IMPACT OF BODY MASS INDEX ON FUNCTIONAL RECOVERY AFTER TOTAL KNEE REPLACEMENT

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SUMMARY – The aim of this study was to determine whether body mass index and age had an impact on functional recovery two years after total knee replacement. The research was conducted at the Lovran Hospital of Orthopedics and Traumatology, School of Medicine, University of Rijeka, Croatia. Study sample included patients who underwent total knee replacement surgery with median parapatellar approach in 2019. Morphological measurements, knee range of motion and WOMAC questionnaire score were examined before and two years after surgery. Descriptive statistics was used for gender, age and body mass index, and inferential statistics was employed to check the correlation of recovery measured by changes in the WOMAC score and change in the range of motion results with age and body mass index. According to study results, male and female patients did not differ in body mass index (t=1.184; p>0.05). There was no statistically significant correlation of functional recovery of the patients with age (p=0.556), or between body mass index and differences in the range of motion (p=0.927) from flexion to extension. The study indicated that knee arthroplasty and thus the impact on functional recovery had an equally good effect regardless of age. In patients who had flexion contracture before surgery, the surgery improved motion amplitude.

Key words: *Functional recovery; Body mass index; Range of motion; Knee replacement implant*

Introduction

The anatomical and biomechanical knee joint alongside the hip joint is the most complex and largest joint in the human body[1]. The lower extremities transfer body weight to the ground and are responsible for bipedal gait. The anatomical structure of lower extremity joints enables three-dimensional movement. Therefore, the knee joint is predisposed to frequent injuries and degenerative changes. Nowadays, when a sedentary lifestyle is increasingly present, body weight and inactivity play an additional role in their development. Osteoarthritis (OA) is one of the most common indications for total knee replacement and represents the gold standard in the treatment of advanced OA. The basic premise for total knee replacement is painless and functional movement[2]. The functionality of movement is not only related to correct motor movement, but also to ensuring independence in daily activities and achieving better quality of life in patients after total knee replacement

surgery. Successful and normal functional movement is influenced by various factors such as the maintained movement integrity and functionality before surgery, appropriate postoperative rehabilitation, and regular physical activity. Few studies have shown the impact of body weight on functional outcome of surgery[3] at a longer period after the surgery. Studies that monitor total knee replacement and body weight are mostly related to a loose prosthesis and the incidence of joint infections[4-6]. There is conflicting research on how and to what extent does body mass index (BMI) affect functional recovery[7-9]. The aim of this study was to determine whether BMI and age had an impact on functional recovery two years after total knee replacement, and assess the correlation between BMI and range of motion (ROM).

Subjects and Methods

This retrospective study was conducted at the Lovran Hospital of Orthopedics and Traumatology from January to February 2022. The research was conducted by searching the Hospital database for data on patients who came for a scheduled total knee replacement surgery. Approval for this research was obtained from the Ethics Committee of the Lovran Hospital of Orthopedics and Traumatology (no. 57-02/2022) and it was conducted according to the principles of the Declaration of Helsinki.

Study sample

Study sample included patients who underwent total knee replacement surgery with median parapatellar approach in 2019. All subjects were examined and tested by the Hospital physiotherapists before surgery and at two-year follow-up. Depending on the date of surgery, the follow-up took place in 2020 or 2021. The criteria for inclusion in the study were fully treated subjects and an implanted artificial joint due to primary OA. Exclusion criteria for the study were secondary OA and reoperation of an artificial knee joint.

Initially, there were 62 subjects with an artificial knee joint. On final data processing two years after total knee replacement, 46 patients applied for a follow-up examination. Out of 46 patients, there were 29 (63%) women and 17 (37%) men. The mean patient age was 73.28 years, mean body height 168.35 cm, mean body weight 86.7 kg, and mean BMI 30.8. The mean ROM

of knee joint flexion before surgery was 95 degrees. Flexion contracture of the knee joint before surgery had 25 patients, while 21 patients had no contracture.

