RESEARCH PAPER

PHYSIOTHERAPY IN ROBOTIC-ASSISTED ABDOMINAL SURGERY: BRIDGING PHYSIOLOGICAL RATIONALE AND CLINICAL PRACTICE — A NARRATIVE REVIEW

Nair Aathira , Naik Varun
Department of Cardiovascular and Pulmonary Physiotherapy
KLE Institute of Physiotherapy, Belagavi

Background: Robotic platforms are now well established across gynaecological, urological and gastrointestinal surgery, largely because they give operators steadier hands, filtered tremor and a three-dimensional view that conventional laparoscopy cannot match [1,2]. That technical advantage comes with a physiological cost: long periods of pneumoperitoneum, steep head-down (Trendelenburg) positioning and extended time under anaesthesia place extra strain on the respiratory and functional systems, and this strain can slow the first days of recovery [4–6,9–11].
Objective: This review pulls together what is currently known about the physiological effects of robotic-assisted abdominal surgery and considers how that evidence translates into the rationale, content and outcome measures used in postoperative physiotherapy for this group of patients. A further aim is to map where the evidence runs thin, since these gaps are what currently prevent rehabilitation protocols from being standardised.
Methods: A narrative rather than systematic approach was taken. Peer-reviewed sources - randomised trials, systematic reviews and meta-analyses, cohort studies and clinical guidelines - covering respiratory physiology, postoperative pulmonary complications, early mobilisation and Enhanced Recovery After Surgery (ERAS) in abdominal, laparoscopic and robotic-assisted surgical populations were located and brought together narratively.
Discussion: Across the literature, pneumoperitoneum together with Trendelenburg positioning is repeatedly shown to lower lung compliance and functional residual capacity, restrict diaphragmatic movement and leave patients more exposed to atelectasis and other pulmonary problems [4–7,19,21,23–25]. Programmes built around respiratory retraining, early mobilisation and musculoskeletal exercise are already well established after open and conventional laparoscopic abdominal surgery and sit comfortably within ERAS thinking [10,14,28–32,35–38]. What is missing is evidence generated specifically in robotic-assisted patients; most current protocols are simply carried over from open or laparoscopic populations [15–18,20,39,40].
Conclusion: The physiological case for structured postoperative physiotherapy after abdominal surgery is well supported in general terms, but dedicated research in robotic-assisted procedures remains thin. Feasibility work and properly powered randomised trials are still needed before rehabilitation protocols tailored to the specific demands of robotic-assisted abdominal surgery can be considered standardised and evidence based.
Keywords: Robotic-assisted surgery, postoperative physiotherapy, pneumoperitoneum, Trendelenburg position, Enhanced Recovery After Surgery, pulmonary rehabilitation, early mobilisation.
How to cite this article: Nair A, Naik V. Physiotherapy in Robotic-Assisted Abdominal Surgery: Bridging Physiological Rationale and Clinical Practice — A Narrative Review. Int J Drug Deliv Technol. 2026;16(70s): 432-438. DOI: 10.25258/ijddt.16.70s.42

1. INTRODUCTION

Robotic-assisted laparoscopic surgery has moved minimally invasive practice forward by giving surgeons steadier instrumentation, filtered tremor and three-dimensional depth perception, all of which sharpen surgical precision compared with standard laparoscopy [1,2]. These advantages explain why the technique has spread so widely through gynaecology, urology and general/gastrointestinal surgery [1,2]. Clinical reviews suggest that outcomes with robotic surgery match, and in some respects exceed, those of traditional approaches, with patients commonly reporting less pain after surgery, shorter admissions and a quicker return to normal activity [1,8].

That said, robotic abdominal surgery brings its own physiological demands. Insufflating the abdomen with gas (pneumoperitoneum), longer operating times, steep Trendelenburg tilt and prolonged general anaesthesia all interact to affect how patients breathe, how the diaphragm moves and how well they oxygenate [4–6,9–11]. These effects are not confined to the operating table; they can carry over into the days that follow and slow the broader recovery process.

