

Analysis of exercise tolerance on the basis of six-minute walk test – 6MWT and Borg RPE scale in men with inguinal hernia before and after Lichtenstein repair

Analiza tolerancji wysiłku na podstawie sześciominutowego testu marszowego – 6MWT i subiektywnej oceny zmęczenia i duszności według skali Borga u mężczyzn z przepuklinami pachwinowymi przed i po operacji sposobem Lichtensteina

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A – Study Design
B – Data Collection
C – Statistical Analysis
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ABSTRACT:

Introduction: Assessment of exercise tolerance (ET) plays an important role in qualifications for treatment and rehabilitation.

Aim: The aim of the study was to assess ET in patients before and after inguinal hernia operations with Lichtenstein method.

Material and methods: The cohort study included men with inguinal hernia divided into the study group (SG) (n = 50) and control (CG) (n = 50) undergone the Lichtenstein surgery. Patients from the SG met the criterion of coexistence of cardiovascular and respiratory diseases. Day before and on the second day after surgery, patients performed 6MWT and subjectively rate the exertion according to Borg- RPE- Scale (before, immediately after and 10 minutes after the test). 6MWT distance, Borg scale ratings were analysed. On the second day after surgery 66% of patients from the SG and 58% from the CG did not complete the test. Patients from the SG before (500,07 ± 40,38 m) and on the second day after surgery (243,46 ± 18,18 m) achieved shorter distances compared to the CG (565,93 ± 20,41 m; 249,47 ± 26,66 m), p < 0,001 i p = 0,481. A statistically significant negative correlation between 6MWT distance before surgery and age of the patients was confirmed. Patients who did not develop complications achieved significantly longer distances on admission (p = 0,003 for SG, p = 0,004 for CG). For 6MWT before surgery and 2 days after surgery, patients from the SG showed a significantly higher level of fatigue compared to the CG after the test (before: p = 0,001, after: p = 0,001). Patients from the SG often discontinued 6MWT and less tolerated effort compared to the CG. Hence, 6MWT is useful tool for ascertaining physical capacity and ET.

KEYWORDS:

Borg scale, exercise tolerance, inguinal hernia, physical capacity, postsurgical rehabilitation, six minute walk test – 6MWT

STRESZCZENIE:

Wstęp: Ocena tolerancji wysiłku odgrywa ważną rolę w kwalifikacji do leczenia i rehabilitacji.

Cel: Celem niniejszej pracy była ocena tolerancji wysiłku u chorych przed i po operacji przepukliny pachwinowej metodą Lichtensteina.

Materiał i metodyka: Do badania włączono mężczyzn operowanych z powodu przepukliny pachwinowej metodą Lichtensteina, których podzielono na grupę badaną (n = 50) i kontrolną (n = 50). Chorzy z grupy badanej spełniali kryterium współistnienia chorób układu krążenia i układu oddechowego. Dzień przed operacją i w 2. dobie po operacji pacjenci zostali poddani testowi 6-minutowego marszu (ang. 6 Minute Walk Test; 6MWT) oraz subiektywnie ocenili poziom zmęczenia według skali Borga (przed, bezpośrednio po i 10 minut po teście). Analizowano dystans 6MWT, poziom zmęczenia wg skali Borga. W 2. dobie po operacji 66% chorych z grupy badanej i 58% z grupy kontrolnej nie ukończyło testu. Pacjenci z grupy badanej przed operacją (500,07 ± 40,38 m) i w 2. dobie po operacji (243,46 ± 18,18 m) osiągnęli krótsze dystanse w porównaniu do grupy kontrolnej (565,93 ± 20,41 m; 249,47 ± 26,66 m), p < 0,001 i p = 0,481. Potwierdzono istotną statystycznie silnie ujemną korelację pomiędzy dystansem 6MWT przed operacją a wiekiem badanych. Pacjenci, którzy nie rozwinęli powikłań, osiągnęli w dniu przyjęcia istotnie dłuższe dystanse (dla grupy badanej p = 0,003, dla kontrolnej p = 0,004). Dla 6MWT przed operacją oraz 2 dni po operacji chorzy z grupy badanej wykazali istotnie wyższy poziom zmęczenia w porównaniu do grupy kontrolnej po teście (przed operacją: p = 0,001, po operacji: p = 0,001). Pacjenci z grupy badanej częściej przerywali 6MWT i gorzej tolerowali wysiłek w porównaniu do grupy kontrolnej. 6MWT jest przydatnym narzędziem do określenia wydolności fizycznej i tolerancji wysiłku.

