Teka Komisji Prawniczej PAN Oddział w Lublinie, vol. XVI, 2023, no. 2, pp. 469-487
https://doi.org/10.32084/tkp.5694

FUNCTIONAL ASSESSMENT OF PATIENTS AFTER HIP AND KNEE ARTHROPLASTY – PRELIMINARY STUDIES

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Abstract. Osteoarthritis is one of the main causes of pain and functional disorders in society, one that often affects the performance of everyday activities. The treatment usually consist of physiotherapy and pharmacotherapy, while in advanced stages, surgical treatment is required. The common method to assess the effectiveness of treatment is the physical examination by standardized scales of quality of life, assessment of pain and functioning. More recently, advances in objective assessment tools have been included such as DIERS formetric III 4D, myotometry or bioimpedance. The aim of the study is to evaluate the functional assessment of patients after hip and knee

ISSN 1899-7694
e-ISSN 2719-7379

arthroplasty performed due to osteoarthritis. Hip and knee arthroplasty clearly improves the functioning of patients, reduces the intensity of pain and the risk of falls. In addition, changes in muscle tone and stiffness were demonstrated before and after the arthroplasty of the lower limbs.

Keywords: osteoarthritis; arthroplasty; VAS; WOMAC; Tinneti; DIERS; Myoton; bioimpedance

INTRODUCTION

Osteoarthritis (OA) of the lower limbs is the most common joint disease and one of the main causes of pain and functional disorders in people over 50 years of age. When present it often affects the performance of everyday activities and consequently leads to a reduced quality of life [Sierakowska, Sierakowski, Wróblewska, et al. 2010]. Whilst OA most often affects people over the age of 50, it can also occur in younger people. OA of the knee affects 19-28% of the population over 45 and 37% of people over 60. According to the World Health Organization, OA is a major cause of reduced mobility in women and men [O'Neill and Felson 2018; Tomaszewski 2016; Xiaotian, Hongchen, Wenwen, et al. 2020; Zhang and Jordan 2010]. Patients with OA often present with pain, joint stiffness, limited mobility, and over time with joint deformation and contractures [Materkowski 2019]. Common risk factors for the development of osteoarthritis are: older age, female gender, overweight and obesity, joint injuries – mainly the knee joint – and long-term joint overload [Biegański and Polewska 2015].

The treatment of OA usually includes health education of patients and changes in lifestyle (e.g. weight loss), physiotherapy (including physical treatment, exercises or manual therapy) or pharmacology (non-steroidal anti-inflammatory drugs and intra-articular injections). In advanced forms of OA, when pain and stiffness significantly affect the functioning of the patient, surgical treatment is undertaken. Endoprosthetic procedures have been demonstrated to significantly improve the quality of life of patients, whilst also reducing pain in 80% of knee replacements and 90% of hip replacements [Katz, Arant, and Loeser 2021; Pop, Bejer, Baran, et al. 2018; Romanowski, Zdanowska, and Romanowski 2016].

The assessment of the effectiveness of treatment and physiotherapy usually includes a physical and subjective examination in combination with standardized but subjective scales, e.g. visual analogue scale (VAS), Tinetti balance and gait assessment scale, Laitnen scale, The World Health Organization Quality of Life scale (WHOQoL), The Western Ontario and McMaster Universities Arthritis Index (WOMAC). More recently, patient examinations have included the use of modern digital technologies like DIERS formetric III 4D device, that assess the body posture and distribution

of center of gravity, or myotometry which provides information regarding the properties of muscles, specifically their stiffness or flexibility. In addition, neuromuscular changes and resting muscle tone can be assessed by superficial electromyography, while the addition of bioimpedance allows to assess the fluid and nutritional status of the patient.

The aim of the study is to evaluate the correlation between these objective measures of muscle properties, with the functional outcomes of patients following hip or knee arthroplasty performed due to osteoarthritis.

1. MATERIALS AND METHODS

The study was conducted among patients with advanced osteoarthritis of the hip and knee joints who were listed and underwent endoprosthetic surgery. The patients were treated in the Department of Orthopedics and Rehabilitation of the Independent Public Clinical Hospital No. 4 in Lublin. The study was approved by the bioethics committee of the Medical University of Lublin – no. KE-0254/149/2021.

Patients undergoing elective endoprosthetic surgery for osteoarthritis of the lower limbs were included in the study. According to the type of surgery patients were divided into those, who were undergone knee arthroplasty (group K) and those who were undergone hip arthroplasty (group H). Patients were qualified from among those reporting to the orthopedic clinic of the Independent Public Clinical Hospital No. 4 in Lublin and identified by doctors as requiring either hip or knee arthroplasty. Patients who had a history of stroke, cerebrospinal injuries, amputation within the lower limbs, multiple sclerosis or rheumatoid arthritis were not included in the study. Patients were also excluded if they had active malignant disease or early severe post-operative complications.

In the study an author's questionnaire was used together with visual analogue scale (VAS), The Western Ontario and McMaster Universities Arthritis Index (WOMAC), Tinetti balance and gait scale. Author's questionnaire was created a priori by the research team and includes socio-demographic information together with information about duration of OA, pain intensity and comorbidities. In addition, measurement of lower limb circumferences was recorded, bioimpedance was measured by the BCM Fresenius Medical Care device, muscle stiffness and flexibility was measured by the MyotonPRO device, and the load on the lower limbs was analyzed using the DIERS formetric III 4 D device.

