Barcelona, Spain: Boscosystem®). Isometric contractions at 90° and 45° were assessed, and three repetitions were performed with a 60 second rest between each, as detailed elsewhere[14].

Results

Of 42 recruited patients with hernia, two were excluded (incorrect test performed). Their mean(s.d.) hernia diameter was 6.6(1.5) cm. Forty healthy subjects were included. The mean(s.d.) age was 57.9(9.8) years, and female patients represented 62.5%. No differences were observed in the demographic characteristics and body composition between groups (*Table S1*).

Abdominal wall strength measurements

Regarding the maximal force generated, significant differences close to 20% were observed between the incisional hernia group and the control group in both 90° for rectus abdominis muscles and 45° for lateral musculature ($P = 0.001$ and $P < 0.0001$). The force generation rates were also lower in the incisional hernia group, with mean differences ranging from 168 to 290 $N \cdot s^{-1}$ ($P = 0.003$ and $P < 0.0001$). Detailed strength data comparing both groups can be found in *Table 1*.

A multivariable analysis included age, sex, BMI and hernia diameter. Both models for 90° and 45° were statistically significant, with R-square values of 0.43 for 90° and 0.39 for 45°, indicating a strong explanatory power.

Our findings indicate that sex was the most influential factor in the regression model (*Table 2*). On average, male patients

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Table 1 Comparison of strength measurements between the incisional hernia group and the control group

	Incisional hernia group	Control group	Mean difference	95% c.i.	P
Rectus abdominis muscles					
Peak force 90° (N·m)					
Attempt 1	169.02(57.31)	208.61(46.87)	39.59	17.32,61.86	0.001
Attempt 2	162.53(51.20)	221.58(54.10)	59.05	36.49,81.62	<0.0001
Attempt 3	164.63(49.23)	213.91(47.27)	49.28	28.86,69.71	<0.0001
RFD 90° ($N \cdot s^{-1}$)					
Attempt 1	366.00(357.21)	741.73(349.52)	202.38	108.31,459.02	0.003
Attempt 2	457.44(365.18)	747.62(403.78)	290.18	110.82,469.55	0.001
Attempt 3	538.98(461.13)	732.27(397.36)	193.28	98.09,383.57	0.053
Lateral abdominal musculature					
Peak force 45° (N·m)					
Attempt 1	151.63(4.33)	195.49(53.60)	43.85	22.95,64.76	<0.0001
Attempt 2	155.81(44.35)	197.45(47.34)	41.64	22.14,61.14	<0.0001
Attempt 3	156.83(45.88)	203.91(46.95)	47.08	26.99,67.18	<0.0001
RFD 45° ($N \cdot s^{-1}$)					
Attempt 1	302.90(219.41)	552.27(343.54)	249.37	107.76,390.99	<0.0001
Attempt 2	388.90(346.99)	557.29(327.41)	168.38	12.18,324.60	0.037
Attempt 3	351.83(263.19)	596.98(338.70)	245.14	104.47,385.82	0.001

N·m, Newtons per meter; $N \cdot s^{-1}$, Newtons per seconds squared; RFD, rate force development. Values are mean(s.d.) unless otherwise indicated.

Table 2 Regression model analysis of peak force at 90° (rectus abdominis muscles) and 45° (lateral abdominal musculature) evaluation

Regression model at 90° (rectus abdominis muscles)	Coefficient	95% c.i.	P
(Constant)	200.84	42.04,287.25	<0.0001
Hernia max diameter (cm)	−5.29	−38.89,−1.35	<0.0001
Age (years)	−0.91	−1.86,0.56	0.067
Female sex	−53.44	−140.52,−5.30	<0.0001
BMI	2.93	1.18,4.72	0.004
Regression model at 45° (lateral abdominal musculature)	**Coefficient**	**95% c.i.**	**P**
(Constant)	224.36	76.97,297.65	<0.0001
Hernia max diameter (cm)	−5.55	−41.31,−1.98	<0.0001
Age (years)	−35.49	−80.86,−3.38	<0.0001
Female sex	1.89	1.10,7.82	0.036
BMI	−1.21	−15.24,−2.68	0.009

exhibited approximately 50 Newtons more strength than their female counterparts (both at 90° and 45°). Additionally, according to our model, an increase of each centimetre in hernia size reduced the peak force by 5 Newtons. Age was an independent factor for abdominal strength at 45° only. Finally, BMI also emerged as an independent predictor of peak force both at 90° and 45°.