The variables and measuring instruments tested

Basic demographic variables (age and sex) and two morphological measurements (body height and body weight) from which we calculated BMI were taken from the database. Anthropometric measurement of body weight was performed using a digital scale with an accuracy of 0.1 kg, and body height with an anthropometric accuracy of 0.1 cm. Measuring ROM is a very important component of the examination that indicates joint function. The ROM in terms of knee flexion and extension was measured using a universal plastic goniometer that is used in most research due to its simplicity[10]. To further assess the function, patients completed the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) questionnaire. The WOMAC index is one of the most frequently used questionnaires in research after total knee and hip replacement, but also of the knee and hip OA[11]. It consists of 24 items divided into 3 subscales with Likert scale answers. The stated summative scale is scored from 0 to 4. The patient must circle the number (0-none; 1-slight; 2-moderate; 3-severe; and 4-extreme) that best describes his/her condition depending on the question. The result of the questionnaire ranges from 0 to 96. The lower the outcome score, the better is functional outcome[12]. The questionnaire has been translated and validated in a large number of languages, and its reliability, validity and sensitivity have been proven in a number of studies[13].

Statistical procedures

Data were processed using the SPSS Statistics v. 26 data processing program. Descriptive statistics (percentages, measures of central tendency and scatter) were used to describe correlation of sex, age, body height and body weight with BMI. Inferential statistical methods (Pearson's correlation coefficient, McNemar test) were used to test correlation of recovery measured by changes in the WOMAC scores and changes in ROM from flexion to extension with age and BMI, and to compare the presence of flexion contractures before and two years after the operation. The normality of distribution was tested by the Shapiro-Wilk test,

and the appropriate method of analysis was used in accordance with the data obtained.

Results

Data on patient age, body height, body weight, and BMI are shown in Table 1. Out of 46 patients, there were 29 (63%) women and 17 (37%) men.

Male and female patients did not differ according to BMI (t=1.184, p>0.05), while female patients were slightly older than male patients (t=2.085, p<0.05).

Correlation between age and recovery

In order to check whether there was a statistically significant correlation between patient age and recovery measured as difference between the WOMAC questionnaire scores before and two years after surgery, a correlation coefficient was calculated. Prior to that, the Shapiro-Wilk test was performed to verify the normality of distribution of both variables. These results are shown in Table 2.

Since no variable deviated significantly from normal, the Pearson's correlation coefficient between the two variables was calculated (Table 3).

The correlation between age and improvement on WOMAC questionnaire was 0.09, and did not reach statistical significance (p=0.556); thus, there was no statistically significant correlation between recovery and patient age.

Correlation between body mass index and recovery

We investigated whether there was a correlation between patient BMI two years after surgery and recovery measured as difference in the ROM from flexion to extension. Before calculating the correlation, the Shapiro-Wilk normality test of distribution of both variables was performed. These results are shown in Table 4.

None of the variables deviated significantly from normal distribution and Pearson's correlation coefficient was calculated (Table 5).

The coefficient was -0.014 (p=0.927), which means that there was no statistically significant correlation between BMI and difference in the ROM from flexion to extension after surgery.

Difference in the number of contractures before and after surgery

In order to verify that there was a change in the number of patients with contractures before and two years after surgery, the McNemar test for paired samples was performed. The p values were calculated by binomial distribution since the number of comparisons in the cells indicating the change was less than 25. These results are shown in Table 6.

There was a statistically significantly higher number of patients who reported change in terms of contractures that existed before the operation and no contractures after the operation (n=19) than those who reported change in another direction (there were no patients who reported having no contractures before to having contractures after the operation), which speaks in favor of recovery after surgery.

Table 1. Age and morphological characteristics of study subjects before surgery

	AM	SD	Mode	Median	Range
Age (yrs)	73.28	5.741	73	73.5	60-88
Body height	168.35	9.066	160	168	150-187
Body weight	86.7	17.839	70	84.5	57-140
BMI	30.809	4.6671	27.1	31.35	19.5-40.0

AM = arithmetic mean; SD = standard deviation; BMI = body mass index; Mode = the value with highest frequency

Table 2. Shapiro-Wilk normality test – age

	Shapiro-Wilk test	p
Age	0.967	0.209
WOMAC	0.973	0.360

WOMAC = Western Ontario and McMaster Universities Osteoarthritis index

Table 3. Pearson's coefficient of correlation (r) between age and differences on the WOMAC questionnaire