The measurements were performed in three time points: 1) examination was done before surgery; 2) examination was done in 8-10 days after

the surgery; 3) examination was done in one month after discharge from the hospital.

Statistical analysis of the collected research results was carried out using the Statistica13.1 (Palo Alto, CA, USA) and Origin2021b (OriginLab, Northampton, MA, USA) programs. To assess the statistical significance of differences between measurements performed at different time points depending on the type of data, the following were used, respectively: ANOVA with repeated measures for continuous variables or ANOVA of Friedman's ranks (non-parametric equivalent of ANOVA with repeated measures) for variables measured on an ordinal scale or not meeting the conditions necessary for the use of parametric analysis (normality of distribution, homogeneity of variance) along with appropriate post hoc tests (Tukey and Dunn's test with Bonferroni correction). In the case of comparisons between the study groups, the Student's t-analysis was used for variables characterized by normal distribution and homogeneity of variance, or, if the variables did not meet certain assumptions, the non-parametric Mann-Whitney U test. The normality of the distribution and the homogeneity of the variance were assessed using the Shapiro-Wilk test and the Levene test, respectively. The significance level of p was set at 0.05.

2. RESULTS

24 patients aged 47 to 77 were studied. The demographic data were presented in table 1. All procedures were performed under spinal anesthesia. In the case of surgery within the hip joint, the patient was placed on the opposite side and posterolateral access to the joint was performed. In the case of knee arthroplasty, the patient was placed on his back and an anteromedial approach to the joint was performed. Each patients received fluid therapy at a dose of 10 to 15 ml per kg of body weight during surgery and 1000 to 1500ml of crystalloids during first post-operative period. Patients were activated the second day after surgery. Every patients received analgesic treatment for 2 days after surgery (pyralgin, perfalgan or oxycodone).

Table 1. Characteristic of the research groups

		K (n=12)	H (n=12)
Age [years]		70,1 ± 5,5	64,5 ± 7,6
Height [cm]		165,3 ± 9,1	172,4 ± 7,9
BMI		31,64 ± 2,3	30,01 ± 1,8
Marital status	single	-	-
	married	50% (6)	92% (11)
	widower	42% (5)	8% (1)
	divorced	8% (1)	-
Education	primary	17% (2)	8% (1)
	basic vocational	42% (5)	17% (2)
	secondary	25% (3)	50% (6)
	higher	17% (2)	25% (2)
Place of residence	Village	50% (6)	42% (5)
	Town	17% (2)	-
	City	33% (4)	58% (7)
Time Since diagnosis [years]	0-1	-	42% (5)
	1-2	-	-
	2-5	25% (3)	25% (3)
	6-10	42% (5)	33% (4)
	11-15	8% (1)	-
	16-20	17% (2)	-
	21-25	-	-
	over 30	8% (1)	-
How long the pain persist [years]	0-1	-	17% (2)
	1-2	-	8% (1)
	2-5	25% (3)	42% (5)
	6-10	33% (4)	25% (3)
	11-15	17% (2)	8% (1)
	16-20	8% (1)	-
	21-25	8% (1)	-
	over 30	8% (1)	-

*Data is presented as mean ± (standard deviation) or frequency % (percentage)

2.1. Assessment of pain intensity based on the VAS scale

A significant reduction was observed in pain scored for all time points in both groups (see figure 1). No statistically significant differences were seen in the level of reduction between the groups.

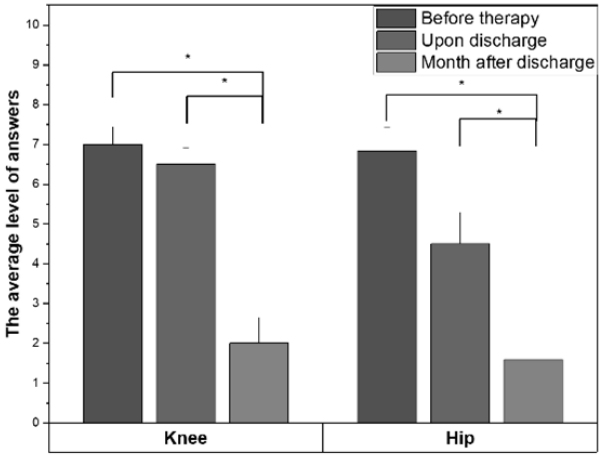


Figure 1. The average level of pain measured by VAS scale for two groups. * means statistically significant differences for the assumed level p<0,05

2.2. Assessment of balance and gait according to the Tinetti scale

The studies conducted to assess the risk of falls showed significant changes in both groups. The greatest risk of falls occurred at the time of discharge from the hospital, although this had shown significant improvement and a reduced risk of falls by one month. Again there were no statistically significant differences between the groups (figure 2).