Within the abdominal cavity sit organs - the stomach, intestines, liver, pancreas, spleen and kidneys - that work in close mechanical partnership with the diaphragm and the surrounding trunk musculature [1–3]. Between them, these structures underpin normal breathing, core stability and general physical function, so any surgical disturbance to this system can shrink lung volumes, restrict diaphragmatic excursion and raise the risk of complications such as atelectasis or pneumonia [4,5]. Laparoscopic surgery causes less tissue trauma than an open incision, but it does not remove the risk of reduced breathing capacity or physical function afterwards [10–12]. In robotic procedures the combination of pneumoperitoneum and prolonged steep positioning appears to add a further layer of respiratory compromise and can delay how quickly a patient is mobilised [20–25], which is precisely why targeted postoperative rehabilitation matters here.

Rehabilitation pathways for open and conventional laparoscopic abdominal surgery are, by comparison, fairly mature, while research addressing the physiotherapy needs of robotic-surgery patients specifically is still sparse. Given the distinct physiological demands robotic surgery introduces, it is worth asking whether existing rehabilitation protocols can simply be transferred to this group or whether they need adapting. This review sets out to examine the physiological rationale for postoperative physiotherapy after robotic-assisted abdominal surgery, describe the components and outcome measures used in current practice, and point to where the evidence base falls short [39,40].

2. PHYSIOLOGICAL CONSEQUENCES OF ROBOTIC-ASSISTED ABDOMINAL SURGERY

Robotic procedures generally call for sustained pneumoperitoneum and a steep Trendelenburg tilt in order to give the surgeon adequate exposure, and both factors can temporarily disturb respiratory mechanics and diaphragmatic movement during and after the operation. Raised intra-abdominal pressure from pneumoperitoneum has been shown to lower lung compliance and functional residual capacity, which in turn hampers ventilation and gas exchange [4,19,23]. Steep Trendelenburg positioning pushes the diaphragm upward toward the head, and this cephalad shift appears to add to the problem, further reducing lung volumes and pushing airway pressures higher [21,24,25].

A number of studies have looked specifically at how these positional and pressure-related changes affect breathing. Work comparing ventilation strategies during robotic and laparoscopic surgery performed in the Trendelenburg position has recorded measurable falls in respiratory system compliance along with altered gas exchange during the procedure itself [22–24]. Postoperative assessments of diaphragmatic function after robotic-assisted laparoscopic surgery with Trendelenburg positioning have found similar short-term reductions in diaphragmatic excursion [25], and observational research in robot-assisted prostatectomy has reported comparable perioperative changes in lung function linked to steep positioning [26]. Taken together, this body of work suggests the physiological stress of robotic surgery does not end when the operation does - it can extend into early recovery and add to the risk of pulmonary complications such as atelectasis and pneumonia [4,5,7,41,42].

3. RATIONALE FOR POSTOPERATIVE PHYSIOTHERAPY AFTER ABDOMINAL SURGERY

Pulmonary complications after surgery remain one of the more significant drivers of illness, longer hospital stays and slower functional recovery following major abdominal procedures [41,42,47,48]. Efforts to prevent them typically rely on anaesthetists and physiotherapists working together to keep ventilation optimised, encourage lung expansion and get patients moving again as early as possible [46,49,50]. Physiotherapy has for a long time been considered a standard part of postoperative abdominal care, and breathing exercises, thoracic expansion work, airway clearance techniques and incentive spirometry have all been shown to help restore lung function and cut the risk of pulmonary complications [28–30]. Cochrane-level evidence backs the use of incentive spirometry as part of a broader strategy for reducing pulmonary complications after upper abdominal surgery [11], and systematic reviews of preoperative and postoperative physiotherapy report similar reductions in respiratory illness after non-cardiothoracic and upper abdominal procedures [3,4].

There is more to the picture than respiratory benefit, though. Early mobilisation and a gradual build-up of exercise also support cardiovascular recovery, lower the risk of venous thromboembolism and help patients get back to everyday activities sooner [31,32]. Where mobilisation is delayed after abdominal surgery, the likelihood of pulmonary complications appears to rise, which is a strong argument for starting physiotherapy early in the postoperative course rather than waiting [45]. Beyond breathing and mobility, abdominal surgery can leave patients with reduced trunk mobility, altered posture and lower physical endurance, all of which affect balance and gait [33,34]. Read together, this evidence points toward a structured, multimodal physiotherapy approach - one that brings together respiratory training, early mobilisation and functional exercise to support recovery on several fronts at once.

