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The association of preoperative physical fitness and physical activity with outcome after scheduled major abdominal surgery

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ABSTRACT

We studied whether reported physical activity and measurements of fitness (hand, leg and inspiration) were associated with postoperative in-hospital mortality, length of stay and discharge destination in 169 patients after major oncological abdominal surgery. In multivariate analysis, adequate activity level (OR 5.5, 95% CI 1.4–21.9) and inspiratory muscle endurance (OR 5.2, 95% CI 1.4–19.1) were independently associated with short-term mortality, whilst conventional factors, such as age and heart disease, were not. Adequate activity level (OR 6.7, 95% CI 1.4–3.0) was also independently associated with discharge destination. The factors that independently associated with length of hospital stay were: COPD (HR 0.6, 95% CI 0.3–1.1); adequate activity level (HR 0.6, 95% CI 0.4–0.8) and inspiratory muscle strength (HR 0.6, 95% CI 0.5–0.9). For all postoperative outcomes physical activity and fitness significantly improved the predictive value compared to the use of known risk factors as age and comorbidities. We conclude that preoperative questionnaires of physical activity and measurements of fitness contribute to the prediction of postoperative outcomes.

INTRODUCTION

The preoperative identification of high-risk patients may reduce postoperative complications.[1] Risk factors associated with complications after major abdominal and thoracic surgery include age and smoking, as well as comorbidities, such as diabetes, COPD, and heart disease.[2-7] Risk evaluation may also include functional status,[8-10] which predicts postoperative outcome in older patients.[11-13]

A poor physical condition and functional status reduces the ability of a person to cope, mentally and physically, with hospitalization and surgery[14] and may compromise postoperative functional recovery, potentially leading to postoperative complications, death, and protracted and sometimes permanent loss of mobility.[2,9,11,15,16] Some authors recommend preoperative evaluation of functional status,[8,17,18] but inexact definitions may preclude its use in research.[19] Functional status has physical, psychological, and social elements, but it is often evaluated crudely, for example with ASA grade[20] and activities of daily living.[21] Functional status is usually based upon the WHO International Classification of Functioning, Disability and Health.[22] This classification distinguishes between activity, reported by questionnaire, and observed physical ability, the combination of which may refine prognostic information.[23]

We believe that this is the first prospective cohort study to investigate the association of this combination of questions and physical tests with the following short-term outcomes after scheduled major abdominal surgery in patients older than 59 years: mortality, length of hospital stay, and discharge destination.

METHODS

We prospectively recorded data for patients older than 59 years scheduled for oncological colorectal surgery between June 2006 and June 2009, at Gelderse Vallei Hospital in Ede, the Netherlands. We excluded from analyses patients we assessed as unable to do the fitness tests, based upon the results of a physical activity readiness questionnaire.[24] The study protocol was approved by the local Medical Ethics Committee of the Gelderse Vallei Hospital.

All patients were referred to the physical therapy outpatient department, as part of the multidisciplinary work-up, between one and three weeks before surgery. The physical therapist offered some patients physical training if their surgery was scheduled more than two weeks in advance. We recorded: age; diagnoses of diabetes, COPD, coronary heart disease, heart failure, metastatic cancer, and histories of smoking or productive cough.

We asked patients the frequency, duration and intensity of various activities over the previous 14 days, such as cycling, gardening and walking, using the LASA physical activity questionnaire (LAPAQ).[25]

An experienced physical therapist tested physical fitness by mobility and muscle function (ICF domains d4 and b7, respectively).[22] Mobility was measured as the time taken to rise from an armchair, walk 3 meters, turn, walk back, and sit down again (known as 'timed up-and-go', TUG).

Function was measured in the hand, leg and inspiratory muscles. Handgrip strength was recorded as the highest measurement in the dominant hand, using a digital device three times, separated by intervals of 30 seconds (Mechatronics Instruments BV, the Netherlands).[28] Leg power and endurance were measured as the time taken to rise from a treatment couch, adjustable in height, 10 times with the arms folded across the chest.[26-28] Maximal inspiratory muscle strength and respiratory cumulative energy were measured with the MicroRPM and MicroRMA respectively (Micro Medical Ltd., Rochester, England).[29]

All patients in this study received usual care. The questionnaires and physical tests were not masked from the healthcare providers.

All assessments were made at the same appointment, always in the following sequence: mobility; leg strength; inspiratory strength; hand strength; questionnaire. We recorded: in-hospital mortality, discharge destination (to the home environment or to a nursing home), and length of hospital stay (in days). We used discharge destination as an outcome for three reasons: patients usually want to return home; it reflects functional recovery; it is an important item for health insurers because of the high costs of admission to a nursing home.