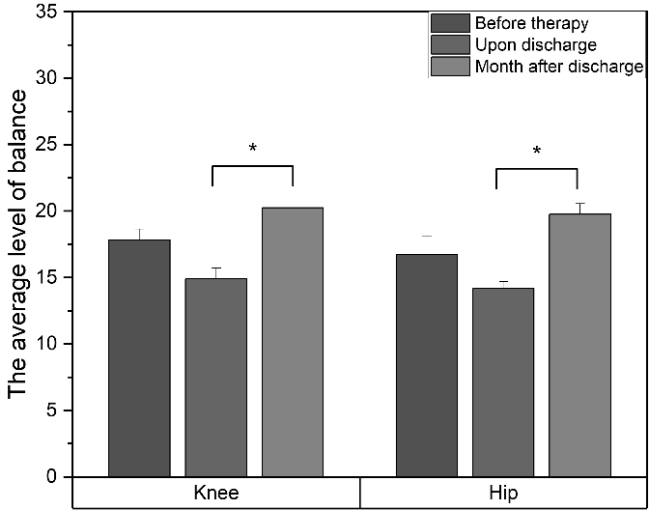


Figure 2. The average level of balance measured by Tinneti scale for two groups. * means statistically significant differences for the assumed level p<0,05

2.3. Evaluation of patients' functioning based on the WOMAC questionnaire

Measurements of the degree of functional limitation measured with the WOMAC questionnaire showed an approximately two-fold and statistically significant increase in the patients' fitness a month after discharge compared to the period before the surgery in both groups (figure 3).

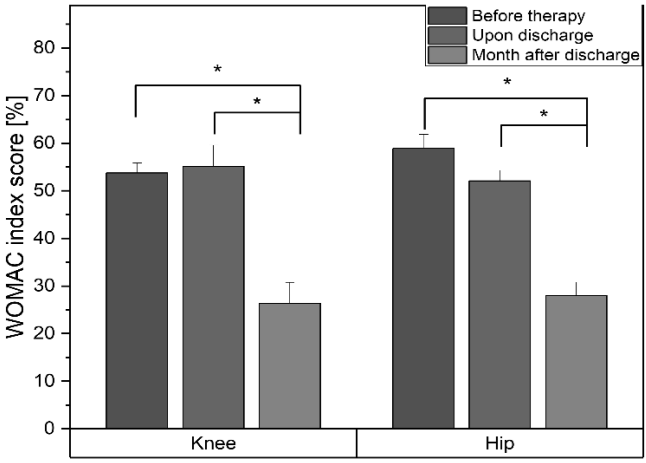


Figure 3. The average functional level measured by WOMAC scale for two groups. * means statistically significant differences for the assumed level $p<0,05$

2.4. Measurement of limb circumferences

The circumferences of both lower limbs were measured in the following locations: first femoral, second femoral, knee, first shin and second shin [Józefowski 2013].

The analysis of the results of our research showed the existence of differences in both measurements of the right and left thighs (F1 and F2) in the study groups. The values observed for group K (knee arthroplasty) were significantly higher than those recorded for group H (hip arthroplasty). This regularity was maintained in all stages of the study. None of the other circuits changed in a statistically significant way. There are statistically significant differences between the groups (table 2).

Table 2. Changes in circumferences of the lower limbs among the subjects

Measurement	Group	Average ± SE		
		Before surgery	After surgery	A month after discharge
First femoral left F 1	K	56,692±1,637	55,375±1,565	55,958±1,467
	H	51,292±1,668	51,250±1,522	50,417±1,602
p – value		p<0,05	p<0,05	p<0,05
First femoral right F 1	K	56,375±1,468	56,333±1,432	55,875±1,364
	H	50,125±1,881	50,000±1,947	50,458±1,678
p-value		p<0,05	p<0,05	p<0,05
Second femoral left F 2	K	48,292±0,836	49,083±1,090	47,667±0,966
	H	44,583±1,190	44,542±1,047	43,692±1,052
p-value		p<0,05	p<0,05	p<0,05
Second femoral right F 2	K	48,542±0,988	50,125±1,228	48,250±1,194
	H	44,125±1,428	43,625±1,322	43,417±0,939
p-value		p<0,05	p<0,05	p<0,05
Knee left K	K	43,333±0,582	44,125±0,973	42,917±0,818
	H	40,875±1,260	42,000±1,006	41,292±1,129
p-value		p>0,05	p>0,05	p>0,05
Knee right K	K	43,042±0,897	45,833±1,006	43,250±0,968
	H	41,500±0,965	41,667±1,052	40,750±1,016
p-value		p>0,05	p>0,05	p>0,05
First shin left Sh-1	K	39,333±1,110	38,750±1,069	38,625±1,195
	H	38,542±1,306	38,458±1,076	37,750±1,109
p-value		p>0,05	p>0,05	p>0,05
First shin right Sh-1	K	39,542±0,847	39,583±0,971	38,750±1,016
	H	38,167±1,322	38,000±1,195	37,208±1,215
p-value		p>0,05	p>0,05	p>0,05
Second shin left Sh-2	K	23,875±0,769	24,167±0,548	24,375±0,691
	H	24,458±0,695	24,958±0,716	24,250±0,695
p-value		p>0,05	p>0,05	p>0,05
Second shin right Sh-2	K	23,792±0,619	24,250±0,475	25,083±1,334
	H	24,458±0,711	24,167±0,664	24,208±0,661
p-value		p>0,05	p>0,05	p>0,05

2.5. Evaluation of the physiological parameters of the muscles of the lower limbs using the MyotonPRO device

Myotometry is used to assess muscle properties such as tension (F), stiffness (S) and elasticity (D). Measurements were made within the following areas: gluteus maximus, rectus femoral, tibialis anterior, gastrocnemius and hamstring muscles.