4. COMPONENTS OF STRUCTURED MULTIMODAL PHYSIOTHERAPY PROGRAMMES

4.1 Respiratory Physiotherapy

The respiratory techniques most often described include the Active Cycle of Breathing Technique (ACBT), thoracic expansion exercises, diaphragmatic breathing and incentive spirometry. Each aims to improve lung expansion, clear the airway and lower the risk of atelectasis [10–12].

Airway clearance techniques in particular are described as adaptable, patient-specific tools for shifting secretions and re-expanding the lungs after surgery [30]. A recent review of physiotherapy practice after major abdominal surgery reaches a similar conclusion: breathing exercises and airway clearance techniques can meaningfully improve pulmonary function and lower rates of postoperative pulmonary complications [28].

4.2 Early Mobilisation and Functional Training

Getting patients moving early - bed mobility, sit-to-stand practice, then supervised or progressive walking - is widely treated as one of the more important elements of postoperative care. Mobilising patients within hours of abdominal surgery has been linked to better peripheral and arterial oxygenation [31], and early physiotherapy input has also been associated with a lower rate of postoperative ileus after abdominal hysterectomy [32]. Functional mobility is commonly tracked using tools such as the Timed Up and Go (TUG) test, and researchers have begun exploring remote or wearable-sensor versions of the TUG test to follow how mobility changes over the course of recovery [33].

4.3 Musculoskeletal and Circulatory Exercises

Active and resisted range-of-motion work, ankle pumps, pelvic tilting and stretching through the neck and upper limbs are routinely built into postoperative programmes to keep joints mobile, support circulation and maintain trunk control. These exercises sit alongside the respiratory and mobilisation components, addressing the postural changes and lowered endurance that often accompany abdominal surgery, and they draw on broader clinical reasoning frameworks used in musculoskeletal rehabilitation [34].

5. ENHANCED RECOVERY AFTER SURGERY (ERAS) AND MULTIMODAL REHABILITATION

Multimodal physiotherapy that brings respiratory training, early mobilisation and functional exercise together within one structured pathway fits naturally within the broader ERAS philosophy, which places emphasis on early recovery and getting physical function back as quickly as possible [37,38]. ERAS pathways, first developed for colorectal and other major abdominal surgery, take a multidisciplinary view, combining preoperative optimisation, minimally invasive technique and structured postoperative rehabilitation, including early mobilisation and respiratory physiotherapy [14,37]. Systematic reviews of complex, multi-component interventions make a related point: rehabilitation programmes need clearly defined components and evaluation frameworks if their feasibility and effect are to be judged meaningfully [36]. Research into prehabilitation adds a further dimension, suggesting that outcomes may improve when physical preparation and recovery are planned across the whole perioperative period rather than treated as a purely postoperative concern [35].

6. OUTCOME MEASURES USED TO EVALUATE POSTOPERATIVE PHYSIOTHERAPY

A number of standardised measures appear repeatedly in the literature on postoperative physiotherapy after abdominal surgery, covering respiratory function, functional mobility, perceived exertion and physical activity.

Respiratory parameters. Inspiratory capacity is usually measured with an incentive spirometer, following the standardised spirometric technique set out in international guidelines [52]. Respiratory rate and peripheral oxygen saturation (SpO_2), recorded via pulse oximetry, offer a quick and non-invasive way of tracking respiratory status before and after treatment [51]. Peak expiratory flow rate, measured with a peak flow meter, adds a further indicator of expiratory muscle strength and airway function [52].

Functional mobility. The Timed Up and Go test remains a widely used and reliable measure of balance, mobility and functional independence, and published reference values support its use across a range of clinical populations, including postoperative patients [53].

Perceived exertion. The Borg Rating of Perceived Exertion scale is often used to capture subjective fatigue and exertion during activity, giving some insight into how well patients tolerate physical tasks during early recovery.

Physical activity. The International Physical Activity Questionnaire (IPAQ) is used to estimate activity levels in MET-minutes per week and has shown acceptable validity as a self-report measure of habitual activity [43].