SŁOWA KLUCZOWE: przepuklina pachwinowa, rehabilitacja pooperacyjna, skala Borga, sześciominutowy test marszowy – 6MWT, tolerancja wysiłku, wydolność fizyczna

ABBREVIATIONS

6MWT – t**6MWT** – 6 Minute Walk Test
ATS – American Thoracic Society
BMI – Body Mass Index
CG – control group(s)
COPD – chronic obstructive pulmonary disease
ERAS – enhanced recovery after surgery protocol
ET – exercise tolerance
MD – difference in means
NYHA – New York Heart Association
RPE – Rating of Perceived Exertion
SG – study group(s)

INTRODUCTION

It is estimated that there are around 20 million inguinal hernia repairs performed annually worldwide [1]. Alongside cholecystectomy, inguinal hernia repairs are recognized as the most common scheduled operations performed in general surgery. In Poland, the data on the number of surgeries are incomplete or outdated, but their number is estimated at approx. 70.000 per year [2]. Inguinal hernias account for ¾ of all abdominal hernias, and are 8 times more likely to develop in men [3], which is related to the content and function of the inguinal canal. In Poland, the dominant surgical technique used in the treatment of inguinal hernias is open mesh method using the Lichtenstein technique. It is believed that these surgeries have contributed positively to reducing the frequency of recurrences and shortening the length of post-operative rehabilitation, and thus accelerated the patient's return to normal activities and work [4, 5]. Nevertheless, the recovery time after inguinal hernia surgery is still a controversial and rather poorly researched issue. Recommendations are based on a few retrospective observational studies but also to a large extent on accepted traditional surgical recommendations [4].

The occurrence of chronic (concomitant) diseases in patients qualified for surgery has a negative effect on the prognosis, hinders rehabilitation and post-operative recovery, and increases the risk of complications. It has been demonstrated that endurance training, both before and after surgery, has a positive effect on patients' health and thus shortens the length of hospital stay [6, 7]. It has been proven that limited, insufficient preoperative physical fitness increases the risk of complications and prolongs the recovery period after abdominal surgeries [8]. Therefore, surgeons and primary care physicians should consider recommending patients eligible for surgery movement exercises that increase exercise tolerance. Thus, the aim should be to optimize the treatment of comorbidities. The above postulates are included in the enhanced recovery after surgery (ERAS) protocol – a modern comprehensive formula of perioperative care to enhance the effects of treatment.

The six-minute walk test (6MWT), also known as the corridor walk test, is well tolerated and safe for the patient, and easy to perform. The test is used in clinical practice to determine exercise tolerance, qualification for treatment, rehabilitation, anticipate the effects of rehabilitation, adapt to 'everyday' activities and prognosis [9]. It has become a popular method for assessing physical fitness in clinical practice – especially in pulmonology, cardiol-

gy, and rehabilitation. The 6MWT test consists in assessing the distance of walking over a total of six minutes on a hard, flat surface and the subjective level of exertion according to the Borg scale. The integrated response of all body systems is assessed, including the circulatory, respiratory and movement systems. The walkers can self-select the pace and intensity of the walk. During the walk, the submaximal level of exercise capacity is reached, i.e. a level achieved during activities of daily living. As a result, it better reflects the level of functional capacity [9]. The test is recommended by cardiologists, pulmonologists, and rehabilitation doctors.