Age and WOMAC recovery, r	0.09
p	0.556
n	46

WOMAC = Western Ontario and McMaster Universities Osteoarthritis index

Table 4. Shapiro–Wilk normality test – BMI

	Shapiro-Wilk test	p
BMI	0.986	0.852
ROM FL-EXT	0.976	0.450

BMI = body mass index; ROM FL-EXT = range of motion from flexion to extension

Table 5. Pearson's correlation coefficient (r) between BMI and difference in ROM from flexion to extension two years after surgery

BMI and ROM, r	-0.014
p	0.927
n	46

BMI = body mass index; ROM = range of motion

Table 6. McNemar test comparing the existence of contractures before and after surgery

	Contractures	No contractures	Total
Before surgery	25	21	46
2 years after surgery	6	40	46
p	0.000		

Discussion

The most important results of this study indicate that there is no statistically significant correlation between functional recovery and patient age, or between BMI and difference in the ROM from flexion to extension two years after surgery. Numerous studies followed-up early outcome of surgery after total knee replacement[14-17], whereas only few studies followed-up complete success of surgery two or more years after surgery[18,19] by assessing functional status and measuring motor skills. In their study, Jiang *et al.* state that early mobilization has a positive effect on functional outcome regardless of age and is safe even in patients older than 65 years[18]. Neuprez *et al.* also point out in their study that even five years after knee and hip replacement surgery, functional outcomes are at a high level measured by the WOMAC index[19]. The study by Silva Arauja *et al.* is in agreement with our study and found that age and BMI did not influence functional outcome, however, they assessed it six months after knee replacement[20]. Some authors state that low-intensity physical activity such as walking protects against the loss of function and reduces the feeling of experiencing pain in OA even after knee or hip replacement[21].

The presented results show that the study patients were homogeneous and did not differ according to BMI (t=1.184, p>0.05), although female patients were slightly older than male patients, and there were 63% of women and 37% of men. This is consistent with the OA epidemiology as it is known that women are more likely to develop OA than men[22]. The higher incidence of OA among women is not only recorded in the knee but also in other joints of the locomotor system[23,24]. In general, one of the biggest predictors of OA is age[25]. In this study, the mean patient age was 73.28 years, and the incidence of OA is known to increase after 60 years of age, which also corresponds to the OA epidemiology in general[26]. In addition to age, excessive body weight also has a great impact on its development[27,28]. The mean BMI in our patients was 30.8. In addition to the development of OA, BMI has a great impact on the success of surgery in such a way that excessive body weight affects stability of the prosthesis and creates a greater chance of developing infection[4,6,29]. There also are conflicting views on the impact of body weight on the outcome of surgery. Some authors believe that body weight does not affect knee revision after surgery[7,30].

In addition to functional parameters, body weight is also associated with increased pain after total knee replacement[31], which ultimately leads to decreased functional abilities because pain is one of the main predictors that can lead to disability.

Furthermore, the analysis in this study showed that there was no statistically significant correlation between the WOMAC questionnaire and age, and recovery was not statistically significantly related to age. The outcome of surgery depends not only on surgery but also on many other components such as comorbidities, ROM before surgery, functional status before surgery, motivation, social environment, etc. Townsend *et al.* state in their study that elderly patients had better functional recovery than younger patients[32], but they also state that this is not the rule in scientific papers[33,34]. Murphy *et al.* state that compared to younger patients, patients older than 80 have a slightly poorer quality of life in terms of physical status, but this is not statistically significant[35]. There are more and more scientific papers that refute the already existing paradigms, which state that physical function depends on age, and the level of daily physical activity depends on BMI. Older people have the same benefits of joint implants in lower extremities as younger people[36]. Given that the population is aging[37] and the level of functionality should remain at an enviable level for as long as possible, more research is needed to link the age and functional outcome of the operation, but with long-term follow-up.