Data were analysed with the software package IBM SPSS Statistics 19.0 (SPSS Inc., Chicago, IL). We dichotomised the results of the questionnaire and each fitness test for two outcomes – mortality and discharge destination – with the best discriminatory point on a receiver operating characteristic curve, as long as the area under curve was more than 0.6. We performed univariate logistic regression for the association of each factor with mortality and discharge destination, and univariate Cox regression for associations with length of stay. We entered significant factors ($p<0.1$) in a multivariate regression analysis for all three outcomes. To obtain a valid assessment of the added value of the physical activity and fitness factors, the significant conventional risk factors were forced into the model. Statistical significance of models was determined by -2 log likelihood values for the regression models and a p-value <0.05 for the chi-square tests. The predictive value for mortality and discharge destination was estimated by the C-index and positive and negative predictive values, the goodness of fit was assessed by the Hosmer & Lemeshow test.

RESULTS

We analysed data from 175 patients referred to the department of physical therapy between June 2006 and June 2009. The operation was cancelled in six patients because of deterioration of their medical condition or at the patient's request. Nine patients were not referred for screening because bowel pathology was not initially recognized as the cause for their symptoms. Table 3.1 lists patient and surgical characteristics.

Table 3.1 Preoperative characteristics including conventional risk factors in 169 subjects

Gender; male/female	99/70
BMI; kg.m^{-2}	26 ± 5
Surgery	
Colon resection (open)	61 (36%)
Colon resection (endoscopic)	14 (8%)
Rectosigmoid resection (open)	72 (42%)
Rectosigmoid resection (endoscopic)	22 (13%)
Open surgery duration; mins	110 (44)
Endoscopic surgery duration; mins	170(53)
Reoperation	31 (18%)
Preoperative radiotherapy	41 (24%)
Conventional risk factors	
Age	
60–69 years	61 (36%)
70–79 years	82 (49%)
>80 years	26 (15%)
Metastatic cancer	15 (9%)
Diabetes	30 (18%)
COPD	15 (9%)
Heart diseases	19 (11%)
Smokers	24 (14%)
Productive cough	23 (14%)

BMI, body mass index; COPD, chronic obstructive pulmonary disease.

Thirteen patients (8%) died in hospital, a median (IQR [range]) of 19 days (10–28 [8–39]) after surgery. No patient died after discharge within this period. We compared mortality rates between two groups of patients, above and below a value for each factor, identified through ROC curve analyses: mobility, 11 seconds; stand-sit repeats, 27 seconds; inspiratory pressure, 90cm H_2O; respiratory cumulative energy 41J; hand strength, 233N; questionnaire 416 kcal. Table 3.2 lists the univariate relative risks and subsequent multivariate odds ratios for each factor. Both the questionnaire score and cumulative respiratory energy were associated with in-hospital mortality. A model containing only

Table 3.2 Preoperative characteristics including conventional risk factors in 169 subjects

			Univariate analyses		Multivariate analyses	
	N	% total	Relative risk (95% CI)	p-value	Forced* Odds ratio (95% CI)	Not forced Odds ratio (95% CI)
Conventional factors						
Age						
60–70 year	61	36%	1			
70–80 year	82	49%	2.6 (0.6–12.1)	0.20		
>80 year	26	15%	4.7 (0.9–24.0)	0.04		
Metastatic cancer	15	9%	3.1 (0.9–10.0)	0.06	3.0 (0.6–14.7)	
Diabetes	30	18%	1.4 (0.4–4.7)	0.60		
Heart disease	19	11%	1.4 (0.3–6.0)	0.62		
COPD	15	9%	0.9 (0.1–6.1)	0.88		
Smoking	24	14%	0.5 (0.1–3.7)	0.48		
Productive cough	23	12%	2.8 (0.9–8.2)	0.07	3.2 (0.7–14.2)	2.9 (0.7–12.5)
Physical activity and fitness						
LAPAQ; kcal						
<416 kcal	60	37%	5.8 (1.7–20.2)	0.0002	5.6 (1.4–22.6)	5.5 (1.4–21.9)
TUG; sec						
>11 sec	24	15%	4.8 (1.8–13.0)	0.001		
CRT; sec						
>27 sec	62	40%	2.2 (0.7–7.6)	0.18		
MIP; cm H_2O						
<90 cm H_2O	104	65%	3.0 (0.7–13.1)	0.12		
RCE; J						
≤41 J	48	32%	4.7 (1.5–14.5)	0.003	5.0 (1.4–18.6)	5.2 (1.4–19.1)
HGS; N						
<233 N	37	24%	2.7 (1.0–7.6)	0.05		