The aim of the study was to assess exercise tolerance in patients before and after inguinal hernia surgery with the use of a synthetic mesh using Lichtenstein repair. Exercise capacity was measured on the basis of a six-minute walk test depending on the length of hospital stay (on the first day of hospitalization, i.e. the day before the surgery and on the fourth day of hospitalization, i.e. 2 days after the surgery), disease burden, occurrence of postoperative complications. One of the key assumptions of the study was the assessment of postoperative changes in exercise tolerance and the assessment of subjective fatigue. The study also aimed to determine the influence of concomitant health burden on the perioperative course. There was also an attempt to address the question whether the assessment of exercise tolerance based on the walk test will be a reliable test in the evaluation of pre- and postoperative fitness.

MATERIAL AND METHODS

The study was conducted at the Department of General, Oncological and Endocrine Surgery at WWCOiT in Łódź. In the period from March 2017 to January 2020, the study group included patients who met at least 1 of the following criteria: age > 65 years, BMI > 30, NYHA – class II, III, IV, heavy smokers > 20 pack-years, Tiffeneau index <70%. The basis for qualifying for the study group was primarily the coexistence of comorbidities of (at least one of the following): the circulatory system (stable coronary syndromes, chronic heart failure, other stable-chronic diseases), the respiratory system (chronic respiratory failure, COPD, bronchial asthma, restrictive and obstructive diseases of the respiratory system and other stable chronic diseases).

The exclusion criteria according to the recommendations of the 'Guidelines for the Six-Minute Walk Test' of the *American Thoracic Society* included: unstable coronary artery disease, recent myocardial infarction within one month, resting heart rate above 120 beats per minute, systolic blood pressure above 180 mmHg, diastolic over 100 mmHg, uncontrolled hypertension.

The analysis covered only the results of male patients whose inguinal hernias were operated on with the Lichtenstein method with the use of synthetic mesh.

A control group was formed; the inclusion criterion was Lichtenstein repair in the absence of comorbidities in the examined patients.

The quantitative and sociodemographic characteristics of the study group and the control group are presented in Tab. I. The characteristic of chronic diseases (it should be noted that one patient may have multiple comorbidities) is presented in Tab. II.

Tab. I. Quantitative and sociodemographic characteristics of the study and control groups.

| | STUDY GROUP | CONTROL GROUP |
|--------|---------------|-----------------|
| N | 50 | 50 |
| Men | 50 (100%) | 50 (100%) |
| Age: | 59.66 ± 10.85 | 45.44 ± 10.21 |
| Height | 1.72 ± 0.12 | 1.73 ± 0.14 |
| Weight | 84.90 ± 39.59 | 79.30 ± 24.7 |
| BMI | 28.79 ± 4.7 | 24.4 = 80 ± 3.8 |

Note. Data presented as n (%) or as arithmetic mean ± standard deviation.

Tab. II. Number of comorbidities in the study group.

| COMORBIDITIES: | STUDY GROUP N = 50 |
|--|--------------------|
| Ischemic heart disease | 28 (56%) |
| HA | 25 (50%) |
| POChP | 12 (24%) |
| Bronchial asthma | 9 (18%) |
| Diabetes | 14 (28%) |
| Cardiovascular diseases other than HA and ischemic heart disease | 13 (26%) |
| Status post abdominal surgeries | 11 (22%) |
| Status post hernia surgery | 10 (25%) |
| Other hernias | 8 (16%) |
| Nicotinism (also in the past) | 16 (32%) |
| Status after prostatectomy | 2 (4%) |
| Connective tissue diseases | 8 (16%) |
| Tumors, including malignant | 5 (10%) |

Patients qualified for the study before and after Lichtenstein repair were subjected to a six-minute walk test and assessed subjective fatigue on the basis of a modified 10-point Borg questionnaire on the day of admission, i.e. the day before surgery and on the 2nd day after surgery (4th day of hospitalization). The study included only stable patients who had met the inclusion criteria and the criteria set out by the ATS. The Borg scale questionnaire was used to subjectively assess the level of fatigue in patients, dyspnea before, immediately after and 10 minutes after the test. Control measurements of heart rate, systolic pressure, diastolic pressure and blood saturation were performed before, immediately after and 10 minutes after the test. During the study, the distance walked over a span of 6 minutes and the subjective level of exertion according to the Borg scale were assessed.

