



Merits of exercise therapy before and after major surgery

Thomas J. Hoogeboom^a, Jaap J. Dronkers^b, Erik H.J. Hulzebos^c, and Nico L.U. van Meeteren^{a,d}

Purpose of review

Advances in medical care have led to an increasing elderly population. Elderly individuals should be able to participate in society as long as possible. However, with an increasing age their adaptive capacity gradually decreases, specially before and after major life events (like hospitalization and surgery) making them vulnerable to reduced functioning and societal participation. Therapeutic exercise before and after surgery might augment the postoperative outcomes by improving functional status and reducing the complication and mortality rate.

Recent findings

There is high quality evidence that preoperative exercise in patients scheduled for cardiovascular surgery is well tolerated and effective. Moreover, there is circumstantial evidence suggesting preoperative exercise for thoracic, abdominal and major joint replacement surgery is effective, provided that this is offered to the high-risk patients. Postoperative exercise should be initiated as soon as possible after surgery according to fast-track or enhanced recovery after surgery principles.

Summary

The perioperative exercise training protocol known under the name 'Better in, Better out' could be implemented in clinical care for the vulnerable group of patients scheduled for major elective surgery who are at risk for prolonged hospitalization, complications and/or death. Future research should aim to include this at-risk group, evaluate perioperative high-intensity exercise interventions and conduct adequately powered trials.

Keywords

exercise therapy, functional status, postoperative, preoperative, surgery

INTRODUCTION

The successes of society in terms of education, urbanization, industrialization and innovation, not in the least in healthcare, have led to an increasing elderly population [1]. This still expanding generation of the elderly should be able to participate in society for as long as possible. However, with an increasing age their adaptive capacity gradually decreases [2], which makes the elderly vulnerable to reduced functioning and societal participation [3] due to gradually diminishing physical activity [4,5], stereotypical 'to be old is to be ill' and 'let it be' beliefs [6,7]. Major life events like hospitalization and surgery can further compromise their functional status and activities of daily living [8]. This decrease in adaptive capacity of (vulnerable) elderly can be reduced by recent medical innovations and can be reduced more or possibly even prevented by therapeutic physical exercise training and maintaining physical activity in the course of an event; enabling the elderly to remain independent

and live independently for a longer period of time after the event [4,9,10].

In case of elective surgery, exercise therapy could be initiated preoperatively in patients at risk

^aDepartment of Epidemiology/CAPHRI research school/Centre for Care technology Research (CCTR), Maastricht University Medical Centre, Maastricht, ^bDepartment of Physical Therapy, Gelderse Vallei Hospital, Ede, ^cChild Development and Exercise Center, Wilhelmina Children's Hospital, University Medical Center Utrecht, Utrecht and ^dTNO, Healthy Living, Leiden, The Netherlands

Correspondence to Thomas J. Hoogeboom, Universiteitssingel 40, 6229 ER, Maastricht, The Netherlands. Tel: +31 622321229; e-mail: thomashoogeboom@gmail.com

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KEY POINTS

- There is high quality evidence that preoperative exercise is effective in reducing the length of stay and the number of complications after cardiac surgery, particularly in the vulnerable patient.
- There is circumstantial evidence that preoperative exercise can aid the postoperative (functional) recovery after thorax, abdominal and major joint replacement surgery, provided that this is offered to the vulnerable patient.
- There is high quality evidence that postoperative exercise training and rehabilitation should be initiated as soon as possible after surgery and be aimed at least at regaining functional mobility.
- The current body of literature on preoperative exercise therapy is largely skewed toward low power randomized clinical trials on relatively healthy patients.

for unsatisfactory surgical outcomes [11], and be continued during the early and late postoperative period [12] until maximal recovery of physical function and societal participation is achieved. This article provides the latest insights and evidence into pre and postoperative therapeutic exercise training to counterbalance the detrimental effects of hospitalization combined with either cardiovascular, abdominal, thoracic, or orthopedic surgery.