Together, these tools let clinicians and researchers capture the many sides of postoperative recovery - physiological, functional and perceptual - and provide a workable basis for judging the feasibility and early effectiveness of structured physiotherapy interventions [18,39,40].

7. EVIDENCE SPECIFIC TO ROBOTIC-ASSISTED SURGERY AND GAPS IN THE LITERATURE

Comparative studies suggest robotic-assisted procedures may have an edge over conventional laparoscopy in terms of postoperative pain and recovery time in some surgical populations [15,17], and the use of robotic surgery continues to grow across specialties and healthcare settings, including in resource-limited contexts [16,18–20]. At the same time, robotic surgery brings its own set of intraoperative considerations - cost, longer operating times, and the physiological load of extended pneumoperitoneum and steep positioning [20–25].

Despite the physiological case set out above, dedicated physiotherapy research in robotic-assisted abdominal surgery is still limited. Much of the current evidence for postoperative respiratory and mobility interventions was generated in open or conventional laparoscopic populations and has simply been carried over to robotic-assisted patients [10–14,28–32,44,45]. Systematic reviews of postoperative respiratory and mobilisation interventions after abdominal surgery generally support their role in cutting complication rates [44], but few studies have asked whether the specific physiological profile of robotic surgery - particularly the combination of prolonged pneumoperitoneum and steep Trendelenburg positioning - calls for a modified or more intensive rehabilitation approach [20–25]. This is a clear gap, and it makes a strong case for dedicated feasibility work ahead of any larger controlled trials in this population [39,40].

8. CLINICAL IMPLICATIONS AND FUTURE DIRECTIONS

The physiological evidence reviewed here supports early, structured, multimodal physiotherapy after robotic-assisted abdominal surgery - combining respiratory retraining, early mobilisation and musculoskeletal exercise within an ERAS-aligned framework [14,37,38]. Even so, most of what is known still comes from open and laparoscopic surgery populations, and solid evidence specific to robotic procedures remains limited. Future work should prioritise adequately powered randomised controlled trials with appropriate comparison groups, to establish how effective structured physiotherapy protocols actually are in this population, along with longer follow-up to see whether early gains hold up over time. Standardising outcome measures across studies - respiratory, functional and patient-reported alike - would also make it easier to compare and pool findings from future research, guided by established methodological recommendations for pilot and feasibility work [39,40].

9. CONCLUSION

Robotic-assisted abdominal surgery offers real technical advantages, but it also brings distinct physiological stressors - prolonged pneumoperitoneum and steep Trendelenburg positioning among them - that can affect respiratory mechanics and slow early recovery. There is a solid physiological and clinical case for structured, multimodal postoperative physiotherapy that includes respiratory training, early mobilisation and musculoskeletal exercise, in keeping with established ERAS principles. Even so, evidence addressing the physiotherapy needs of patients undergoing robotic-assisted abdominal surgery specifically remains limited, and much of current practice is still borrowed from open and conventional laparoscopic populations. Further feasibility studies and adequately powered randomised controlled trials are needed before standardised, evidence-based rehabilitation protocols can be established for this growing group of surgical patients.

REFERENCES

1. Bordoni B, Zanier E. Anatomic connections of the diaphragm: influence of respiration on the body system. Journal of multidisciplinary healthcare. 2013 Jul 25:281-91.

2. Hodges PW, Gandevia SC. Activation of the human diaphragm during a repetitive postural task. The Journal of physiology. 2000 Jan;522(1):165-75.

3. Lawrence, V. A., Cornell, J. E., Smetana, G. W., & American College of Physicians (2006). Strategies to reduce postoperative pulmonary complications after non-cardiothoracic surgery: systematic review for the American College of Physicians. Annals of internal medicine, 144(8), 596--608. https://doi.org/10.7326/0003-4819-144-8-200604180-00011

4. Boden, I., Skinner, E. H., Browning, L., Reeve, J., Anderson, L., Hill, C., Robertson, I. K., Story, D., & Denehy, L. (2018). Preoperative physiotherapy for the prevention of respiratory complications after upper abdominal surgery: pragmatic, double blinded, multicentre randomised controlled trial. BMJ (Clinical research ed.), 360, j5916. https://doi.org/10.1136/bmj.j5916

5. De Troyer A, Boriek AM. Mechanics of the respiratory muscles. Comprehensive Physiology. 2011 Jul 1;1(3):1273-300.

6. Loring SH, Behazin N, Novero A, Novack V, Jones SB, O\'Donnell CR, Talmor DS. Respiratory mechanical effects of surgical pneumoperitoneum in humans. Journal of Applied Physiology. 2014 Nov 1.