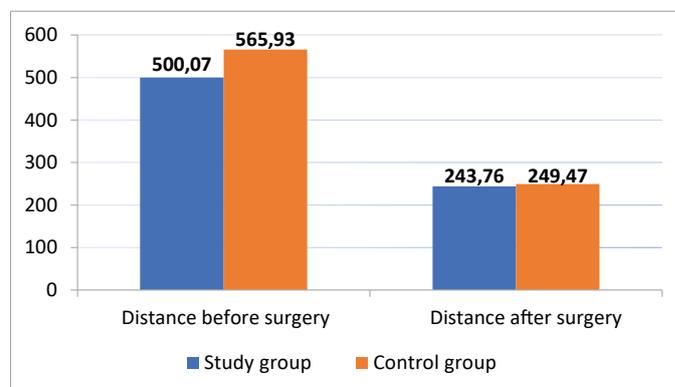
RESULTS

The results of the 6MWT test as well as the subjective assessment of fatigue and dyspnea according to the Borg scale for the study group compared to the control group were analyzed. Before surgery, all patients from the control and study groups completed 6MWT. On the second day after surgery, 33 patients (66%) from

Tab. III. Characteristics and results of 6MWT, subjective assessment of fatigue and dyspnea according to the Borg scale for the study and control groups.

| | STUDY GROUP | CONTROL GROUP | P |
|------------------------------------|------------------|------------------|--------|
| N | 50 | 50 | |
| Age, years | 59.66 ± 10.85 | 45.44 ± 10.21 | <0.001 |
| 6MWT distance before surgery | 500.07 ± 40.38 | 565.93 ± 20.41 | <0.001 |
| Completion of 6 MWT test, n (%) | 50 (100.0%) | 50 (100.0%) | >0.999 |
| Borg scale before test | 0.00 (0.00;0.00) | 0.00 (0.00;0.00) | n/a |
| Borg scale after test | 2.00 (1.00;3.38) | 1.00 (0.13;1.00) | <0.001 |
| Borg Scale 10 min. after test | 0.00 (0.00;1.00) | 0.00 (0.00;0.00) | <0.001 |
| 6MWT distance after surgery | 243.76 ± 18.18 | 249.47 ± 26.66 | 0.481 |
| Completion of 6MWT test, n (%) | 17 (34.0%) | 21 (42.0%) | 0.537 |
| Complications after surgery, n (%) | 12 (24.0%) | 8 (16.0%) | 0.453 |
| Borg scale before test | 0.00 (0.00;0.00) | 0.00 (0.00;0.00) | n/a |
| Borg scale after test | 2.50 (2.00;3.00) | 2.00 (1.50;2.50) | <0.001 |
| Borg scale 10 min. after test | 1.00 (0.00;1.00) | 0.00 (0.00;0.00) | <0.001 |

Data presented as arithmetic mean ± standard deviation or as median (Q1; Q3) unless otherwise indicated. The groups were compared by chi-square, t-student or Mann-Whitney U test. n/a – the test cannot be performed due to the same values for all patients.

**Fig. 1.** Graph showing the average distance achieved during 6MWT for the study and control groups.

the study group and 29 (58%) patients from the control group did not complete the test (they discontinued it during the procedure). Patients with comorbidities were more likely to withdraw from completing the 6MWT (in all cases due to symptoms). Data showing the characteristics, results – distance achieved during the 6MWT, subjective assessment of fatigue and dyspnea according to the Borg scale depending on the group are presented in Tab. III. A visual presentation of the mean results – distance achieved during the 6MWT for patients in the study group compared to the control group is presented in Fig. 1.

Before the operations, the distance traveled by the patients in the study group was on average 500.07 ± 40.38 m, and for the control group I – 565.93 ± 20.41 m. A significant difference in the distance traveled before the operation was confirmed between the two groups. On the other hand, for the test carried out two days after

Tab. IV. Comparative analysis of the distance traveled in 6MWT and changes in distance for the study and control groups.

| DISTANCE TRAVELED IN 6MWT, m | STUDY GROUP n=50 | CONTROL GROUP n=50 | P |
|------------------------------|----------------------------|--------------------------|-----------|
| (o) Before surgery | 513.4 (480.2; 525.9) | 568.3 (550.4; 580.2) | p < 0.001 |
| (1) 2 days after surgery | 240.2 (230.8; 260.4) | 250.1 (230.4; 270.2) | p = 0.481 |
| Change: (1) – (o) | –282.0 (–295.0; –270.0) | –328.0 (–340; –306.0) | p < 0.001 |
| (1) to (o) | p < 0.001 | p < 0.001 | – |

Note. Data presented as median (Q1; Q3), Mann-Whitney U test, Wilcoxon pair test.