Discussion

The study primary outcome revealed that individuals with incisional hernias larger than 4 cm exert approximately 20% less force in abdominal wall muscle function compared with those without abdominal wall defects, when matched for sex, age, BMI and body composition. It is evident that patients with incisional hernia show significantly reduced abdominal strength compared with healthy individuals. Identifying this early could have an impact on perioperative management, improving their overall QoL.

Previous research indicated reduced muscle strength with larger hernias[16], while the findings of this study extend this association to hernias larger than 4 cm. The prevalence of W2 hernias suggests a substantial population with compromised abdominal strength. Jensen *et al.*'s validation study[12] observed a decline of strength in patients with hernia, but without substantial sample or comparable groups, leading to potential biases.

While the isokinetic dynamometer is considered the 'standard' for strength assessment[17], its cost makes it impractical for clinical use. This study proposes the strain gauge as a cost-effective, clinically practical alternative for assessing abdominal muscle strength, overcoming limitations of other devices. The use of a strain gauge in the trunk region presents additional challenges, such as the difficulty in isolating the musculature of the abdominal wall from other accessory muscle groups.

Several variables emerged as independent predictors of abdominal functional capacity in our study. The most prominent predictor was sex, with the size of the hernia defect also playing a significant role. Moreover, the observed differences in peak force at 45° with age imply a more substantial impact of ageing effects on the lateral musculature. A previous report[18] linked sex to abdominal wall strength, but not age nor BMI, although these were studies with a small number of subjects. In this regard it is well established that both age and BMI exert a direct influence on the onset of sarcopenia, which is implicated in functional decline and the occurrence of adverse health events[19]. Consequently, these new findings enable us to identify potential risk groups that could benefit from specific therapies aimed at preventing the decline in abdominal wall function.

The generation of this strength is accompanied by the speed at which it is produced, assessed by means of the rate force development (RFD), which correlates with physical function and neuromuscular health[20]. According to the results of the present study, hernia patients exhibited a significant decrease in RFD values compared with the control group. A possible explanation could be the presence of a limiting psychological factor, such as fear of movement in patients with some type of hernia, especially when generating force rapidly. However, the present study did not evaluate the fear factor, thus potential future directions of research could establish the relationship between fear or kinesiophobia and the rapid generation of force.

Finally, this study has some limitations. First, the baseline level of physical activity for both groups was not factored in; therefore, the findings are solely grounded on demographics and body composition data. Since only patients capable of performing the strength test were included, a selection bias in that regard cannot be excluded. Despite the relatively small sample size, it outperforms previous studies. Back pain, which could affect the performance of the tests, was not taken into account.

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Disclosure

The authors declare no conflict of interest.

Supplementary material

Supplementary material is available at *BJS Open* online.

Data availability

The data that support the findings of this study are available from the corresponding author (A.F.M.) upon reasonable request.

Author contributions

Alejandro Sánchez Arteaga (Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing—original draft, Writing—review & editing), Jose Luis Gil Delgado (Data curation, Methodology, Resources, Software, Validation, Writing—original draft), Adrián Feria Madueño (Conceptualization, Methodology, Software, Validation, Visualization, Writing—review & editing), Luis Tallon-Aguilar (Conceptualization, Investigation, Supervision, Writing—review & editing), Borja Sañudo (Conceptualization, Project administration, Resources, Supervision, Validation, Writing—review & editing) and Javier Padillo Ruiz (Supervision, Validation, Writing—review & editing)