7. Hedenstierna G, Tokics L, Strandberg Å, Lundquist H, Brismar B. Correlation of gas exchange impairment to development of atelectasis during anaesthesia and muscle paralysis. Acta Anaesthesiologica Scandinavica. 1986 Feb;30(2):183-91.

8. Haisley KR, Hunter JG, Brunicardi F, Andersen DK, Billiar TR. Schwartz\'s Principles of Surgery.

9. Townsend CM Jr, Beauchamp RD, Evers BM, Mattox KL, eds. Sabiston Textbook of Surgery. 21st ed. Philadelphia, PA: Elsevier; 2021.

10. Kehlet H. Multimodal approach to control postoperative pathophysiology and rehabilitation. Survey of Anesthesiology. 1998 Aug 1;42(4):233.

11. do Nascimento Junior, P., Módolo, N. S., Andrade, S., Guimarães, M. M., Braz, L. G., & El Dib, R. (2014). Incentive spirometry for prevention

of postoperative pulmonary complications in upper abdominal surgery. The Cochrane database of systematic reviews, 2014(2), CD006058. https://doi.org/10.1002/14651858.CD006058.pub3

12. Milsom JW, Böhm B, Hammerhofer KA, Fazio V, Steiger E, Elson P. A prospective, randomized trial comparing laparoscopic versus conventional techniques in colorectal cancer surgery: a preliminary report. Journal of the American College of Surgeons. 1998 Jul 1;187(1):46-54.

13. Veldkamp, R., Kuhry, E., Hop, W. C., Jeekel, J., Kazemier, G., Bonjer, H. J., Haglind, E., Påhlman, L., Cuesta, M. A., Msika, S., Morino, M., Lacy, A. M., & COlon cancer Laparoscopic or Open Resection Study Group (COLOR) (2005). Laparoscopic surgery versus open surgery for colon cancer: short-term outcomes of a randomised trial. The Lancet. Oncology, 6(7), 477--484. https://doi.org/10.1016/S1470-2045(05)70221-7

14. Fearon, K. C., Ljungqvist, O., Von Meyenfeldt, M., Revhaug, A., Dejong, C. H., Lassen, K., Nygren, J., Hausel, J., Soop, M., Andersen, J., & Kehlet, H. (2005). Enhanced recovery after surgery: a consensus review of clinical care for patients undergoing colonic resection. Clinical nutrition (Edinburgh, Scotland), 24(3), 466--477. https://doi.org/10.1016/j.clnu.2005.02.002

15. Kawka, M., Fong, Y., & Gall, T. M. H. (2023). Laparoscopic versus robotic abdominal and pelvic surgery: a systematic review of randomised controlled trials. Surgical endoscopy, 37(9), 6672--6681. https://doi.org/10.1007/s00464-023-10275-8

16. Ho, C., Tsakonas, E., Tran, K., Cimon, K., Severn, M., Mierzwinski-Urban, M., Corcos, J., & Pautler (2012). Robot-assisted surgery compared with open surgery and laparoscopic surgery. CADTH technology overviews, 2(2), e2203.