Tab. V. Correlation between age and distance in 6MWT test.

| AGE-DISTANCE CORRELATION OF 6MWT | BEFORE SURGERY | | AFTER SURGERY | |
|----------------------------------|----------------|--------|---------------|-------|
| | r_s | P | r_s | P |
| Study group | –0.84 | <0.001 | –0.43 | 0.089 |
| Control group | –0.74 | <0.001 | –0.50 | 0.022 |

Spearman's correlation coefficient.

Tab. VI. Distance in 6MWT test relative to the presence of complications.

| | LACK OF COMPLICATIONS | COMPLICATIONS | MD (95% CI) | P |
|------------------------------|-----------------------|----------------|-------------------------|-------|
| Study group | | | | |
| 6MWT distance before surgery | 512.89 ± 26.90 | 459.48 ± 49.64 | 53.41 (21.07; 85.74) | 0.003 |
| 6MWT distance after surgery | 243.76 ± 18.18 | - | - | - |
| Control group | | | | |
| 6MWT distance before surgery | 570.45 ± 17.41 | 542.20 ± 19.38 | 28.25 (11.68; 44.82) | 0.004 |
| 6MWT distance after surgery | 249.47 ± 26.66 | - | - | - |

Data presented as arithmetic mean ± standard deviation. The groups were compared with the t-student test. MD – difference in means between patients with complications and without complications with 95% confidence level.

surgery, the distance decreased by more than 2x for both groups (it was significantly lower than before the surgery) and amounted to: 243.46 ± 18.18 m for the patients in the study group and 249.47 ± 26.66 m for the control group. The results of the test performed two days after surgery differed significantly between groups. The comparison of the average change in the distance covered between the individual 6MWT tests gives grounds for stating a considerable difference in the change in the distance between the study and control groups. Patients from the study group, i.e. with burdens in the form of concomitant heart or respiratory diseases, achieved shorter distances during the 6MWT before and on the second day after the operation. A comparative analysis of the median distance traveled during the 6MWT and changes in distance for the groups is presented in Tab. IV.

The most common reasons for not completing 6MWT were pain in the operated area, discomfort in the groin and lower limbs, weakness, dizziness, dyspnea, and coordination difficulties. The fear of excessive exercise and possible complications was noted in all

patients and was the reason for discontinuing 6MWT or for interruptions during the test. The above ailments were more often reported by patients in the study group.

There were no intraoperative complications in the study and control group. Postoperative complications occurred in 24% (12 patients) of the study group and 16% (8 patients) of the control group. It was confirmed that the incidence of complications was higher in the study group. There have been cases where patients developed multiple complications. Complications reported (in the study and control group) are pain in the operated area – 18 cases, hematoma, swelling in the operated area – 8 cases, exacerbation of heart failure – 2 cases, uncontrolled hypertension – 5 cases, episode of urinary retention – 2 cases. Hospitalization was not extended in patients with complications. No wound infections were found in patients in the early postoperative period.

A statistically significant, strongly negative correlation was confirmed between the distance covered during the 6MWT performed before the surgery and the age of the respondents, both for the study group and the control group. This implies that older patients achieved shorter distances compared to younger patients. In the case of the post-operative 6 MWT test, patients who had completed the test demonstrated a strong negative correlation between the test distance and age in the control group, while a moderate negative correlation was found for the study group, Tab. V.