*Inclusion of physical activity and fitness increased the chi-square from 5.85 to 20.12 and the p-value from 0.12 to 0.0004: their inclusion also increased the c-index (95% CI) from 0.67 (0.51–0.84) to 0.82 (0.69–0.95). LAPAQ, LASA physical activity questionnaire; TUG, timed up-and-go; CRT, chair rise time; MIP, maximal inspiratory pressure; RCE, respiratory cumulative energy; HGS, hand grip strength.

conventional factors was not associated with mortality ($p=0.12$) but the model including physical fitness and activity factors was associated with in-hospital mortality ($p=0.0005$), confirmed by a significant difference in the log likelihood values of the two models (85.33 versus 66.62, $p=0.001$). The c-index for the model including the physical fitness and activity factors was 0.82 versus 0.67 for the model with conventional factors. The frequencies of patients correctly and incorrectly predicted to die were 18 and 72 per 1000 for the conventional model and 30 and 28 for the model also including physical activity and fitness, respectively. The frequencies of patients correctly and incorrectly predicted to survive were 851 and 59 per 1000 patients for the conventional model and 895 and 47 for the model also including physical activity and fitness, respectively. The goodness of fit hypothesis of all models was not rejected by the Hosmer and Lemeshow test. Sixteen survivors were discharged to a nursing home and 140 to home.

ROC curve analyses generated different preoperative discriminatory values for discharge destination: mobility, 8 seconds; stand-sit repeats, 26 seconds; inspiratory pressure, 90cm H_2O; respiratory cumulative energy 60J; hand strength, 270N; questionnaire 530kcal. Both the questionnaire score and maximal inspiratory pressure were associated with discharge destination as determined by multivariate analysis. A model containing only conventional factors was not associated with discharge destination ($p=0.51$) but the model including physical fitness and activity factors was associated with discharge destination ($p=0.004$), confirmed by a significant difference in the log likelihood values of the two models (97.23 versus 68.61; $p=0.003$). The c-index for the model including the physical fitness and activity factors was 0.80 versus 0.66 for the model with conventional factors. The frequencies of patients correctly and incorrectly predicted to discharge to a nursing home were 26 and 116 per 1000 for the conventional model and 59 and 137 for the model also including physical activity and fitness, respectively. The frequencies of patients correctly and incorrectly predicted to discharge to home were 782 and 77 per 1000 patients for the conventional model and 760 and 44 for the model also including physical activity and fitness, respectively. The goodness of fit hypothesis of all models was not rejected by the Hosmer and Lemeshow test. The median (IQR [range]) length of stay was 12 (9–21[4–130]) days. Discriminatory values for the association with physical activity and fitness were: mobilisation, 8 seconds; stand-sit repeats, 25 seconds; inspiratory pressure, 90cm H_2O; respiratory cumulative energy 375 J; handgrip strength, 240 N; questionnaire 530 kcal. Table 3.3 shows the association of various factors with length of stay as determined by univariate Cox regression analysis. Diabetes, COPD, activity level and maximal inspiratory pressure were associated with increased length of stay on multivariate regression. Addition of physical activity and fitness factors to the model with only conventional factors confirmed a significant difference in the log likelihood values (p=0.002). The chi-square value improved from 9.85 (p=0.007) to 16.47 (p=0.00002).

Table 3.3 Univariate and multivariate Cox regression analyses for associations between factors and postoperative length of stay. The inclusion of questionnaire results (LAPAQ) and the maximal inspiratory pressure (MIP) increased the statistical association with postoperative length of stay.