17. Lin, C. Y., Liu, Y. C., Chen, C. C., Chen, M. C., Chiu, T. Y., Huang, Y. L., Chiang, S. W., Lin, C. L., Chen, Y. J., Lin, C. Y., & Chiang, F. F. (2025). Robotic-Assisted Colon Cancer Surgery: Faster Recovery and Less Pain Compared to Laparoscopy in a Retrospective Propensity-Matched Study. Cancers, 17(2), 243. https://doi.org/10.3390/cancers17020243

18. Nayak S, Nayak VC and G. S. S. Exploring the acceptance of robotic assisted surgery among the Indian population: An empirical investigation \[version 3; peer review: 2 approved\]. F1000Research 2024, 13:544 (https://doi.org/10.12688/f1000research.145052.3)

19. Sinha, R., Jain, V., Sp, S., Saha, S. C., Sunkavalli, C., Kiran, L., Shylasree, T. S., Pandey, K., & Mohanty, G. S. (2023). Multi-Institutional Trends in Gynecological Robotic Surgery in India: A Real-World Scenario. Cureus, 15(3), e36564. https://doi.org/10.7759/cureus.36564

20. Ng, A. P., Sanaiha, Y., Bakhtiyar, S. S., Ebrahimian, S., Branche, C., & Benharash, P. (2023). National analysis of cost disparities in robotic-assisted versus laparoscopic abdominal operations. Surgery, 173(6), 1340--1345. https://doi.org/10.1016/j.surg.2023.02.016

21. Nguyen, N. T., & Wolfe, B. M. (2005). The physiologic effects of pneumoperitoneum in the morbidly obese. Annals of surgery, 241(2), 219--226. https://doi.org/10.1097/01.sla.0000151791.93571.70

22. Nguyen, T. K., Nguyen, V. L., Nguyen, T. G., Mai, D. H., Nguyen, N. Q., Vu, T. A., Le, A. N., Nguyen, Q. H., Nguyen, C. T., & Nguyen, D. T. (2021). Lung-protective mechanical ventilation for patients undergoing abdominal laparoscopic surgeries: a randomized controlled trial. BMC anesthesiology, 21(1), 95. https://doi.org/10.1186/s12871-021-01318-5

23. Veerasamy, S., Kumar, L., Kartha, A., Rajan, S., Kumar, N., & Purushottaman, S. S. (2022). Comparison of arterial to end-tidal carbon dioxide gradient P (a-ET)CO2 in volume versus pressure controlled ventilation in patients undergoing robotic abdominal surgery in the Trendelenburg position. A randomised controlled study. Indian journal of anaesthesia, 66(Suppl 5), S243--S249. https://doi.org/10.4103/ija.ija_902_21

24. Li, J., Ma, S., Chang, X., Ju, S., Zhang, M., Yu, D., & Rong, J. (2022). Effect of pressure-controlled ventilation-volume guaranteed mode combined with individualized positive end-expiratory pressure on respiratory mechanics, oxygenation and lung injury in patients undergoing laparoscopic surgery in Trendelenburg position. Journal of clinical monitoring and computing, 36(4), 1155--1164. https://doi.org/10.1007/s10877-021-00750-9

25. Xue, S., Wang, D., Tu, H. Q., Gu, X. P., Ma, Z. L., Liu, Y., & Zhang, W. (2024). The effects of robot-assisted laparoscopic surgery with Trendelenburg position on short-term postoperative respiratory diaphragmatic function. BMC anesthesiology, 24(1), 92. https://doi.org/10.1186/s12871-024-02463-3

26. Syrafe, M., Köhne, W., Börgers, A., Löwen, H., Krege, S., & Groeben, H. (2023). Perioperative lung function following flow controlled ventilation for robot-assisted prostatectomies in steep trendelenburg position: an observational study. Intensive care medicine experimental, 11(1), 49. https://doi.org/10.1186/s40635-023-00537-z

27. Pelosi, P., Croci, M., Ravagnan, I., Cerisara, M., Vicardi, P., Lissoni, A., & Gattinoni, L. (1997). Respiratory system mechanics in sedated, paralyzed, morbidly obese patients. Journal of applied physiology (Bethesda, Md. : 1985), 82(3), 811--818. https://doi.org/10.1152/jappl.1997.82.3.811

28. Boden I. (2024). Physiotherapy management of major abdominal surgery. Journal of physiotherapy, 70(3), 170--180. https://doi.org/10.1016/j.jphys.2024.06.005