The distance traveled during 6 MWT on the first day of hospitalization (before surgery) differed significantly between patients with later postoperative complications and those who did not develop complications. In the study group, patients without complications achieved an average distance of 512.89 ± 26.90 m on the day of admission, while patients with subsequent complications achieved 459.48 ± 49.64 m, MD = 53.41, CI95 [21.07; 85.74], p = 0.003. In the control group, the distance covered by patients without complications during the six-minute walk on the first day of hospitalization was on average 570.45 ± 17.41 m, while patients with postoperative complications covered 542.20 ± 19.38 m, MD = 28.25, CI95 [11, 68; 44.82], p = 0.004. After surgery, none of the patients with postoperative complications completed the 6MWT test in both the study and control groups, Tab. VI.

All patients from the study and control groups assessed the level of dyspnea and fatigue before carrying out the 6MWT as zero – that is, they negated the feeling of discomfort (this concerns both the test before the surgery, 2 days after the surgery). For the 6MWT test before surgery and two days after surgery, patients from the study group showed a significantly higher level of fatigue compared to the control group immediately after the test (for 6MWT before surgery: p = 0.001, for 6MWT 48 h after surgery: p = 0.001). Fatigue assessment performed 10 minutes after 6MWT also differed significantly between the groups before and two days after surgery. The increase in the level of fatigue immediately after the test as compared to the pre-test assessment was significantly higher for the study group than for the control group for the 6MWT before the surgery and two days after the surgery. Change in assessed fatigue 10 minutes after the test, compared to the baseline level, differed significantly for the test before surgery and for the test two days after surgery for both groups and was higher for the study group. Comparison of the change in the level of fatigue 10 minutes after the test compared to the evaluation immediately

Tab. VII. Comparative analysis of the distance traveled in 6MWT and changes in distance for the study and control groups.

| BORG SCALE | STUDY GROUP | CONTROL GROUP | P |
|---------------------------|------------------|------------------|--------|
| 6MWT before surgery | | | |
| (0) Before test | 0.0 (0.0;0.0) | 0.0 (0.0;0.0) | n/a |
| (1) After test | 2.0 (1.0;3.0) | 1.0 (0.0;1.0) | <0.001 |
| (2) 10 min. after test | 0.0 (0.0;1.0) | 0.0 (0.0;0.0) | <0.001 |
| Change: (1) – (0) | 2.0 (1.0;3.0) | 1.0 (0.0;1.0) | <0.001 |
| Change: (2) – (1) | –2.0 (–2.0;1.0) | –1.0 (–1.0;0.0) | <0.001 |
| Change: (2) – (0) | 0.0 (0.0;1.0) | 0.0 (0.0;0.0) | <0.001 |
| 6MWT 2 days after surgery | | | |
| (0) Before test | 0.0 (0.0;0.0) | 0.0 (0.0;0.0) | n/a |
| (1) After test | 2.5 (2.0;3.0) | 2.0 (1.5;2.5) | <0.001 |
| (2) 10 min. after test | 1.0 (0.0;1.0) | 0.0 (0.0;0.0) | <0.001 |
| Change: (1) – (0) | 2.5 (2.0;3.0) | 2.0 (1.5;2.5) | <0.001 |
| Change: (2) – (1) | –2.0 (–2.0;–1.5) | –2.0 (–2.0;–1.5) | 0.659 |
| Change: (2) – (0) | 1.0 (0.0;1.00) | 0.0 (0.0;0.0) | <0.001 |

Note. Data presented as median (Q1; Q3), Mann-Whitney U test, n/a – not applicable (all patients obtained the same result, which makes it impossible to perform a statistical test).

after the test shows that for the 6MWT test before surgery, fatigue decreased significantly in patients from the study group than in patients from the control group ($p < 0.001$). However, two days after the surgery, no correlation was found between the change in the assessment of fatigue and dyspnea according to the Borg scale between the study and control groups, Tab. VII.