2.5.1. Gluteus maximus muscle

Significant differences in the values measured for knee and hip arthroplasty in terms of tension (F) and flexibility (D) were demonstrated (see figure 4).

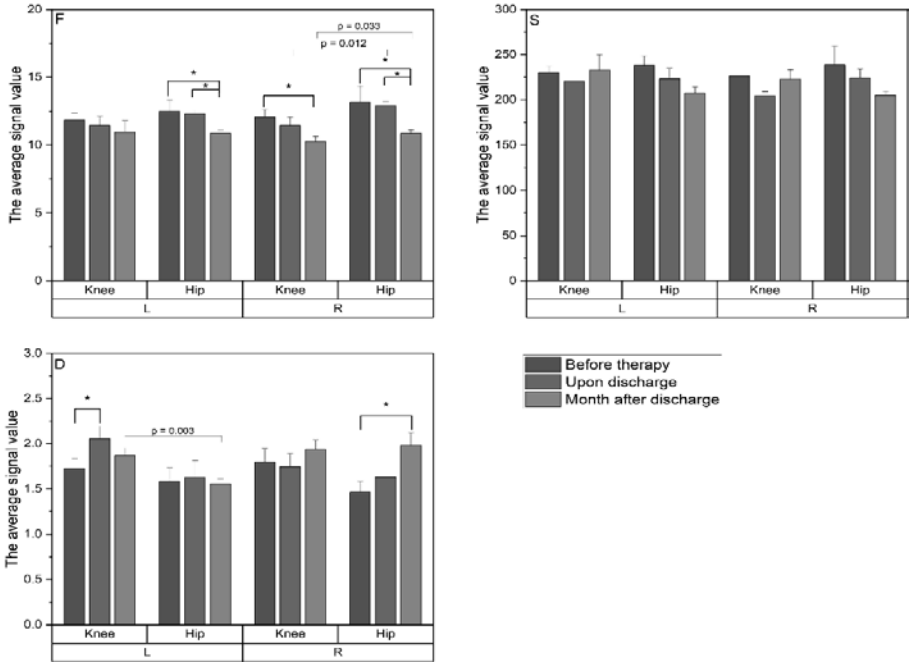


Figure 4. The average signal value for gluteus maximus muscle measured by MyotonPro device for two groups. * means statistically significant differences for the assumed level p<0,05

2.5.2. Rectus femoral muscle

There were statistical differences in the tension of the right rectus femoral muscle measured in a month after discharge between group K and H, where the values for the H group were significantly higher than those for group K. A significant difference was also observed for the right rectus femoral

muscle in the stiffness values (S), but only for the measurements carried out before the therapy (figure 5).

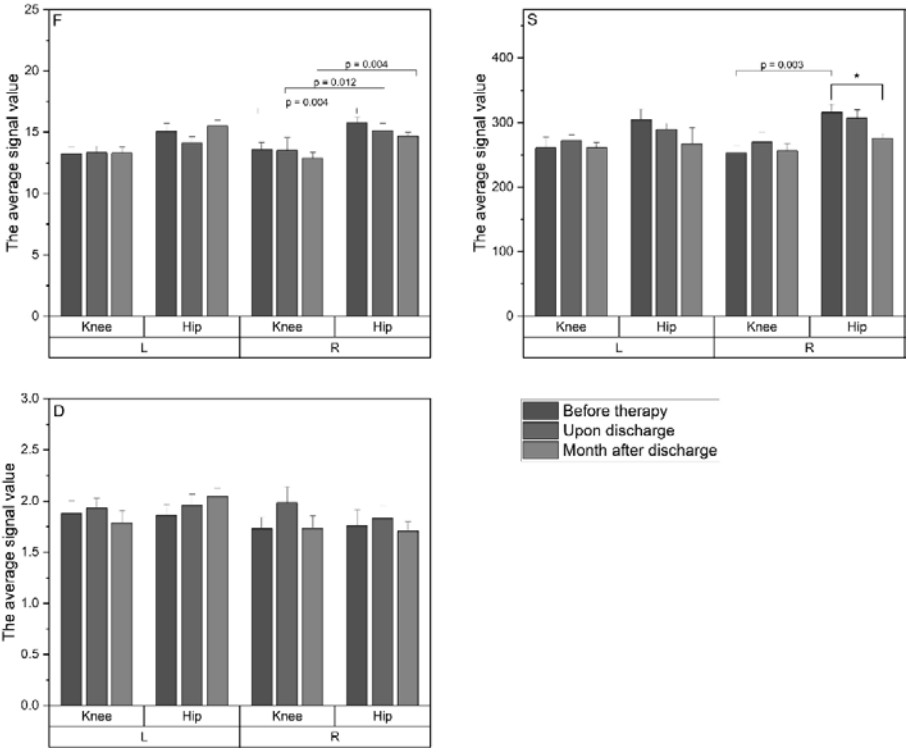


Figure 5. The average signal value for rectus femoral muscle measured by MyotonPro device for two groups. * means statistically significant differences for the assumed level p<0,05

2.5.3. Hamstring muscles

The conducted analyzes showed statistically significant differences between knee and hip arthroplasty for measurements in three stages of the study in the case of the left muscle in terms of tension (F) and the right muscle in terms of stiffness (S) (figure 6).