EFFECTS OF HOSPITALIZATION AND SURGERY IN OLDER PATIENTS

Temporary functional decline among the elderly as a result of decreased physical activity is a common side-effect before, during, and after hospitalization and major surgery [13,14^{***}]. Already before admission, up to 50% of the elderly patients experience loss of functioning [14^{***}]. Some hospitalized patients spend around 80% of the hospital stay lying in bed, generally without medical reason [15^{*}]. This bed rest leads to a marked and rapid loss of lower extremity strength, power and aerobic capacity [16], particularly in those with distinct risk profiles [17]. Surgery is known to augment this muscle wasting due to surgical stress [18], which may even lead to more serious or even life-threatening conditions as is the case with patients undergoing surgical manipulations close to the diaphragm. Here, the muscular component of the diaphragm suffers an additional degradation by reflex inhibition of phrenic nerve output and/or mechanical ventilation, further compromising the diaphragmatic function thereby increasing the risk of serious pulmonary complications [16]. Apart from decreased inpatient

physical activity and temporary sedentary behavior, the so-called, surgical stress syndrome, is a physiological contributor to functional decline. This surgical stress response includes a wide range of physiological effects that directly impair cardiopulmonary, muscle and neurological function [19], and contribute to an accelerated loss of lean tissue [20]. Aforementioned consequences of hospitalization and surgery lead to protracted functional decline, which can be considered an iatrogenic process in elderly patients, as it leads to a higher risk of postoperative complications and mortality, a prolonged hospital stay and/or readmissions, and/or a prolonged and sometimes even permanent loss of mobility and activities of daily living.

We depicted these phenomena in Fig. 1, in which preoperative functional status plays a key role in the adaptive responses from hospitalization and surgery [21]. We define functional status as part of patients' health and consider health a dynamic property [22]. Thus, a physically healthy person has the capacity to cope with physiological stress (including surgical stress) and to restore the body's physiological balance, a process called allostasis [2].

MODIFIABLE COURSE OF FUNCTIONAL STATUS BEFORE AND AFTER SURGERY

After major surgery functional status thus dips immediately and substantially, with a recovery of functional status during the postoperative period [23,24]. The majority of patients demonstrate an adequate surgical stress response and most patients

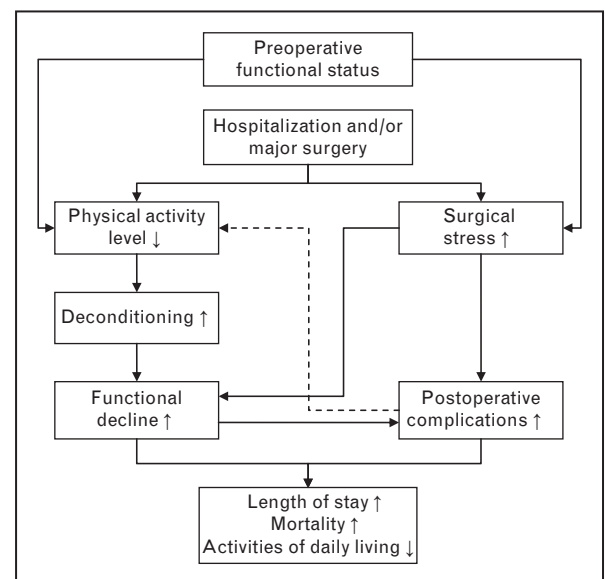


FIGURE 1. Depiction of possible effects of surgery and hospitalization in older patients and the role of preoperative functional status [21].

regain prehospitalization level of functioning [2,23]. However, patients with a poorer preoperative physical condition might not be able to respond to the detrimental effects of hospitalization and surgery, which may hamper postoperative recovery, increasing hospitalization times and operative mortality.

Knowing the detrimental impact of surgical interventions it is important to determine whether the risk of surgery is personally acceptable for each individual patient. Therefore, health professionals need to screen and monitor for known risk factors. They need to determine physical fitness and activity factors in each patient to ascertain whether and when surgery is an appropriate intervention, and identify patients who may need additional necessary preventive care. Functional status can be improved by high-quality therapeutic exercise, even in the (very) old and frail [25] and even in a short timeframe like the waiting for surgery [26]. Therapeutic exercise training should be considered to improve perioperative outcomes and functional status [24].

Risk stratification enables one to identify patients who are eligible for preoperative training, to optimize their physical status prior to elective surgery, so that they can withstand the negative consequences of surgery and minimize decrease in their perioperative functional status. The latter could be amplified with timely mobilization and, again, training after surgery an intervention. This is known as 'Better in, Better out'. In the following paragraphs, we discuss the merits of screening for risks, preoperative and postoperative exercise therapy in the physically frail patients in respectively cardiovascular, thorax, abdominal and major joint replacement surgery.

THERAPEUTIC PHYSICAL EXERCISE TRAINING IN CARDIOVASCULAR SURGERY

Undergoing cardiac surgery is a significant life event and has an important psychoemotional impact on patients and their families. Most patients report fear and anxiety and many report that uncertainty about the future is more disturbing than their chest pain. The longer a patient stays on the waiting list for cardiac surgery, the more likely they are to reduce their leisure activities, causing them to experience anxiety, reduced physical and social functioning, poorer vitality and general health [27].