In the study and control group, all patients before the 6MWT test on the day of admission and two days after surgery subjectively rated fatigue and dyspnea according to the Borg scale at 0. In the study group, a statistically significant, strongly negative correlation was confirmed between the distance covered in the 6MWT test carried out before surgery and the result in the Borg test immediately after the test, as well as 10 minutes after the test. On the other hand, in the control group, a moderate negative correlation was confirmed between the distance in the 6MWT test conducted before the surgery and the result in the Borg test immediately after the test. When measured 10 minutes after the pre-operative 6MWT test, all control subjects had a Borg test score of 0 again. In the case of the 6MWT test performed after the surgery, a statistically significant negative correlation was confirmed between the distance and the assessment of dyspnea and fatigue according to the Borg scale indirectly after the test for the study group, and a weak correlation in the control group between the distance and the assessment of fatigue and dyspnea 10 minutes after the test. In other cases, the relationship between 6MWT distance and Borg score was not confirmed after surgery, Tab. VIII.

DISCUSSION

Research has identified that the six-minute walk test proved to be a useful tool for monitoring postoperative recovery and determining preoperative physical fitness and postoperative physical

status. Based on research, many authors recommend a similar use of 6MWT and apply it in clinical practice before or after cardiac [10, 11], thoracic [12, 13], and orthopedic surgery [14]. More frequently, it is also preferred as a preoperative tool to analyze the risk of postoperative complications [12, 13, 15, 16, 17]. Pecorelli et al. indicate a justified application of the test in the assessment of rehabilitation after colorectal surgeries and for the assessment of interventions aimed at postoperative rehabilitation of patients [18]. Crucially, however, there is still a small number of scientific studies into early postoperative exercise capacity. Consequently, there was no existence of prior studies analyzing pre- and postoperative exercise tolerance in patients with inguinal hernias also depending on the existence of health burden – comorbidities.

According to research evidence, there is a decrease in postoperative physical capacity in patients by a more than doubled distance achieved during 6MWT (for the study group from approx. 500.07 ± 40.38 before surgery to 243.76 ± 18.18 after surgery and for the control group from 565.93 ± 20.41 before surgery to 249.47 ± 26.66 after surgery) and increased intensity of dyspnea and fatigue assessed according to the Borg scale immediately after the test on the second postoperative day (both for the study and control groups). It is noteworthy that in patients with cardiovascular and respiratory diseases, fatigue and shortness of breath lasted longer after surgery compared to measurements before surgery. It was confirmed that patients with health burden both before and after inguinal hernia surgery achieved significantly shorter distances during the walk test compared to the control group. According to data we can notice that patients in the study group had worse tolerance for exercise and that exercise was much more often limited by the experienced symptoms related to comorbidities (which were intensified after operations). This resulted in quite frequent discontinuation of the test by the respondents (33 cases – 66% in the study group and 29–58% in the control group) on the second

Tab. VIII. Correlation between Borg test and distance in 6MWT test.

| CORRELATION OF BORG TEST – 6MWT DISTANCE | DISTANCE TRAVELED BEFORE SURGERY | | DISTANCE TRAVELED AFTER SURGERY | |
|---|----------------------------------|--------|---------------------------------|-------|
| | R | P | R | P |
| Study group | | | | |
| Borg scale before 6 MWT (1 st day) | . | . | . | . |
| Borg scale immediately after 6MWT (1 st day) | –0.83 | <0.001 | –0.71 | 0.001 |
| Borg scale 10 minutes after 6MWT (1 st day) | –0.75 | <0.001 | . | . |
| Borg scale before 6MWT (4th day) | . | . | . | . |
| Borg scale immediately after 6MWT (4th day) | –0.32 | 0.022 | –0.30 | 0.241 |
| Borg scale 10 minutes after 6MWT (4th day) | –0.24 | 0.094 | 0.06 | 0.829 |
| Distance traveled before surgery | 1.00 | . | 0.53 | 0.027 |
| Distance traveled after surgery | 0.53 | 0.027 | 1.00 | . |
| Control group | | | | |
| Borg scale before 6MWT (1 st day) | . | . | . | . |
| Borg scale immediately after 6MWT (1 st day) | –0.45 | 0.001 | 0.03 | 0.893 |
| Borg scale 10 minutes after 6MWT (1 st day) | . | . | . | . |
| Borg scale before 6 MWT (4th day) | . | . | . | . |
| Borg scale immediately after 6MWT (4th day) | –0.55 | <0.001 | 0.00 | 0.988 |
| Borg scale 10 minutes after 6MWT (4th day) | –0.33 | 0.019 | –0.26 | 0.258 |
| Distance traveled before surgery | 1.00 | . | 0.60 | 0.004 |
| Distance traveled after surgery | 0.60 | 0.004 | 1.00 | . |