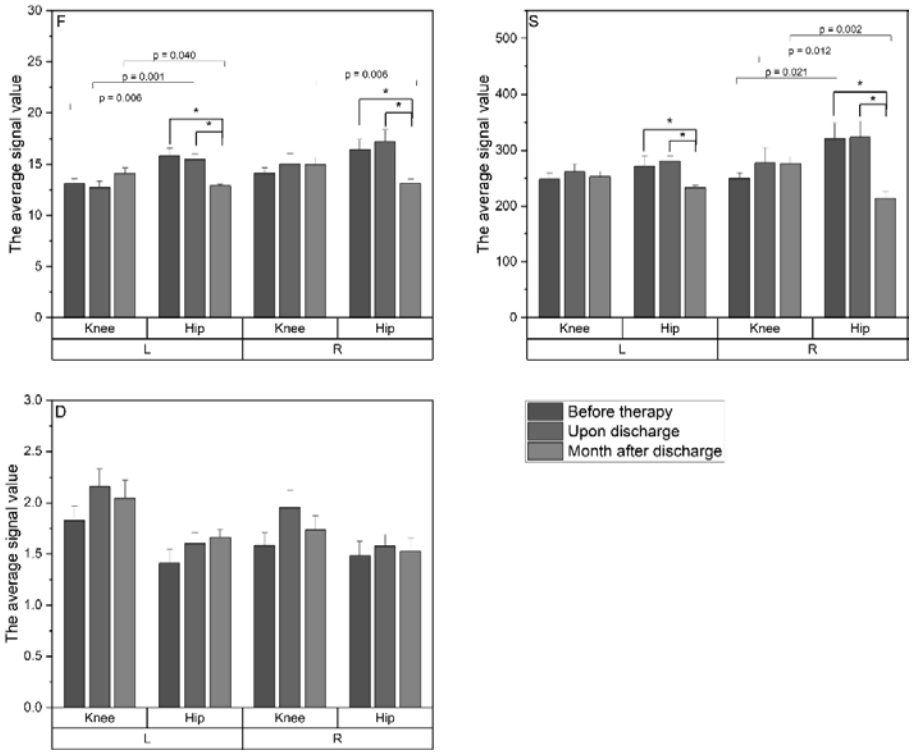


Figure 6. The average signal value for hamstring muscles measured by MyotonPro device for two groups. * means statistically significant differences for the assumed level p<0,05

2.5.4.Ttibialis anterior muscle

When comparing the parameter values for knee and hip arthroplasty, statistically significant differences were revealed between the values of tension (F) and stiffness (S) in the second and third tests. In terms of flexibility (D), the measurements for both limbs were significantly different (figure 7).

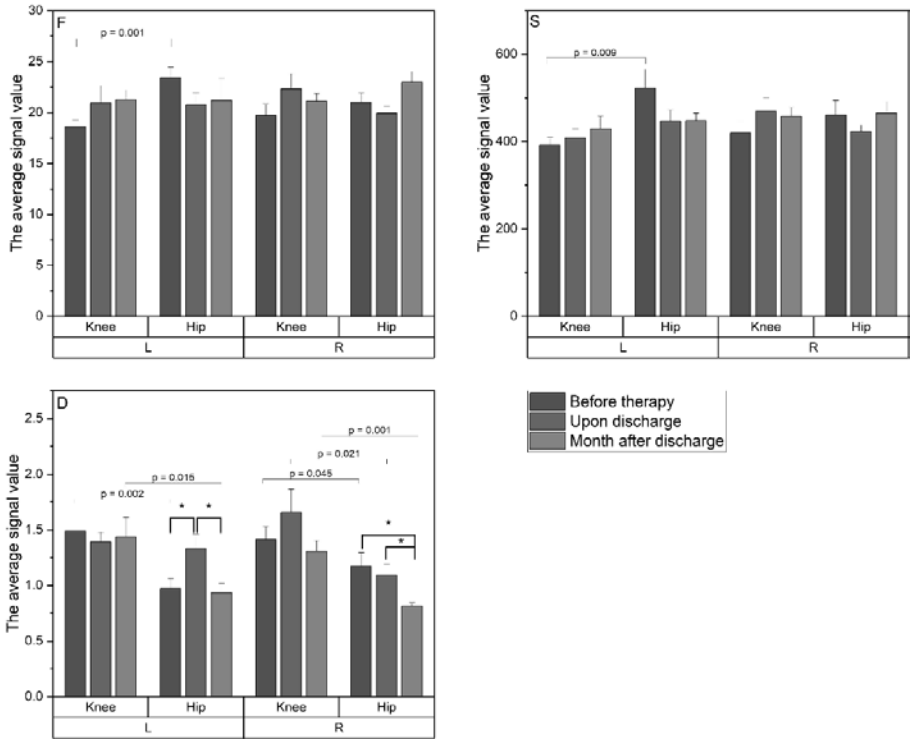


Figure 7. The average signal value for tibialis anterior muscle measured by MyotonPro device for two groups. * means statistically significant differences for the assumed level p<0,05

2.5.5. Gastrocnemius muscle

Comparing the values for knee and hip arthroplasty, it can be seen that statistically significant differences between the groups are found in the left gastrocnemius muscle in terms of tension (F) and elasticity (D), and the right one in terms of tension (F) and stiffness (S) only for measurements made one month after discharge (figure 8).