Further analysis of the data found that there was no statistically significant correlation between a higher BMI and poorer recovery, as measured by a motor function test two years after total knee replacement. A review of the studies[18,19] shows that a small number of studies monitor the long-term outcome of surgery through the motor and morphological variables. When talking about short-term outcomes of surgery, increased BMI is associated with longer hospital stays, greater blood loss during surgery, higher pain intensity, and a greater chance of developing postoperative infections[3]. Many studies have linked BMI to poor operational outcomes only if BMI was higher than 30[38-40]. Patients in this study had a mean BMI of 30.8, and mode (the value with the highest frequency) was 27.1. The area where the research is conducted should be taken into account and whether they could be generalized to the research population. Many studies

included a BMI higher than 30 or grade II or III obesity. It is not enough to only compare BMI but a research that has approximately the same BMI needs to be found. It is an indispensable fact that obesity is a disease of today's society[41], and in line with this, more research is needed to monitor the impact of BMI on the long-term outcome of surgery.

An additional part of this study was to check whether knee mobility in patients who had joint contracture changed two years after the total knee replacement surgery. The main indications for patients to undergo surgery are pain and limited ROM. Both factors disrupt the patient's daily life and are an indicator of how impaired joint function and daily activities are. Prior to surgery, 25 patients had a limited ROM, unable to fully extend the knee. Two years after surgery, only 6 patients had residual contractures. Full extension is required for normal gait biomechanics to take place[42]. Full ROM, in addition to providing better functionality, also shows that there is less pain and that it can be performed at full amplitude. Some studies indicate how difficult it is to solve this problem and sometimes conservative treatment is not sufficient, and patients have to undergo surgery again to get a better ROM[43]. To achieve satisfactory results, persistent therapeutic exercise and quick return to daily life activities are needed. Only when all the abovementioned factors are satisfied can the patient's quality of life before and after surgery be assessed. In patients who have severe functional limitations before surgery, therapeutic exercise (kinesitherapy) is recommended in order to better prepare for surgical procedures. Before surgical preparation, it can improve flexibility, reduce inflammation and pain, and improve muscle strength[44]. There are few studies that monitored functional outcome of surgery through patient motor skills and BMI. More such clinical trials are needed to obtain a more complete picture of these problems. Research should be conducted on a larger number of patients over a longer period of time (e.g., more than four years).

Conclusion

Body mass index was not associated with poorer recovery, as measured by a motor function test, two years after implantation of an artificial knee joint. This study showed that total knee replacement and thus the impact on functional recovery has, regardless of patient age, an equally good effect. Total knee replacement in patients who have flexion contracture before surgery improved ROM, which is very important for normal gait biomechanics.

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Sažetak

UTJECAJ INDEKSA TJELESNE MASE NA FUNKCIONALNI OPORAVAK NAKON UGRADNJE UMJETNOG ZGLOBA KOLJENA

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Cilj ovog istraživanja bio je utvrditi imaju li indeks tjelesne mase i dob utjecaj na funkcionalni oporavak nakon ugradnje umjetnog zgloba koljena. Istraživanje je provedeno u Klinici za ortopediju Lovran te su uključeni ispitanici koji su došli na elektivni zahvat ugradnje umjetnog zgloba koljena medijalnim parapatelarnim pristupom 2019. godine. Istražile su se morfološke mjere, opseg pokreta koljena te upitnik WOMAC prije navedenog zahvata te dvije godine nakon operacije. Deskriptivno su prikazani spol, dob i indeks tjelesne mase. Inferencijalnim statističkim metodama provjerila se povezanost oporavka mjerena promjenom rezultata na upitniku WOMAC te promjenom rezultata u opsegu pokreta koljena s dobi i indeksom tjelesne mase. Prema rezultatima muški i ženski ispitanici se međusobno ne razlikuju po indeksu tjelesne mase (t=1,184; p>0,05). Funkcionalni oporavak ispitanika nije bio statistički značajno povezan s dobi (p=0,556) i nije bilo statistički značajne korelacije između indeksa tjelesne mase i razlike u opsegu pokreta (p=0,927) iz fleksije u ekstenziju dvije godine nakon operacije. Istraživanje je pokazalo da ugradnja umjetnog zgloba koljena, time i utjecaj na funkcionalni oporavak ima jednako dobar učinak neovisno o dobi. Kod bolesnika koji su imali fleksornu kontrakturu prije operacije, operacija je smanjila kontrakturu u koljenom zglobu.

Ključne riječi: *Funkcionalni oporavak; Indeks tjelesne mase; Opseg pokreta; Umjetni zglob koljena*