Spearman's correlation coefficient. n/a – correlation coefficient cannot be calculated due to the same values obtained for all patients.

day after the Lichtenstein repair. Nevertheless, it should be noted that in most cases, the 6MWT was most often interrupted due to pain or discomfort in the operated area, which was combined with dyspnea, dizziness and even fear of continuing the walk. Therefore, the significantly high percentage of incomplete 6MWT immediately after the surgery does not give reason for concern for the researcher, but allows to conclude that in the future, in similar analyses, it is necessary to evaluate each distance covered by the patient in relation to time, despite interruptions or decision not to continue the test. The disproportionate shortening of the distance after the procedure compared to the distance before the procedure in the control group also requires more closer study. In the fourth day of hospitalization, younger, disease-free patients covered merely 249.47 ± 26.66 m (on the first day of admission to the hospital – 565.93 ± 20.41 m), which is on average only 5.71 m more than patients in the study group with limited exercise tolerance. The result could have been influenced by a greater number of completed post-treatment test trials (21 for the control group, 17 for the study group). That said, during the follow-up of patients, a conclusion was drawn that individual postoperative status, postoperative complaints, and fears of excessive physical exertion in most cases limited the results achieved by the respondents. Previously, many authors, based on studies, concluded that the 6MWT distance and the clinical symptoms were correlated [10, 19]. According to other publications [10, 18, 20], higher exercise tolerance was reported in younger patients than in older patients. The analysis of the distance covered and the assessment of dyspnea and fatigue according to the Borg scale in patients who developed early complications after surgery must be recognized.

On the day of admission, patients covered shorter distances (in the study group – 459.48 ± 49.64 m, in the control group 542.20 ± 19.38 m) compared to patients with an optimal course of hospitalization (in the study group 512.89 ± 26.90 m, in the control group 570.45 ± 17.41 m). The incidence of complications was higher in the group of patients with cardiovascular and pulmonary burdens (12 in the study group and 8 in the control group). Previous reports confirmed that patients with comorbidities with low exercise tolerance, who achieve shorter distances during 6MWT, are predisposed to developing postoperative complications [13, 15, 16, 19]. In the study group there were cases of exacerbation of circulatory failure (2 cases) and uncontrolled arterial hypertension (5 cases). Hematomas and swelling of the wound and operated area were more frequent in the study group, especially in patients using anticoagulants. No cases of completed 6MWT were reported in patients with complications. This demonstrates a significant limitation of physical capacity and exercise tolerance of patients in the complicated early postoperative period. It should be noted that, to our knowledge, there has been no study analyzing physical capacity based on 6MWT in patients with inguinal hernia. Therefore, we do not have objective data with which the obtained results could be compared. According to the literature, the average distance traveled by healthy men in various age groups was 576 m (377–778 m) [21], 735 ± 98 [22], 638 ± 44 [23], 685 ± 49 [24], 429 ± 47 [25] (data compiled in the article by Dourado) [26]. The mean results achieved by patients in the study and control groups before the surgery, taking into account health burdens, correspond to the results of previous reports (despite other assumptions of the study) [27, 28].

After inguinal hernia surgeries, patients are recommended a 6–8-week period of limiting physical effort (especially professional activity, depending on work severity), including lifting items heavier than 10 kg [29]. Despite many studies stating that early rehabilitation does not increase the incidence of complications and recurrences of hernias [29, 30], there still prevails a conviction amongst surgeons about the benefits of strict limitation of physical activity after surgery. It is undisputed that early

rehabilitation accelerates the recovery period, therefore simple everyday activities such as walking, should be the first rehabilitation exercises.

Patients from the study group with comorbidities more frequently discontinued 6MWT and has lesser tolerance to physical effort compared to the control group. 6MWT is a useful tool for determining exercise capacity and exercise tolerance.

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