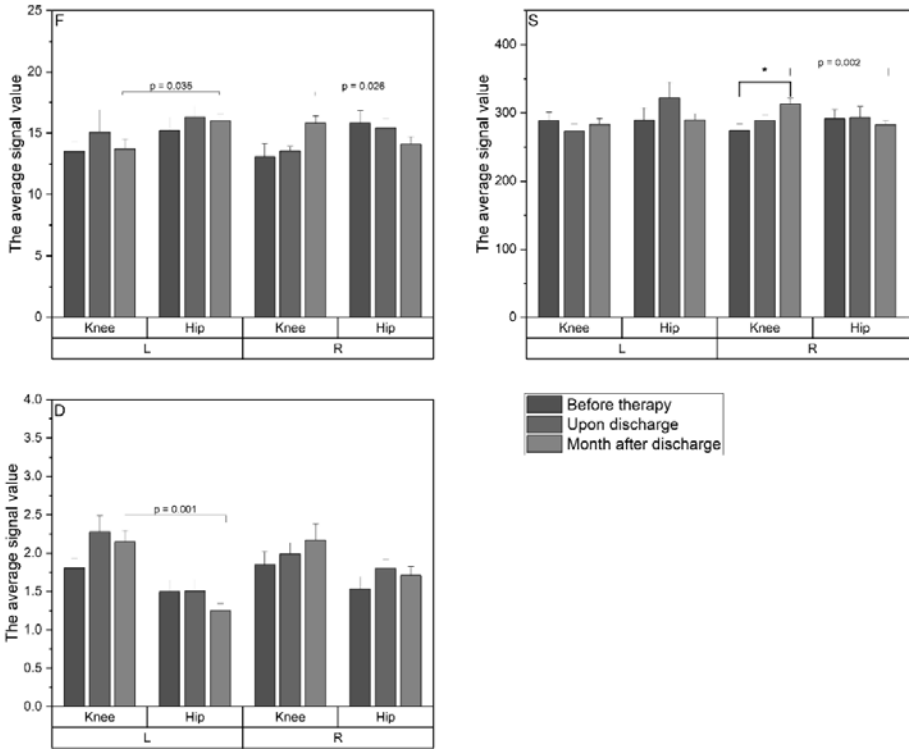


Figure 8. The average signal value for gastrocnemius muscle measured by MyotonPro device for two groups. * means statistically significant differences for the assumed level $p<0,05$

2.6. Assessment of bioimpedance using the BCM Fresenius Medical Care device

During the study, the following measurements were taken: body hydration (OH), adipose tissue mass (ATM), lean tissue mass (LTM), total body water (TBW), intracellular water (ICW) and extracellular water (ECW).

Comparing the data between the groups, statistically significant changes were shown in the measurements of the amount of total body water and the amount of intracellular water obtained one month after discharge, with higher variables among patients after hip arthroplasty. In the case of the LTM variable, measurements made for knee and hip arthroplasty before the therapy and one month after discharge were statistically different (figure 9).

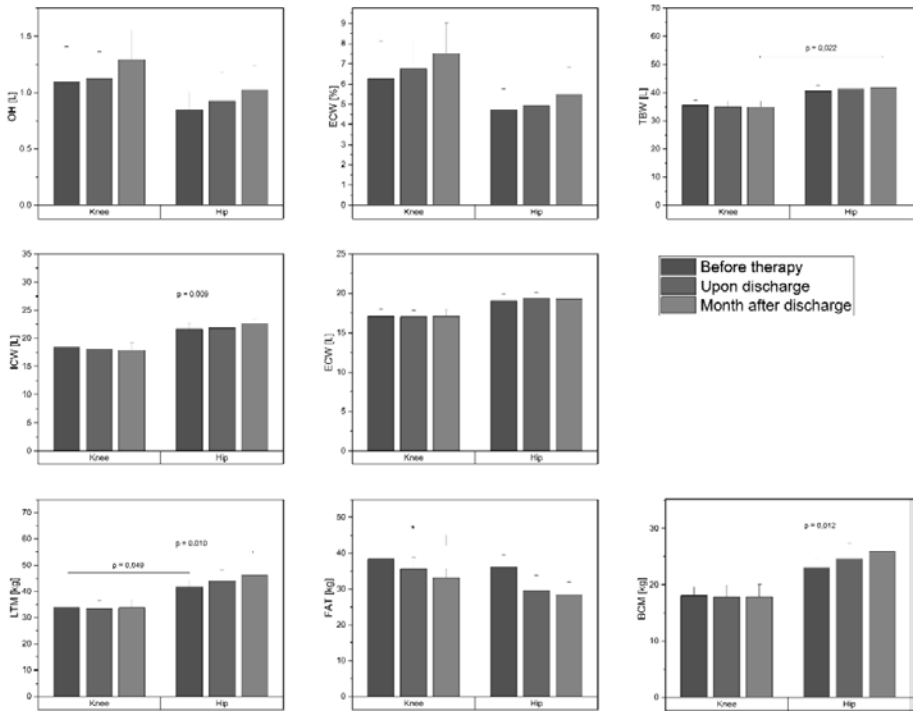
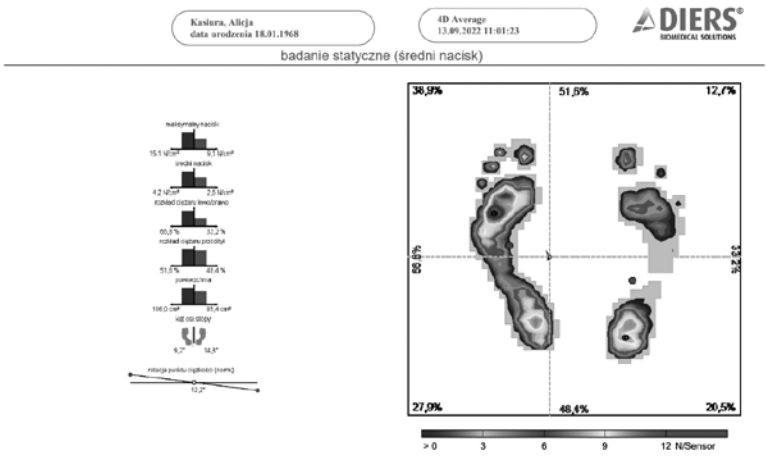