References

1. Deerenberg EB, Henriksen NA, Antoniou GA, Antoniou SA, Bramer WM, Fischer JP *et al.* Updated guideline for closure of abdominal wall incisions from the European and American Hernia Societies. *Br J Surg* 2022;**109**:1239–1250
2. Gillion JF, Sanders D, Miserez M, Muysoms F. The economic burden of incisional ventral hernia repair: a multicentric cost analysis. *Hernia* 2016;**20**:819–830
3. Parker SG, Windsor ACJ. Ventral hernia surgery in Europe: trends and actual situation. In: Campanelli G (ed.), *The Art of Hernia Surgery*. Cham: Springer International Publishing, 2018, 103–113
4. Pereira-Rodríguez JA, Bravo-Salva A, Argudo-Aguirre N, Amador-Gil S, Pera-Román M. Defining high-risk patients suitable for incisional hernia prevention. *J Abdom Wall Surg* 2023;**2**:10899
5. Helgstrand F, Rosenberg J, Kehlet H, Jorgensen LN, Bisgaard T. Nationwide prospective study of outcomes after elective incisional hernia repair. *J Am Coll Surg* 2013;**216**:217–228
6. Holihan JL, Alawadi Z, Martindale RG, Roth JS, Wray CJ, Ko TC *et al.* Adverse events after ventral hernia repair: the vicious cycle of complications. *J Am Coll Surg* 2015;**221**:478–485
7. Mitura K, Śmietański M, Kozieł S, Garnysz K, Michałek I. Factors influencing inguinal hernia symptoms and preoperative evaluation of symptoms by patients: results of a prospective study including 1647 patients. *Hernia* 2018;**22**:585–591
8. Van Ramshorst GH, Eker HH, Hop WCJ, Jeekel J, Lange JF. Impact of incisional hernia on health-related quality of life and body image: a prospective cohort study. *Am J Surg* 2012;**204**:144–150
9. Reis RB, Rodrigues Neto AA, Reis LO, Machado RD, Kaplan S. Correlation between the presence of inguinal hernia and the intensity of lower urinary tract symptoms. *Acta Cir Bras* 2011;**26**:125–128
10. Pérez Lara FJ, del Rey Moreno A, Oliva Muñoz H. Do we really know the symptoms of inguinal hernia? *Hernia* 2015;**19**:703–712
11. Mussack T, Ladurner R, Vogel T, Lienemann A, Eder-Willwohl A, Hallfeldt KK *et al.* Health-related quality-of-life changes after laparoscopic and open incisional hernia repair: a matched pair analysis. *Surg Endosc* 2006;**20**:410–413
12. Jensen KK, Kjaer M, Jorgensen LN. Isometric abdominal wall muscle strength assessment in individuals with incisional hernia: a prospective reliability study. *Hernia* 2016;**20**:831–837
13. Licari L, Guercio G, Campanella S, Scerrino G, Bonventre S, Tutino R *et al.* Clinical and functional outcome after abdominal wall incisional hernia repair: evaluation of quality-of-life improvement and comparison of assessment scales. *World J Surg* 2019;**43**:1914–1920
14. García Moriana AJ, Sánchez Arteaga A, Gil Delgado JL, Maroto Sánchez R, Feria Madueño A, Tallón Aguilar L *et al.* Evaluation of rectus abdominis muscle strength and width of hernia defect in patients undergoing incisional hernia surgery. *Hernia* 2023;**27**:919–926
15. Cuschieri S. The STROBE guidelines. *Saudi J Anaesth* 2019;**13**:S31–S34. doi:10.4103/sja.SJA_543_18
16. Strigård K, Clay L, Stark B, Gunnarsson U, Falk P. Giant ventral hernia-relationship between abdominal wall muscle strength and hernia area. *BMC Surg* 2016;**16**:50
17. Gunnarsson U, Johansson M, Strigård K. Assessment of abdominal muscle function using the Biodex System-4. Validity and reliability in healthy volunteers and patients with giant ventral hernia. *Hernia* 2011;**15**:417–421
18. Roy NB, Khan WF, Krishna A, Bhatia R, Prakash O, Bansal VK. A comparative study to evaluate abdominal wall dynamics in patients with incisional hernia compared to healthy controls. *Surg Endosc* 2023;**37**:9414–9419
19. Su YC, Chang SF, Tsai HC. The relationship between sarcopenia and injury events: a systematic review and meta-analysis of 98,754 older adults. *J Clin Med* 2022;**11**:6474
20. Lomborg SD, Dalgas U, Hvid LG. The importance of neuromuscular rate of force development for physical function in aging and common neurodegenerative disorders—a systematic review. *J Musculoskelet Neuronal Interact* 2022;**22**:562–586