In cardiac surgery, short-term mortality is frequently used as a measure of performance, whereas postoperative pulmonary complications (PPCs) are recognized as being a major determinant of hospital costs and quality of life after heart surgery [28]. PPCs can lead to postoperative

morbidity and mortality, increased use of medical resources, length of hospital stay and healthcare costs [29]. Preoperative identification of patients at high risk of developing functional decline and/or PPCs (e.g. pneumonia) after cardiac surgery can help clinicians to direct their interventions toward these patients. A six-factor model (age ≥ 70 years, productive cough, smoking, diabetes mellitus, inspiratory vital capacity and maximum expiratory mouth pressure lower than 75% of the predicted value) is a useful tool to predict the risk of developing PPCs in patients undergoing elective cardiac surgery [30].

Evidence demonstrates that preoperative physical therapy reduces PPCs (i.e. atelectasis and pneumonia) and length of hospital stay in patients undergoing elective cardiac surgery [26]. In particular, preoperative inspiratory muscle training has positive effects in patients with a high risk of developing PPCs awaiting cardiac surgery [31], while its effects in relatively healthy patients are likely negligible [11]. Maximal inspiratory muscle strength is a clinically relevant indicator of respiratory fitness that can be improved by training the inspiratory muscle before surgery; thus improving the preoperative respiratory condition of patients. A reference chart is developed to monitor the maximal inspiratory muscle strength and to provide feedback for both patient and their therapist [32^{*}]. Feedback given to patients may improve their motivation, and thus contribute further to lower the risk of PPCs.

Exercise therapy after cardiac surgery is generally used for the prevention and/or treatment of PPCs and motor complications in an attempt to accelerate the recovery of (lung) function and functional status. In a literature review on the different techniques used in chest physiotherapy after cardiac surgery, there is no consensus regarding the superiority of one technique over the other [33]. Regarding the recovery of function, evidence suggests that postoperative fast-track mobilization reduces the time to extubation and shortens the length of stay in the ICU after cardiac surgery [34].

THERAPEUTIC PHYSICAL EXERCISE TRAINING IN MAJOR ABDOMINAL AND THORACIC SURGERY

As in open heart surgery, successful postoperative recovery from abdominal and thoracic surgery also depends on the ability of patients to cope with impaired cardiopulmonary and (respiratory) muscle function. An insufficient adaptive capacity may compromise postoperative functional recovery, potentially leading to postoperative complications, death, and protracted and sometimes permanent loss of mobility [8]. Conventional risk factors in

abdominal surgery are generally related to demographics, such as age and smoking habits, and comorbidities, such as diabetes, chronic obstructive pulmonary disease and heart disease [35]. More recently, the relationship between postoperative outcomes and measures of physical fitness and activity like cardiorespiratory fitness and muscle function was demonstrated [36,37]. For instance, cardiorespiratory fitness is a strong independent predictor of survival after lung surgery for nonsmall cell lung cancer [38]. Moreover, in older patients undergoing abdominal surgery, physical fitness and activity are significantly and strongly associated with the postoperative outcomes such as mortality, length of stay and recovery of functional. The addition of these variables to prediction models involving conventional factors significantly improved the prediction of mortality, discharge destination and length of stay [36].

Apart from a predictive factor, physical fitness is also a modifiable and treatable factor during the preoperative phase. If there is a cause–effect relationship with the postoperative course, patients will benefit from preoperative interventions to improve their physical fitness. Evidence is accumulating that inspiratory muscle training decreases the incidence of PPCs after abdominal and thoracic surgery [39]. Moreover, preoperative aerobic exercise training is associated with improved physical fitness of patients before [40] and improved functional recovery after abdominal and thoracic surgery [41]. Evidence for the prevention of postoperative complications is still weak [40,42–44], as most studies lack statistical power to demonstrate an effect on postoperative complications. Therefore, in order to determine the effectiveness of this intervention, it is recommended to include patients at high risk for postoperative complications. Personalized and well monitored and titrated high-intensity training is necessary to achieve improvements, given the often short time available before surgery [45].

In the postoperative period, recovery of patients' physical fitness and activity is also of importance as immobilization in this period is associated with postoperative complications and poor functional outcome [12]. Studies investigating early physical training demonstrated improvements on physical fitness and on disability measures at discharge and a reduction in the number of transfers to a nursing home [12,46]. Physical training is often part of a multi(parallel) or inter(integrated) disciplinary rehabilitation approach, known under the names as fast-track or enhanced recovery after surgery. These programs also include dietary guidance and adequate analgesia to enable physical activity. The merits of these programs have been

proven, demonstrating a decrease in the length of hospital stay and postoperative complications [47].