Figure 9. Body composition measurements performed by BCM Fresenius Medical Care device for two groups. * means statistically significant differences for the assumed level $p<0,05$

2.7. Assessment of the load on the lower limbs using the DIERS formetric III 4 D device

During the examination, the load on the lower limbs of the patient was analyzed in terms of pressure force, body weight distribution both in the front-back and right-left direction.



Picture 1. Assessment of the load distribution on the lower limbs by DIERS formetric 4D device.

Comparing the data obtained for group K and group H, it can be seen that the only statistically significant differences between them showed the average pressure variable (right side), for which the values obtained for group K were significantly lower compared to those obtained for group H at each stage of the study (figure 10).

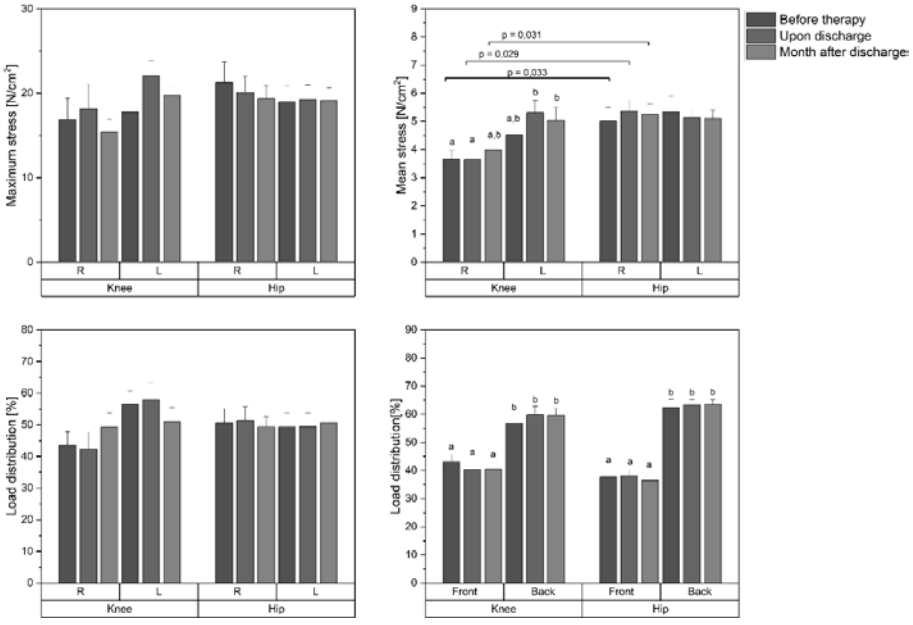


Figure 10. Assessment of limb load measure by Diers device for two groups. Letters *a* and *b* means statistically significant differences for the assumed level p<0,05

3. DISCUSSION

Hip and knee arthroplasty significantly improves patients functioning, reduces pain intensity and the risk of falls. We documented a significant improvement in fitness according to the WOMAC questionnaire and a reduction in the risk of falls according to the Tinetti scale after knee and hip arthroplasty. The improvement in the functioning of patients can be directly linked to the reduction in the intensity of the pain experienced. Similar observations by Ramlall et al. demonstrated a correlation between the knee arthroplasty procedure and the pain experienced by the patient [Ramlall, Andrion, Cameron, et al. 2019]. The study by Sierakowska et al., points to chronic pain as the main symptom of osteoarthritis of the lower limbs. The authors showed a correlation between disease duration and increased disability in patients. According to their results, long-term osteoarthritis increases patients' functional problems and negatively affects their ability to move and perform activities of daily living [Sierakowska, Sierakowski, Wróblewska, et al. 2010]. In their work Vitaloni et al. conducted a systematic review of 610 articles assessing the quality of life of patients with lower limbs osteoarthritis. The authors clearly stated that arthritis of the knee joints significantly affects the deterioration of the functioning of the patients, however, knee arthroplasty brings much better results in improving the quality of life compared to other methods of treatment [Vitaloni, Botto-van Bemden, Sciortino Contreras, et al. 2019].