29. Kehlet, H., & Wilmore, D. W. (2008). Evidence-based surgical care and the evolution of fast-track surgery. Annals of surgery, 248(2), 189--198. https://doi.org/10.1097/SLA.0b013e31817f2c1a
30. Belli, S., Prince, I., Savio, G., Paracchini, E., Cattaneo, D., Bianchi, M., Masocco, F., Bellanti, M. T., & Balbi, B. (2021). Airway Clearance Techniques: The Right Choice for the Right Patient. Frontiers in medicine, 8, 544826. https://doi.org/10.3389/fmed.2021.544826
31. Svensson-Raskh, A., Schandl, A. R., Ståhle, A., Nygren-Bonnier, M., & Fagevik Olsén, M. (2021). Mobilization Started Within 2 Hours After Abdominal Surgery Improves Peripheral and Arterial Oxygenation: A Single-Center Randomized Controlled Trial. Physical therapy, 101(5), pzab094. https://doi.org/10.1093/ptj/pzab094
32. Zia, Z., Riaz, H., & Imtiaz, I. (2023). Effect of early physical therapy interventions on post-operative ileus following abdominal hysterectomy. JPMA. The Journal of the Pakistan Medical Association, 73(3), 650--652. https://doi.org/10.47391/JPMA.5447
33. Saporito, S., Brodie, M. A., Delbaere, K., Hoogland, J., Nijboer, H., Rispens, S. M., Spina, G., Stevens, M., & Annegarn, J. (2019). Remote timed up and go evaluation from activities of daily living reveals changing mobility after surgery. Physiological measurement, 40(3), 035004. https://doi.org/10.1088/1361-6579/ab0d3e
34. Jones MA, Rivett DA. Clinical reasoning. In: Jones MA, Rivett DA, editors. Clinical reasoning in musculoskeletal practice. 2nd ed. Edinburgh: Elsevier; 2019. p. 3--24.
35. Santa Mina, D., Clarke, H., Ritvo, P., Leung, Y. W., Matthew, A. G., Katz, J., Trachtenberg, J., & Alibhai, S. M. (2014). Effect of total-body prehabilitation on postoperative outcomes: a systematic review and meta-analysis. Physiotherapy, 100(3), 196--207. https://doi.org/10.1016/j.physio.2013.08.008
36. Campbell, M., Fitzpatrick, R., Haines, A., Kinmonth, A. L., Sandercock, P., Spiegelhalter, D., & Tyrer, P. (2000). Framework for design and evaluation of complex interventions to improve health. BMJ (Clinical research ed.), 321(7262), 694--696. https://doi.org/10.1136/bmj.321.7262.694
37. Ljungqvist, O., Scott, M., & Fearon, K. C. (2017). Enhanced Recovery After Surgery: A Review. JAMA surgery, 152(3), 292--298. https://doi.org/10.1001/jamasurg.2016.4952
38. Fearon, K. C., Ljungqvist, O., Von Meyenfeldt, M., Revhaug, A., Dejong, C. H., Lassen, K., Nygren, J., Hausel, J., Soop, M., Andersen, J., & Kehlet, H. (2005). Enhanced recovery after surgery: a consensus review of clinical care for patients undergoing colonic resection. Clinical nutrition (Edinburgh, Scotland), 24(3), 466--477. https://doi.org/10.1016/j.clnu.2005.02.002
39. Thabane, L., Ma, J., Chu, R., Cheng, J., Ismaila, A., Rios, L. P., Robson, R., Thabane, M., Giangregorio, L., & Goldsmith, C. H. (2010). A tutorial on pilot studies: the what, why and how. BMC medical research methodology, 10, 1. https://doi.org/10.1186/1471-2288-10-1
40. Lancaster, G. A., Dodd, S., & Williamson, P. R. (2004). Design and analysis of pilot studies: recommendations for good practice. Journal of evaluation in clinical practice, 10(2), 307--312. https://doi.org/10.1111/j..2002.384.doc.x
41. Miskovic, A., & Lumb, A. B. (2017). Postoperative pulmonary complications. British journal of anaesthesia, 118(3), 317--334. https://doi.org/10.1093/bja/aex002
42. Canet, J., Gallart, L., Gomar, C., Paluzie, G., Vallès, J., Castillo, J., Sabaté, S., Mazo, V., Briones, Z., Sanchis, J., & ARISCAT Group (2010). Prediction of postoperative pulmonary complications in a population-based surgical cohort. Anesthesiology, 113(6), 1338--1350. https://doi.org/10.1097/ALN.0b013e3181fc6e0a
43. Lee PH, Macfarlane DJ, Lam TH, Stewart SM. Validity of the International Physical Activity Questionnaire Short Form (IPAQ-SF): a systematic review. Int J Behav Nutr Phys Act. 2011 Oct 21;8:115. doi: 10.1186/1479-5868-8-115. PMID: 22018588; PMCID: PMC3214824.
44. Kokotovic, D., Berkfors, A., Gögenur, I., Ekeloef, S., & Burcharth, J. (2021). The effect of postoperative respiratory and mobilization interventions on postoperative complications following abdominal surgery: a systematic review and meta-analysis. European journal of trauma and emergency surgery: official publication of the European Trauma Society, 47(4), 975--990. https://doi.org/10.1007/s00068-020-01522-x
45. Haines, K. J., Skinner, E. H., Berney, S., & Austin Health POST Study Investigators (2013). Association of postoperative pulmonary complications with delayed mobilisation following major abdominal surgery: an observational cohort study. Physiotherapy, 99(2), 119--125. https://doi.org/10.1016/j.physio.2012.05.013
46. Futier, E., Constantin, J. M., Paugam-Burtz, C., Pascal, J., Eurin, M., Neuschwander, A., Marret, E., Beaussier, M., Gutton, C., Lefrant, J. Y., Allaouchiche, B., Verzilli, D., Leone, M., De Jong, A., Bazin, J. E., Pereira, B., Jaber, S., & IMPROVE Study Group (2013). A trial of intraoperative low-tidal-volume ventilation in abdominal surgery. The New England journal of medicine, 369(5), 428--437. https://doi.org/10.1056/NEJMoa1301082
47. Fernandez-Bustamante, A., Frendl, G., Sprung, J., Kor, D. J., Subramaniam, B., Martinez Ruiz, R., Lee, J. W., Henderson, W. G., Moss, A., Mehdiratta, N., Colwell, M. M., Bartels, K., Kolodzie, K., Giquel, J., & Vidal Melo, M. F. (2017). Postoperative Pulmonary Complications, Early Mortality, and Hospital Stay Following