THERAPEUTIC PHYSICAL EXERCISE TRAINING IN HIP (THR) AND KNEE REPLACEMENT (TKR)

Elective major joint replacement is generally advocated as a highly successful operation for relieving symptoms in people suffering from hip or knee osteoarthritis. Such claims are often made from a medical and biomechanical perspective (i.e. in terms of low rates of complications and prosthesis failure), rather than the perspective of the patient (i.e. pain, functional status and societal participation). Hawker *et al.* [48] demonstrated that nearly half of the people had poor outcomes on pain and functioning; these were mostly the elderly patients with additional comorbidities. Pre and postoperative exercise therapy might augment the postoperative functional recovery of patients undergoing total hip replacement (THR) or total knee replacement (TKR). To date, several reviews are available that systematically synthesized the literature on preoperative exercise in individuals awaiting major joint replacement; concluding that preoperative exercise has little worth on postoperative outcomes [49]. However, most of the included studies investigated the effectiveness of preoperative exercise in generally healthy adults, whereas in essence eligible people with comorbidities and/or higher age were excluded [50]; yielding at best small effect sizes [51]. The inclusion of the fit elderly distorts results, as patients of higher age with comorbidities are the ones with a significant risk of disappointing surgery outcomes [48]. Therefore to understand and appreciate the true potential of preoperative therapeutic exercise, we need to evaluate studies that did include individuals with a higher risk for disappointing outcomes after surgery.

To date two studies are available that investigated the merits of preoperative exercise in patients with an increased risk for delayed functional recovery or increased length of hospital stay in a typical Western care setting [52,53]. Topp *et al.* [52] investigated the effectiveness of therapeutic exercise in patients with low preoperative functional level awaiting TKR. They found that after 3 months the functional performance level and strength of the people in the preoperative exercise group was better restored than in the control group. Hansen *et al.* [53] demonstrated that, in the context of fast-track rehabilitation, preoperative therapeutic exercise of individuals with an increased risk of delayed recovery, can further shorten the hospital stay by one additional day after THR or TKR. The previous

study suggests that an adequate selection of high-risk patients before surgery is essential for the success of preoperative exercise in THR and TKR. Considering that preoperative exercise is fairly cheap, well tolerated and clinically relevant, it needs to be considered an intervention of choice in aiding the recovery after total joint replacement [54].

For postoperative exercise therapy, evidence suggests that the retraining of functional abilities should be initiated within 4 h after surgery [55]. However, the effectiveness of postdischarge exercise is still under debate [55,56]. Experts in the field conclude that therapeutic exercise training is often of limited intensity and/or offered too late after surgery [57,58]. The latter is confirmed by the study of Pozzi *et al.* [56] who recommend strength and functional exercise therapy highly tailored to the needs of the patient to improve postoperative recovery. To do so, supervision by a trained physical therapist is essential. Low intensity, unsupervised exercise should be avoided.

RECOMMENDATIONS FOR FUTURE RESEARCH

The current evidence for perioperative exercise therapy is currently skewed toward small RCTs with relatively fit elderly patients, testing mostly generalized ('one size fits all') low-to-moderate intensity general exercise programs, which is neither cost-effective nor a targeted approach. Instead, research should identify which aspects of (preventive) exercise training programmes [strength, (an) aerobic capacity or functional mobility] are appropriate and tolerable for individual or specific groups of patients [50]. Moreover, exercise training-related research should also incorporate monitoring principles to establish the optimum in training parameters for each individual patient [32[■]]. High-intensity training is necessary to achieve improvements given the often short time available before surgery. Fortunately, frail and older patients can tolerate the programs [25].

CONCLUSION

There is high quality evidence that perioperative exercise in patients scheduled for cardiac surgery is well tolerated and effective. Moreover, there is circumstantial evidence suggesting the same for thorax, abdominal and major joint replacement surgery provided that this is offered to the high-risk patients. We conclude that this participatory, preventive, predictive and preferably personalized perioperative exercise training intervention might be a valuable asset to concepts like 'strong for surgery' [59] as a component of an elderly friendly healthcare

system as a whole [60]. Implementation should be guided by proper monitoring of the effects in the real-life context of the care system.

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Conflicts of interest

There are no conflicts of interest.

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