In our study we found a significant changes in muscle tone and stiffness before and after lower limb arthroplasty. The difference was seen primarily in measurements of rectus femoral and hamstring muscles. Our data showed a decrease in stiffness only among patients after total hip arthroplasty, while in post-knee arthroplasty patients, stiffness parameters remained unchanged for rectus femoral and increased in hamstring muscles. Muscles tone measurement changed slightly at all stages of the research for both groups, being generally higher among patients after hip arthroplasty. An interesting study on the relationship between pain and muscle strength was presented by Waldon et al. in which they showed that advanced knee osteoarthritis is accompanied by severe pain. Additionally, they presented correlations between chronic lower limb joint pain and decreased muscle strength [Waldon, Szczypiór-Piasecka, Mińko, et al. 2021]. Similar observations were made by Basat et al., who identified a relationship between reduced muscle strength with the development of lower limbs osteoarthritis. In the study, they showed weakness in the rectus femoral muscle, which is, according to the authors, a direct factor in the development of arthritis in the knee joint [Basat, Sivritepe, Ortaboz, et al. 2021]. These results are only partially consistent with our research. Therefore, further research in this direction

should be conducted to confirm the hypothesis that osteoarthritis affects the reduction of muscle strength. Quadriceps femoral stiffness has also been studied by Chang et al. The authors showed that in patients with degenerative changes in the knee joint, there is greater stiffness of the vastus laterals muscle compared to healthy individuals [Chang, Zhu, Li, et al. 2022].

Our study with myotonometry showed the increase in tension and stiffness in the tibialis anterior and gastrocnemius muscles among patients after knee arthroplasty, while in the group of patients after hip arthroplasty, only a slight increase in gastrocnemius muscle tension was observed as well as in the tibialis anterior muscle. The collected results were confirmed with the studies of Chen et al., where an increase in stiffness of the Achilles tendon was demonstrated in patients with advanced knee osteoarthritis [Chen, Ye, Shen, et al. 2021]. Several authors in their publications focus on muscle stiffness values during myotometric examination. In own study, the authors additionally considered the following variables: muscle tension and flexibility.

In our study, we obtained slightly higher values of adipose tissue mass in knee arthroplasty patients at each stage of the examination, and higher amounts of lean tissue mass were noted in patients after hip arthroplasty. In addition, during all three stages of the study, a decrease in the amount of total body water and intracellular water was noted in patients after knee arthroplasty. In the second group of patients, these values increased slightly, but were not statistically significant. Similar data showed authors DeMik and Marinier et al. in their study. They checked the effect of osteoarthritis of the hip and knee joints on the patient's body composition components. In their results, lower values of adipose tissue mass were observed in patients with changes in the knee joint, without changes in other parameters. The lean tissue mass values of patients with knee and hip arthritis were within similar limits, while adipose tissue mass values were slightly higher in patients with the affected knee joint. They also showed that in patients with unilateral hip arthritis, the amount of total water in the lower limb, as well as intracellular water, and the amount of lean and adipose tissue mass were significantly lower compared to the unaffected limb. [DeMik, Mariner, Gulbrandsen, et al. 2022].

We also studied a load analysis on the lower limbs before and after surgery. The data collected show that the average pressure on the ground was higher in patients after hip arthroplasty, while a much higher load on the rear foot was observed in all patients, regardless of the location of the changes. During lower limbs osteoarthritis, patients experience multiple trunk compensations due to pain and limited joints mobility. Fu and Duan et al. have shown in their studies a greater pelvic anteversion and a greater inclination of the trunk in the anteroposterior direction in patients with arthritis

of the lower limbs compared to healthy individuals [Fu, Duan, Hou, et al. 2021]. In their work, Kechagias et al., examined 34 patients after hip arthroplasty and 45 patients after knee surgery. They came to an interesting conclusion that knee or hip arthroplasty does not improve spinal position and compensation, which may indicate that osteoarthritis does not necessarily change body posture [Kechagias, Grivas, Papagelopoulos, et al. 2022]. It is consistent with our observation that arthroplasty of hip or knee joint does not alter the load distribution of patients' lower limbs. This finding indicates that we should take a closer look at the posture of patients with osteoarthritis and conduct more detailed research in this area.

Limitations: This study is preliminary work, that allowed to verify suitability of selected research tools for the functional assessment of patients after hip and knee arthroplasty. However, further studies should be carried out to create larger groups in terms of the reliability of the research. The presented results of the study should be compared with the control group, which is subjected to non-surgical treatment.

CONCLUSIONS

The conducted study clearly showed functional improvement of patients after hip and knee arthroplasty. Analysis of the collected results shows a significant change in the intensity of the pain and the risk of falls at all stages of the study for both groups. Changes in muscle tone and stiffness were demonstrated before and after the arthroplasty of the lower limbs. Hip and knee arthroplasty improve balance and body weight distribution on the lower limbs.

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