Noncardiothoracic Surgery: A Multicenter Study by the Perioperative Research Network Investigators. JAMA surgery, 152(2), 157--166. https://doi.org/10.1001/jamasurg.2016.4065
48. Gupta, H., Gupta, P. K., Fang, X., Miller, W. J., Cemaj, S., Forse, R. A., & Morrow, L. E. (2011). Development and validation of a risk calculator predicting postoperative respiratory failure. Chest, 140(5), 1207--1215. https://doi.org/10.1378/chest.11-0466
49. Warner D. O. (2000). Preventing postoperative pulmonary complications: the role of the anesthesiologist. Anesthesiology, 92(5), 1467--1472. https://doi.org/10.1097/00000542-200005000-00037
50. Canet, J., & Gallart, L. (2014). Postoperative respiratory failure: pathogenesis, prediction, and prevention. Current opinion in critical care, 20(1), 56--62. https://doi.org/10.1097/MCC.0000000000000045
51. Jubran A. (2015). Pulse oximetry. Critical care (London, England), 19(1), 272. https://doi.org/10.1186/s13054-015-0984-8
52. Miller, M. R., Hankinson, J., Brusasco, V., Burgos, F., Casaburi, R., Coates, A., Crapo, R., Enright, P., van der Grinten, C. P., Gustafsson, P., Jensen, R., Johnson, D. C., MacIntyre, N., McKay, R., Navajas, D., Pedersen, O. F., Pellegrino, R., Viegi, G., Wanger, J., & ATS/ERS Task Force (2005). Standardisation of spirometry. The European respiratory journal, 26(2), 319--338. https://doi.org/10.1183/09031936.05.00034805
53. Bohannon R. W. (2006). Reference values for the timed up and go test: a descriptive meta-analysis. Journal of geriatric physical therapy (2001), 29(2), 64--68. https://doi.org/10.1519/00139143-200608000-00004