			Univariate analyses		Multivariate analyses	
	N	% total	Hazard ratio (95% CI)	p-value	Forced* Hazard ratio (95% CI)	Not forced Hazard ratio (95% CI)
Conventional factors						
Age						
60–70 year	61	36%	1			
70–80 year	82	49%	0.9 (0.6–1.3)	0.59		
>80 year	26	15%	0.9 (0.6–1.5)	0.75		
Metastatic cancer	15	9%	0.8 (0.5–1.5)	0.52		
Diabetes	30	18%	0.6 (0.4–0.9)	0.02	0.7 (0.5–1.2)	
Heart disease	19	11%	0.9 (0.5–1.4)	0.58		
COPD	15	9%	0.5 (0.3–0.9)	0.03	0.6 (0.3–1.2)	0.6 (0.3–1.1)
Smoking	24	14%	0.9 (0.6–1.3)	0.52		
Productive cough	23	12%	0.8 (0.5–1.3)	0.37		
Physical activity and fitness						
LAPAQ; kcal						
<530 kcal	79	48%	0.6 (0.4–0.8)	0.0004	0.6 (0.4–0.8)	0.6 (0.4–0.8)
TUG; sec						
>8 sec	66	42%	0.8 (0.6–1.1)	0.15		
CRT; sec						
>25 sec	81	52%	0.8 (0.5–1.1)	0.10		
MIP; cm H_2O						
<90 cm H_2O	104	65%	0.6 (0.4–0.9)	0.003	0.6 (0.5–0.9)	0.6 (0.5–0.9)
RCE; J						
≤375 J	122	82%	0.7 (0.4–1.1)	0.10		
HGS; N						
<233 N	40	26%	0.9 (0.6–1.3)	0.44		

*Inclusion of physical activity and fitness increased the chi-square from 9.85 to 16.47 and the p-value from 0.007 to <0.0001: their inclusion decreased the -2 log likelihood from 1303.49 to 1176.78 (p=0.002).
LAPAQ, LASA physical activity questionnaire; TUG, timed up-and-go; CRT, chair rise time; MIP, maximal inspiratory pressure; RCE, respiratory cumulative energy; HGS, hand grip strength.

DISCUSSION

This study revealed that preoperative physical activity and physical fitness are statistically significant and independent predictors of postoperative recovery in addition to conventional predictors. Individual determinants of physical activity and physical fitness were significantly correlated with one or more of the postoperative outcome measures. The same was true for three conventional risk factors; age, diabetes, and COPD. The performance of the prediction models for mortality, discharge destination and length of stay were all significantly improved by addition of the physical activity and fitness factors. In the multivariate regression analyses, physical activity, measured with a questionnaire, was the only factor that was significantly correlated with all outcome measures after correction for mutual correlation in logistic regression analyses. Thus LAPAQ was the most robust predictor of postoperative recovery identified in this study.

Compared with the conventional factors, the physical activity and physical fitness factors predominated in explaining the variance in the postoperative measurements. Age was the most important conventional predictor, but was statistically overruled by the physical activity and physical fitness factors in regression analyses. This suggests that physiological age, i.e. the way that age affects physical functioning, is a better predictor than chronological age. Our results hold even when age was forced into the model. This seems to justify the addition of the physical activity and fitness factors to preoperative evaluation. The major role of physical activity as a preoperative predictor of postoperative outcome is consistent with recent research showing that the activity level, measured with an accelerometer, is correlated with postoperative complications.[30] It is also consistent with the general recommendation that older people should adopt and/or maintain a physically active lifestyle.[31] Robinson et al. also included comorbidities and functional measures in the prediction of postoperative mortality and found functional measures to be of added value.[12] These authors made a plea toward a preoperative assessment using geriatric-specific markers. Independent functioning in terms of self-reported ADL is a frequently mentioned predictor of the postoperative course[32-35]: our findings with the 'timed up-and-go' test, a capacity-based measure of ADL, confirmed its importance. In the univariate analysis, handgrip strength was significantly correlated with mortality and discharge destination, which corroborates the results of three studies evaluating handgrip strength as single predictor.[36-38] The handgrip strength cut-off for mortality was very similar to that reported by Chen et al. for patients with oesophageal cancer.38 The predictive role of respiratory function is not widely recognised, but is probably due to the additional deterioration in inspiratory muscle function after major abdominal and thoracic surgery.[39]

Although we included patients scheduled for elective colon surgery, the results could probably be extrapolated to other abdominal or thoracic surgery, because physical activity and fitness reflect the general capacity of the body to withstand the physiological and functional effects of major surgery.[40] A potential limitation of this study was our assessment of physical fitness. We did not use cardiorespiratory function as a marker of frailty. A bicycle ergometry test or stair-climb test could complement the assessments used here to predict the postoperative course.[5,41] The study was also limited by the number of participants, which limited the statistical power of the study, especially because the mortality rate was low. This study focused on the short-term functional recovery: we suspect that the factors we identified would also associate with long-term survival, which is recommended as follow-up research.

The results of this study emphasise the role of physical activity and physical fitness in the preoperative evaluation of elderly patients and the need to include these factors in prediction models of postoperative recovery after major surgery. An accurate preoperative evaluation enables a timely start to be made to appropriate interventions to prevent postoperative complications and provides the patient with information to enable him/her to give truly informed consent.

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